FULL REPORT

Digital with Purpose: Delivering a SMARTer2030

GeSI ENABLING DIGITAL SUSTAINABILITY

Deloitte.

GeSI
ENABLING
DIGITAL
SUSTAINABILITY

Deloitte.

Contents

For more information, please visit:

digitalwithpurpose.gesi.org

About the authors

About GeSI

The Global Enabling Sustainability Initiative (GeSI) is a strategic partnership of the Information and Communication Technology (ICT) sector and organisations committed to creating and promoting technologies and practices that foster economic, environmental and social sustainability. Formed in 2001, GeSI's vision is a sustainable world through responsible, ICT-enabled transformation. GeSI fosters global and open cooperation, informs the public of its members' voluntary actions to improve their sustainability performance, and promotes technologies that foster sustainable development.

GeSI enjoys a diverse and global membership, representing around 40 of the world's leading ICT companies and partners with over 12 global business and international organisations such as the International Telecommunications Union (ITU), the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Environment Program (UNEP), the World Business Council for Sustainable Development (WBCSD), the World Resources Forum Association (WRFA) - as well as a range of international stakeholders committed to ICT sustainability objectives to share and develop ideas, launch joint initiatives, and collaborate on a broad range of sustainability projects. These partnerships help shape GeSI's global vision regarding the evolution of the ICT sector, and how it can best meet the challenges of sustainable development. For more information, see www.gesi.org

CONTACT INFORMATION
Global e-Sustainability Initiative (GeSI)
c/o Scotland House, Rond Point Schuman 6
1040 Brussels, Belgium

Tel: +32 2 282 84 42
Fax: +32 2 282 84 14

General enquiries: info@gesi.org or luis.neves@gesi.org

Press enquiries: press@gesi.org

About Deloitte

Deloitte refers to one or more of Deloitte Touche Tohmatsu Limited ("DTTL"), its global network of member firms, and their related entities. DTTL (also referred to as "Deloitte Global") and each of its member firms are legally separate and independent entities. DTTL does not provide services to clients. Please see www.deloitte.com/about to learn more.

Deloitte is a leading global provider of audit and assurance, consulting, financial advisory, risk advisory, tax and related services. Our network of member firms in more than 150 countries and territories serves four out of five Fortune Global 500® companies. Learn how Deloitte's more than 286,000 people make an impact that matters at www.deloitte.com

Deloitte Consulting delivers strategy and implementation, from a business and technology view, to help clients lead in the markets where they compete.

Deloitte's Purpose and Sustainability Strategy team in particular helps clients to articulate their role in society, embed a commitment to societal impact into their core business model, and measure that impact to ensure long-term success.

Deloitte's Economic Consulting team combine analytical foresight with commercial acumen to shape strategy and policy that unlocks economic, financial and social value.

CONTACT INFORMATION
Purpose and sustainability strategy consulting:
sambaker@deloitte.co.uk

Economic Consulting:
sblackie@deloitte.co.uk

UK Chair:
nickowen@deloitte.co.uk

Acknowledgements

The Global Enabling Sustainability Initiative and Deloitte thank the many people who have contributed, including use case providers and subject matter experts, who generously provided their time, insights, and feedback to strengthen the quality of this report.

Particular thanks go to the core #DIGITALWITHPURPOSE team:
GeSI project lead: Luis Neves
Supporting team: Yanying Li, Andrew Lewis

Steering committee: AT&T: Tim Fleming; Dell: John Pflueger; Telstra: Pauline Gregg; Taiwan Mobile: Iris Liu; EIT Climate-KIC: Sira Saccani

Expert panel: Christiana Figueres, Jeffrey Sachs, Elizabeth Corley, Lise Fuhr, Carlo Jaeger, Malcolm Johnson, Georg Kell, Dirk Messner, Nick Owen (Deloitte LLP), Chris Tuppen, Veerle Vandeweerd

Case study development: AT&T: John Schulz, Louise Stimie, Tim Fleming; Deutsche Telekom: Birgit Klesper, Michael Kimberger; EIT Climate-KIC: Felicity Spors, Rahul Bansal, Sira Saccani; T-Mobile: Alex Rosenthal, Chad Wilkerson; Verizon: James Gowen, Serhad Doken, Matthew Smith-Marino, Sanyogita Shamsunder, Winfred Chao, Greta Knappenberger

Deloitte Consulting: Sam Baker, Rafi Addlestone, Claire Butler, Hannah White, Ollie Harris, Elena Kalyva, Justine Autour, Matthew Raja Kumar, Tash Abrahams, Hope Davidson, Harry Burton

Deloitte Economic Consulting: Sam Blackie, Andy Tong, Matthew Sinclair, Nicola Delf, Ian Rodger, Lisa Reisch

Design support: Tenacity Works www.tenacityworks.com

Gold Sponsors

AT&T

eit Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

ICC INTERNATIONAL CHAMBER OF COMMERCE

The world business organization

verizon

Silver Sponsors

swisscom

Taiwan Mobile

Disclaimer

This publication has been prepared by Deloitte MCS under the terms of the contract with GeSI. This publication has been written in general terms and therefore cannot be relied on to cover specific situations; application of the principles set out will depend upon the particular circumstances involved and we recommend that you obtain professional advice before acting or refraining from acting on any of the contents of this publication. Deloitte MCS Limited would be pleased to advise readers on how to apply the principles set out in this publication to their specific circumstances. Deloitte MCS Limited accepts no duty of care or liability for any loss occasioned to any person acting or refraining from action as a result of any material in this publication.

Deloitte MCS Limited is registered in England and Wales with registered number 03311052 and its registered office at Hill House, 1 Little New Street, London, EC4A 3TR, United Kingdom.

Deloitte MCS Limited is a subsidiary of Deloitte LLP, which is the United Kingdom affiliate of Deloitte NSE LLP, a member firm of Deloitte Touche Tohmatsu Limited, a UK private company limited by guarantee ("DTTL"). DTTL and each of its member firms are legally separate and independent entities. DTTL and Deloitte NSE LLP do not provide services to clients. Please see www.deloitte.com/about to learn more about our global network of member firms.

Quotes

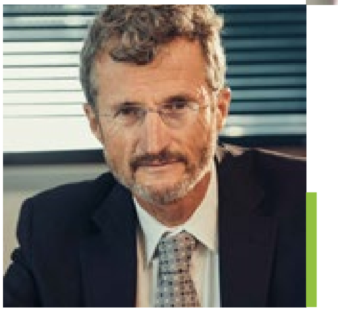
Digital with Purpose: Delivering a SMARTer 2030

"Digital technology is the great lever to move the world towards sustainable development. In this bold and important report, GeSI and Deloitte provide a powerful perspective on how ICTs and the digital sector can help lead the global transformations to create a more prosperous, inclusive, and sustainable world."

Professor Jeffrey D. Sachs
Director of the United Nations Sustainable Development Solutions Network

"The call to address climate change could not be more urgent. Leaders need to take bold action, and we all need to follow. This report helps us understand how digital technologies can play a role in the transition needed. That role can be hugely impactful, but needs us to subscribe to the 2030 Agenda, to better understand how our actions impact the world, and to be alert to the promise digital technologies hold."

Christiana Figueres
Former Executive Secretary, UN Climate Convention & Founding Partner, Global Optimism



"Decarbonisation and digitalisation are key drivers of the big market transformation needed to safeguard our future. This report demonstrates how ICT companies can harness technological change as a force for good and deliver solutions for the 2030 Agenda."

Georg Kell
Founder and former Executive Director of the United Nations Global Compact and Vice Chairman of Arabesque Partners

"This report illustrates the transformative impact of ICT on the implementation of the SDGs. It makes a clear and cogent case for the ICT sector to come together to deploy, at scale, digital technology for positive impact. G-STIC shares the aspirations set out in this report to promote market-ready, innovative technological solutions that can substantially contribute to the SDGs, in a socially, economically, and environmentally acceptable and feasible manner. We look forward to working with our partners in doing so."

Veerle Vandeweerd
Policy Director, Global Sustainable Technology and Innovation Conference Series

"Climate change is the defining challenge of our times. As discussed in this report, digital technologies can help in multiple ways including through de-materialisation and travel substitution. Maximising the abatement potential and minimising direct emissions needs to be a primary priority for both users of digital technology and the ICT sector."

Paul Dickinson
Co-founder and Executive Chair of CDP

"Climate change and digitalisation are two of the biggest drivers of change in the 21st century. With this pioneering effort, GeSI begins to connect the two, showing ICT companies first steps towards creating a future of hope in the face of daunting global challenges."

Carlo Jaeger
Co-Founder and Chairman of the Global Climate Forum (GCF) and Professor at Potsdam University, Germany

"This report has three critical messages for investors: the need to align investor strategy to the SDGs; the broad role digital technology can play in catalysing progress towards the SDGs; and the need for impact transparency. It adds up to great opportunity, but also the need to do things differently."

Dame Elizabeth Corley DBE
Vice Chair, formerly CEO and managing director, of Allianz Global Investors

"Artificial intelligence, virtual realities, automated decision making systems will change our societies profoundly and impact any dimension of the SDGs. This report is aiming at creating the missing links between digital revolutions and sustainability transformations."

Prof. Dr. Dirk Messner
Director, United Nations University - Institute for Environment and Human Security / UNU – EHS

"Facts and figures in this report show that an extensive uptake of digital networks and services will speed up the achievement of the SDGs. As 5G is being rolled out across the world, its adoption can help traditional sectors to empower societies and dramatically reduce their environmental footprint. Public policies can help by promoting extensive adoption of the latest technologies, including fibre connectivity, 5G and digitally-enabled services."

Lise Fuhr
Director General, European Telecommunication Network Operators' Association

"The role of digital services in delivering the SDGs is clear. The challenge is to do this whilst delivering ever more bandwidth for less waste and lower carbon emissions."

Dr Chris Tuppen
Advancing Sustainability Ltd

“We are not currently on track to achieve the SDGs. This must change, and the ICT sector is critical to scaling our collective efforts. I commend GeSI for embracing digital with purpose.”

John Denton
Secretary General of the International Chamber of Commerce

“Digital technologies need to be developed and deployed with positive societal impact in mind. The report convincingly makes the case for urgent action and more contribution from digital technologies to address the interrelated challenges of sustainable development and climate change. The ICT sector and its organisations shall take a leadership role in building impact transparency; in assuming responsibility to address negative externalities; and in working at a systemic level through a clear commitment to embed the SDGs more deeply into their core business and supply chains to become truly transformative.”

Sira Saccani
Theme Director, Sustainable Production Systems, EIT Climate-KIC

“The study shows clearly that the ICT industry can make a significant contribution to reach the UN Sustainable Development Goals. At Deutsche Telekom we are building the infrastructure for a better tomorrow: a climate-friendly society with products that enable sustainable lifestyles everyone can #takepart in.”

Birgit Bohle
Chief Human Resources Officer and Labour Director, Deutsche Telekom AG

“The report markedly recognises the criticality of delivering impactful solutions at scale to many of the world’s most pressing problems. In the meantime, it is acknowledged that even the most promising solution needs to be carefully executed in order to maximise its positive impact. Taiwan Mobile’s priority is therefore in devising and delivering well-thought-out programs that speed up the transition to a sustainable world.”

Jamie Lin
President, Taiwan Mobile

"This report demonstrates the tremendous opportunities that digital technologies offer to catalyse real progress towards the SDGs. Swisscom is acting to ensure digitisation is managed responsibly and equitably, to secure the greatest benefit for people, society and our future."

Urs Schaeppi
CEO, Swisscom AG

"T-Mobile is changing wireless for GOOD – and that includes following through on our commitment to social and environmental responsibility! We're making huge strides forward in our pledge to use 100% renewable energy by 2021 -- but that's just the start! As this report shows, new digital technologies like IOT and 5G will play a tremendous role in empowering communities to be more sustainable. T-Mobile is ALL IN on continuing to be a leader in building that future for everyone!"

John Legere
CEO, T-Mobile

"This report highlights the urgent need for action and the opportunity each stakeholder in the ICT industry has to put the world on a sustainable path. At TDC, we view the Sustainable Development Goals as key guides to both ensure that our business creates positive value for society and challenges us to deliver that in a responsible manner. That is why building trust in society is a key pillar of our corporate strategy."

Allison Kirkby
Group CEO and President, TDC A/S

"I wholeheartedly endorse the Global e-Sustainability Initiative's call for the global Information and Communications Technology sector (ICT) to 'accelerate the benefits and limit the downsides' of our work for the sake of a sustainable future. As someone who has long believed in the great potential of ICT to accelerate the shift toward low-emission economies, I hope GeSI's report motivates companies across our industry to step up to the immense responsibilities and opportunities of this moment."

Hans Vestberg
CEO, Verizon

"The report highlights how the ICT sector, through the development and deployment unique innovations, has the opportunity to lead on delivering the SDG Agenda and making a meaningful impact on society. At AT&T, making a difference in the communities where we live and work is a core value. That's why we are at the forefront of using innovative technologies – from IoT and 5G to the Grind2Energy solution and beyond – to help transform the lives of people around the world and protect our planet."

Lori Lee
CEO, AT&T Latin America and Global Marketing Officer

Foreword

The Global Enabling Sustainability Initiative (GeSI) is made up of leading ICT companies, partners and international organisations, all committed to achieving integrated social, environmental and economic sustainability as defined by the transformative Sustainable Development Goals (SDGs) Agenda.

Our vision is to create a sustainable world through responsible, ICT-enabled transformation, using the SDGs as a central framework for action. In particular, we are focused on researching and addressing climate change (SDG 13), by accelerating the development of digital solutions to usher in an era of innovation and low-carbon growth.

We are proud to introduce this new report, #DigitalWithPurpose, which identifies and quantifies the ways in which digital technologies, both established and cutting-edge, are capable of delivering transformative impact against each of the 17 SDGs. It also clearly lays out where these technologies can have a negative impact.

The opportunity, both for the ICT sector and the sectors and organisations at the forefront of deployment, is enormous. Given the slow pace of progress against the SDGs, it is also non-negotiable. We conclude this report with some specific commitments for all who are on this journey – the first commitment being to share a common purpose to secure a SMARTer2030.

We are grateful to Deloitte, all the GeSI members and the amazing high-level group of external experts who have supported us in developing this thorough and powerful report. We do hope you find it useful and agree to join us, commit, and take action.

Luis Neves
GeSI CEO

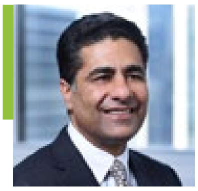
James Gowen
GeSI Chairman
Verizon CSO

The Sustainable Development Goals represent the opportunity for our generation to move the world onto a sustainable path. At Deloitte, we place our role in society at the heart of what we do. Our purpose is to make an impact that matters and we embed this ideal in our work every day. By helping our clients to succeed sustainably; by operating responsibly and through our corporate responsibility programmes; we are dedicated to making a global impact.

Digital technology is interwoven into all that we do. But digital technology in and of itself does not deliver impact. Rather, it's how we develop and deploy technology that matters.

Through this report, we stand with GeSI to call on the ICT sector, on business, and on governments, to commit to 'Digital with Purpose.' This means taking on the 2030 Agenda as our own. It means calling out our intended contribution to the delivery of the SDGs. And, it means identifying how we can use digital technology to maximise our impact.

As detailed in this report, digital technology is already being used in ways that can help drive incredible positive change in our world. But there is still so much more to do. Together with our clients, we at Deloitte are committed to help meet this challenge so that we can all enjoy a sustainable future.



Punit Renjen
Global CEO, Deloitte

Key messages

Urgent intervention is required

On its current trajectory, the world will be unable to deliver the 2030 Agenda for Sustainable Development.[1] Our **biosphere** is under threat from rising carbon emissions, our **society** sees persistent inequality and lack of access to basic services, and our **economy** continues to drive the unsustainable consumption of natural resources. Climate action (SDG 13) is a critical precondition for the 2030 Agenda. Addressing the climate crisis transcends geography and local interests and is an issue that nation states have committed to; but one that requires truly integrated and innovative solutions.

Digital technologies are having a powerful impact

In the face of this challenge, digital technologies, the powerful collection of seven technologies[2] that increasingly pervade our lives, drive positive progress across the 2030 Agenda in four key ways. They help us:

- **Connect & Communicate**, opening up relationships, information, ideas and opportunity;
- **Monitor & Track** the world around us, so that our impact is transparent and we can make targeted interventions;
- **Analyse** vast swathes of information; **Optimise** processes, procedures and resource productivity; and **Predict** where we need to intervene; and
- **Augment** our human abilities and **Autonomate** systems to carry out activities on our behalf by creating an ‘active bridge’ between the physical and digital worlds.

Of the 169 SDG targets, 103 are directly influenced by these technologies, with established examples of deployment that provide insight into their potential to make an impact. Analysis of 20 targets and their indicators across the SDGs shows that the expected deployment of existing digital technologies will, on average, help accelerate progress by 22% and mitigate downward trends by 23%.

Digital technologies can and need to contribute more

Whilst digital technologies will help close the gap to some of the 2030 targets, performance against approximately a third of targets analysed is expected to deteriorate even after increased technology adoption. Digital technologies need to do much more, and there is plenty to suggest they can:

- This report analyses the emissions abatement potential of seven existing applications. It is estimated that emissions abated in 2030 as a result of greater adoption of these use cases will be equivalent to nearly seven times the size of the growth in the total ICT sector emissions footprint between now and 2030.
- A more optimistic scenario featuring ambitious policy and sector interventions could reverse the growth of the ICT sector footprint and enable emissions reduction equivalent to 9% of total world emissions.
- Over $3 trillion is likely to be spent on research and development in the ICT sector in the ten years up to 2030, indicating huge potential for innovative solutions to the SDGs if effectively directed and as existing technologies mature.

Digital technologies can also be deployed in ways that counter the Goals: fuelling consumption; hardening the digital divide; creating dislocation in the labour markets; and consolidating power of the few over the many. Enhancing the positive impact needs to go hand in hand with minimising any negative impacts.

Key messages

Digital with purpose is the way forward

To fully support the transformation required by the SDGs, digital technologies need to be developed and deployed with positive societal impact in mind and within a context of shared aspiration: **digital with purpose**. Digital with purpose has three components:

- Commitments for all;
- Leadership by the ICT sector; and
- Roles for each of the key stakeholder groups.

Commitments for all

All organisations and individuals need to make four "universal commitments":

1) recommit to the 2030 Agenda;

2) state their intended impact on the SDGs, including a specific commitment to reduce greenhouse gases by 50% by 2030;[3]

3) embrace the principles of **transparency and collaboration**; and

4) harness the power of digital technologies to support these commitments.

Organisations need to do this to secure not only all our futures, but also their own long-term success. The two are increasingly, indivisibly, interdependent.

Leadership by the ICT sector

According to analysis by Arabesque, the ICT sector performs well across a range of broad environmental, social and governance themes – relative to the wider market. This provides a good basis for the sector to provide sector-level leadership and individual organisation dedication to:

- **Lead on the universal commitments,** recognising the need to collectively support the entire 2030 Agenda. This includes areas that may be more difficult to deliver with existing business models, e.g. providing digital access to all;
- **Build impact transparency** across the ICT sector; partner sectors; at individual, village, city, state, country levels; and globally. To help build the data, systems and governance to link activities to impact on the SDGs, enhancing impact and locking in longer term success;
- **Recognise and address negative externalities.** This will necessarily include investment to better understand contexts, cause and effects, and potential solutions to mitigate the negative impacts; and
- **Operate responsibly.** The sector, and particularly the services subsector, needs the credibility of both acting, and being seen to act, as the responsible sector if it is to lead on this broader agenda.

Roles for each of the key stakeholder groups

Critical stakeholder groups include governments, NGOs, institutional investors, businesses and partner sectors, and citizens. Each group needs to embrace the universal commitments, and for each this report proposes some specific additional commitments, with the single most important for each being:

- **Governments:** work with the ICT sector, NGOs, investors and other stakeholders to develop precompetitive approaches to ensure more equal access to the benefits of digital technology, both inter- and intra-economy;
- **NGOs:** hold stakeholder groups to account for their use of digital technologies, and help form multi-sector partnerships with the ICT sector to drive impact;
- **Institutional investors:** demand evidence of commitment to the 2030 Agenda and transparency of impact from investee companies. Utilise the capability of ICT sector to help evolve impact transparency together;
- **Businesses and partner sectors:** deploy digital technologies with an understanding of their impact, and recognise and help manage negative externalities; and
- **Citizens:** become educated on the role of digital technologies in the 2030 Agenda, take responsibility for positive and negative impacts of personal usage and use power as a consumer to promote impact.

GeSI commits to delivering a SMARTer2030

GeSI, its members and partners stand by these commitments and announce their intention to work across the industry and with the key stakeholder groups to make Digital with Purpose a reality. **Join us!**

GeSI ENABLING DIGITAL SUSTAINABILITY

Executive summary

1 Introduction

More informed and purposeful development and deployment of digital technologies will catalyse progress towards the Sustainable Development Goals (SDGs).

This report builds on GeSI's previous work, particularly the 'Smart' series; and through research, dialogue with over 40 GeSI members and partner organisations and the challenge of a distinguished expert panel, lays out the following:

- **Digital technologies:** an introduction to the technologies explored in the report and an overview of the opportunities they provide to develop and deploy for maximum impact on the SDGs;
- **Impact on the SDGs:** the impact these technologies have now and will have in the future, supported by a deep dive which details the opportunities for each Goal individually;
- **Impact on the SDGs – Sectors:** an exploration of the scope for key sectors to deploy digital technologies for impact on the SDGs;
- **Impact on the SDGs – Geography:** reflections on the most immediately relevant Goals for six major global regions; progress against these and the comparative impact of digital technologies;
- **The ICT sector: the Catalyst for Sustainable Development:** estimations on the current scale and impact of the ICT sector, as well as projections to 2030; and
- **Actions to deliver a SMARTer2030:** delineation of the critical roles for both the ICT sector and related stakeholders in developing and deploying digital technologies to maximise positive impact and minimise negatives.

Digital technologies could have a transformational impact on our ability to meet the 2030 Agenda. This, however, requires both the ICT sector and the key sectors (or 'partner sectors') who deploy these technologies to put this Agenda more intentionally at the centre of who they are and what they do. It also requires a substantially enhanced understanding of how actions lead to impact on the achievement of the SDGs, be they the actions of government, businesses, NGOs, or citizens.

This report comes at a time when the world is waking up, albeit slowly, to the existential challenge it faces from climate change and to the slow progress against the broader 2030 Agenda, which has such profound implications for everyone. This awakening is resulting in pressure on all organisations from their many stakeholders – not least investors, customers, employees and regulators – to articulate and demonstrate how societal impact is at the core of what they do. The result is that a greater commitment to societal impact is not just about securing a license to operate, but a critical element of building long-term success, with application to all organisations including business.

It also comes at a time when the ICT sector is viewed by many with distrust, often seen as the source of products and services that harm rather than heal our society and environment. Digital technologies can be leading contributors to positive societal value, but this will only become a reality if the focus of technological development and deployment is framed by a clear commitment to the SDGs. If the ICT sector can demonstrate to the world that it is moving the dial on progress towards the 2030 Agenda, and assumes responsibility to address and prevent negative outcomes that result, the world will substantially benefit and the sector will be assured of long-term success.

2 Approach

This report explores the relationship between the development and deployment of digital technologies and the achievement of the SDGs. It employs an explanatory framework of 'impact functions' to categorise example 'use cases' that illustrate this relationship across each of the 17 Goals. For each Goal, new quantitative modelling explores the expected contribution of digital technologies to progress against a selection of priority targets, compared to a business-as-usual scenario in which the adoption of digital technology is held constant. Further quantitative analysis explores the impact of the ICT sector itself.

3 Digital technologies

Seven digital technologies have been chosen as broadly representative of the way digital capability will evolve in the medium term and for their critical influence on the world. These technologies are:

1. Digital Access: connectivity for people to people, and people to the internet;

2. Fast Internet: next generation connectivity, personified by 5G, that provides speed and capacity at fundamentally different levels;

3. Cloud: the provision of highly scalable, advanced IT capabilities as 3rd party services;

4. IoT (Internet of Things): the connecting of physical objects to the internet enabling communication from, and to, the object;

5. Cognitive: the application of advanced analytics, machine learning and artificial intelligence approaches to big data to develop insight;

6. Digital Reality: virtual digital worlds or systems (virtual reality) or mixed virtual and physical worlds (augmented reality); and

7. Blockchain: a system of digital, distributed ledgers of transactions comprising a database of information, with an append-only structure, governed by a network of computers instead of a central party.

These technologies typically work together both in their development and deployment. AI for instance is crucial to the effective development and operation of the networks that underpin the evolution of 5G; whilst scaled deployment of AI by an organisation will often involve cloud services.

The seven technologies vary significantly in maturity: digital access is both global and at scale, if not pervasive. Blockchain is in its comparative infancy. Every one of the technologies still has plenty of opportunity to scale in terms of deployment, and therefore by extension, in terms of impact.

Each of these technologies affects the world in multiple ways. To help navigate these effects, this report uses a new framework specifying 'impact functions' that link the technologies and their combinations with the way they impact the world. The four top level impact functions concern:

Connect & Communicate
Connecting people to each other and to critical information;

Monitor & Track
The real-time, extensive observation of the world and its natural and man-made systems;

Analyse, Optimise & Predict
The development of insights from data, and the use of those insights to drive process efficiency and infer the future; and

Augment & Autonomate
Provision of an 'active bridge' between digital and physical, from simulation through augmentation to the creation of autonomous systems.

These functions can lead to good and bad impacts. This report uses the functions and the underlying technologies to explain the depth of the positive contribution they make, now and in the future, to the SDGs.

Whilst this contribution is profound and will be critical to the achievement of the 2030 Agenda going forward, maximising potential will depend on a more collaborative, more integrated approach to deployment. Organisations rarely optimise internal coordination around the deployment of digital technologies, let alone externally, which falls short of the imperative of the SDGs for coordination, cohesion, and integration. An approach that puts partnerships and collaboration at its core will be vital to making tangible progress towards the 2030 Agenda.

4 Impact on the SDGs

This report details the many different ways in which digital technologies can impact the SDGs, focusing on 103 of the total 169 SDG targets which are not primarily reliant on policy, aid financing, or non-digital interventions. These targets have been reviewed for current progress and the four impact functions have been used as a framework to establish links between each target and the seven focus digital technologies, and to categorise how digital technology drives impact. In order to illustrate these drivers, example use cases have been noted, along with instances in which digital technologies can have a negative, rather than positive, impact. Illustrative modelling has also been undertaken to demonstrate the potential impact of digital technologies on one or more SDG indicator.

This modelling of the expected increased adoption of digital technologies assumes no significant changes to technology, policy, or infrastructure, and shows a range of possible achievements against a business-as-usual scenario. For example, an additional 150kg of cereal could be produced per hectare for smallholder farms globally through improved access to and use of data – an enhancement of just under 10%.

Analysis of 20 targets and 25 associated indicators across a range of SDGs shows that the expected deployment of existing digital technologies will, on average, help accelerate progress by 22% and mitigate downward trends by 23%.

There is, however, much more that needs to be done. Whilst the increased adoption of digital technologies will help close the gap to some of the 2030 targets, performance of 8 out of 25 indicators analysed is still expected to deteriorate. So to meet the Goals, the world needs to progress further and faster. Key actors within the ICT sector and partner sectors need to significantly shift the extent to which the 2030 Agenda is truly a common focus in order for digital technologies to be truly transformative. There needs to be a fundamentally different, and systemic, understanding of the impact of digital technology. By having a better understanding of both the positive and negative impacts of digital technologies, these sectors will be able to work together more effectively to accelerate the benefits and limit the downsides. The focus must be on both optimising the capabilities currently existing, and directing research and development at new capabilities on the basis of the impact they have.

The SDGs are an integrated framework, which this report presents here under the domains of Biosphere, Society, and Economy.[1] For each we summarise the main opportunities that digital technologies can help deliver and note any possible negative externalities.

Biosphere

The biosphere, representing the planet we depend upon, is covered across the topics of climate change and natural resources:

- **Climate change** focusses on SDG 13 (Climate Action), and includes the need to reduce emissions, ensure resilience to natural hazards, and enhance our ability to act; and
- **Natural resources** covers SDG 6 (Clean Water and Sanitation), SDG 14 (Life Below Water), and SDG 15 (Life On Land), and addresses the conservation of these domains.

Digital technologies have a critical role to play in protecting the biosphere and reversing negative progress against the four biosphere SDGs and their targets. The most relevant impacts are particularly concentrated within *monitoring and tracking* the state of the natural world (SDGs 6, 14, 15), and *analysing and optimising* energy and material usage across sectors to minimise the impact of climate change (SDG 13). There will be increasing opportunities in the future for emission savings under *augment and autonomate*, as the automation of processes across agriculture, industry and manufacturing becomes increasingly sophisticated and automated, helping in the fight against climate change.

Impact modelling for climate change suggests that the expected adoption of digital technology will lead to the abatement of 668 Mt CO2e (accounting for rebound effects), equivalent to 1.3% of global emissions in 2030. This is the result of efficiency gains from the optimisation of existing processes in agriculture, on roads, in energy networks, and in manufacturing.

Six impacts have been modelled for natural resources: agriculture and municipal water withdrawals, clean drinking water, sustainable fish stocks, the global forest area, and net emissions from forests. For example, impact analysis on water withdrawals shows that digital technologies can have a significant positive impact. Excess water withdrawals can lead to water stress or scarcity, where water supply does not meet demand, and hence managing water use is important. This report estimates that the expected increased deployment of smart water infrastructure could mitigate around 22% of the estimated increase in global municipal water withdrawals against a business-as-usual scenario.

Likely negative impacts on the biosphere resulting from widespread technological deployment include: an increase in emissions directly related to this deployment, quantified below under the section on the ICT sector; the increased extraction of scarce resources; and the creation of e-waste, resulting from, for example, increased proliferation of IoT devices.

Digital technologies have a critical role to play in protecting the biosphere and reversing negative progress against the four biosphere SDGs and their targets.

Society

Society, representing our ability to live together in an equitable and peaceful way, is covered across the topics of basic human needs, amenities and utilities, and a fair and just society:

- **Fulfilment of basic human needs** spans SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), and SDG 4 (Quality Education);
- **Sustainable amenities and utilities** addresses SDG 7 (Affordable and Clean Energy), and SDG 11 (Sustainable Cities and Communities); and
- **A fair and just society** covers SDG 5 (Gender Equality), and SDG 16 (Peace, Justice and Strong Institutions).

Digital technologies, if carefully managed, have an important role to play in ensuring sustainable and equitable societies. Three major opportunities have been identified: i) continuing to connect the unconnected and vulnerable to basic digital access, to enable financial inclusion, education and empowerment; ii) taking advantage of machine learning (ML) and artificial intelligence (AI), as well as the computing power promised by cloud, to accelerate drug and crop development, and improve targeting of areas of poverty and hunger, disaster impact, and education and health outcomes through the processing of complex datasets; and iii) autonomous machines to transform agriculture, and city utility, service, and security provision.

Eight impacts have been modelled out to 2030 across the different areas covering sustainable and productive agriculture, skilled birth attendance, youth literacy, access to electricity, renewable energy consumption, mean levels of air pollutants (specifically the pollutant PM2.5), and reproductive rights. For example, the proportion of births attended by skilled health personnel is estimated to increase from 84% today to 92% under a scenario with increased deployment of digital technologies that improve communication between health professionals and expectant mothers. Of this increase, 32% can be attributed to digital technology. This indicator is important as it has been shown to have a strong relationship with rates of maternal mortality.

Whilst the benefits from the development and deployment of digital technologies are critical to addressing the society-related SDGs, there are multiple possible negative outcomes. These include: enhanced inequalities unless access to technology is more even, reduced resilience of core society supporting systems unless cyber security is invested in, and the spread of disinformation leading to misinformation unless appropriate weight is given to transparency and truth.

Economy

The economy, the system through which we gather, produce and distribute resources, is covered across the topics of inclusive growth and sustainable industry:

- **Inclusive growth** comprises SDG 8 (Decent Work and Economic Growth), and SDG 10 (Reduced Inequalities); and
- **Sustainable industry** comprises SDG 9 (Industry, Innovation and Infrastructure), and SDG 12 (Responsible Consumption and Production).

Digital technologies have a critical role to play in enabling inclusive growth and sustainable industry. Two major opportunities stand out: i) monitoring supply chains accurately to create transparency in production; and ii) optimising processes to increase productivity while reducing energy and material usage and emissions.

Five impacts have been modelled to 2030 across SDGs 8, 9, 10 and 12 covering financial inclusion, remittance costs, manufacturing value add, domestic material consumption, and food loss in the supply chain. For example, the global deployment of Industry 4.0 has the potential to increase gross value added from manufacturing, which will be especially important to the development of emerging economies. This report estimates that with increased digital technology in manufacturing, global manufacturing value add per capita could increase from around $1,800 currently to over $2,700 in 2030. Of this increase, 22% can be attributed to Industry 4.0.

Negative externalities that should also be considered include: a greater divide between developed and less developed economies as the former get better access to digital technologies, an increase in consumption as wealth increases, job displacement as digital technologies contribute to increased automation across sectors, and an increase in system-wide risk from centralised control and cyber attack.

5 Impact on the SDGs – Sectors

To realise the potential of digital technologies for the achievement of the SDGs, the ICT sector needs to collaborate on the basis of impact with the key sectors involved in delivering the 2030 Agenda.

Some SDG targets explicitly refer to individual sectors; with others the sectoral responsibility and opportunity is more implicit. The report lays out a set of priority SDG targets and key actions for each partner sector to consider, reflecting the intersection of their core business activity and the potential deployment of digital technologies for impact. The list below provides one example per sector, selected on the extent to which the responsibility lies with the sector:

- **Agriculture and Fisheries:** improved monitoring of farm and fishing activities (Target 14.4) with solutions using IoT, satellite imagery, AI, and digital access;
- **Consumer Products and Industrials:** evolution of the circular economy (Targets 8.4, 9.4, 12.2, 12.5, 13.2) through enhanced transparency on provenance, material composition and the CO2 footprint of products and smart recycling systems;
- **Energy, Extractives and Utilities:** increase in the share of renewable energy in the global energy mix (Targets 7.2, 7.3) facilitated by IoT/ AI-driven efficiency in plants and on the grid, and pay-as-you-go solar access;
- **Financial Services:** encourage and expand access to banking, insurance and financial services for all (Target 8.10) through digital access and better informed and tailored products and services facilitated by big data and AI;
- **Government and Public Services:** provision of unique identities for the c. 1 billion people without them (Targets 16.9, 1.3) through use of e.g. digital access, AI and blockchain;
- **Life Science and Health Care:** ensure universal access to sexual and reproductive healthcare services (Target 3.7) through connectivity, remote access to patient records and AI-driven diagnosis; and
- **Transport and Logistics:** provide access to safe, accessible and sustainable transport (Target 11.2) through access to mobility on demand type platforms.

6 Impact on the SDGs – Geography

A global response to the SDGs is vital for the 2030 Agenda to be realised, however the priorities for the deployment of digital technology against specific SDG targets vary for each geographic region.

Profiling of the UN-defined major regions of the world has been undertaken to highlight the most immediately relevant targets for each. Expected progress against these priority goals has been assessed with an exploration of the comparative impact of digital technologies to achieve these priorities, as detailed in the list below:

- **Africa:** Digital access will support improvements in maternal mortality (Target 3.1) by increasing the number of births attended by skilled healthcare professionals, and increase smallholder farm productivity (Target 2.3);
- **Asia:** Digital access, IoT and AI will help reduce air pollution (Target 11.6) from road transport, and enable more sustainable farming (Target 2.4), reducing the amount of synthetic nitrogen fertiliser used;
- **Oceania:** Digital access will support an increase in women's access to family planning services (Target 5.6) and improvement in youth literacy (Target 4.6);
- **Latin America and the Caribbean:** IoT and cloud will enable a reduction in food loss in the supply chain (Target 12.3), and AI and cloud will enable more sustainable management of forests (Target 15.2);
- **North America:** Digital access, AI and IoT will support more sustainable use of water resources (Target 6.4) and improve energy efficiency (Target 7.3);
- **Europe:** IoT will help achieve greater sustainability and resource efficiency in industry (Targets 8.4, 9.4, 12.2) and help develop more sustainable agriculture (Target 2.4), reducing emissions from the sector.

7 The ICT sector: the Catalyst for Sustainable Development

Whilst the deployment of digital technologies is the primary focus of this report, it is also important to consider the primary source of these technologies – the ICT sector itself. The ICT sector's commitment and contribution to the SDGs can be construed in terms of its shape and size, emissions, and its management of externalities.

Shape and size

The sector's direct contribution amounted to an estimated €3.7 trillion in GVA (gross value add) in 2019, split around 80/20 between services and manufacturing. Services are distributed roughly in line with GDP, whilst manufacturing is concentrated in the US and a group of East Asian economies. The sector is a major contributor to R&D e.g. accounting for 20% of all business R&D in Japan; and in 2015 employed 48 million people, amounting to 1.5% of global employment. The sector also drives an indirect economic contribution through the use of products and services.

Growth

The sector has been growing and is expected to continue to grow to around €6 trillion to 2030 – an increase of €2.3 trillion from 2019, with commensurate growth in both R&D and employment.

There are significant risks to the accuracy of this projection. It could be considered too conservative since disruptive new technologies could result in the creation of major new digital business models that result in rapid economic activity shifts, such as moving entire subsectors into the ICT sector. Alternatively it could be an overestimate since the sector faces a rapidly increasing burden of constraints and demands by regulators, consumers, and other key stakeholders over concerns around its societal contribution slowing its rapid expansion.

ICT sector growth is likely to be highly dependent on the ability of the industry to manage, and verify, its emissions and other critical negative externalities, and crucially demonstrate its social value and contribution to SDG achievement in all key sectors to all key stakeholders.

Management of externalities

According to analysis by Arabesque, the ICT sector performs better than the wider market on environmental and social issues, reflecting above-average commitment to relevant policies and procedures. In particular, the sector performs well relative to the wider market in terms of its specific commitment to addressing climate change – with above-average commitment to meeting the Paris Agreement to limit climate change to 1.5 ºC. However, despite this commitment, there is a need to consider the potential impact on the environment of the sector's expected growth. The greenhouse gas impact of energy use by the ICT sector is estimated to be just over 800 Mt CO2 in 2019, rising to over 900 Mt CO2 in 2030 – an increase of 11%. This means that, on expected trajectories, the sector footprint is estimated to rise from 1.6% of global GHG emissions in 2017 to 1.7% in 2030. The increase is driven by the growth of the sector and an increase in the energy intensity of transmission networks, although this is partially offset by a reducing energy intensity in manufacturing and data centres, and differing rates of growth of clean energy by country. Many large companies are announcing public plans to curb their emissions, which may result in improvements on this projection, as would a broader and more rapid shift to clean energy. Risks include the continued rise of data volumes without corresponding efficiencies in infrastructure, e.g. legacy networks often continue to be run in parallel with next gen implementations. Accounting for the beneficial impact of the abatement in carbon emissions delivered by the expected deployment of digital technology, the sector is expected to deliver emissions savings estimated to be seven times the growth in its own footprint between 2019 and 2030.

The potential impact of action to reduce ICT emissions and enhance the ICT impact on emissions in the wider economy can be illustrated by considering a scenario for more ambitious decarbonisation. This scenario envisages action from policymakers to reduce energy consumption; the energy sector decarbonising in line with more ambitious IEA scenarios; the telecoms sector and its manufacturing supply chain acting to arrest the rise in network energy consumption; and the ICT sector in general working with its stakeholders to drive adoption of the various use cases that diminish emissions to 100% take-up. In this scenario, the sector GHG footprint would fall by 70 Mt CO2, instead of rising, and ICT use cases would enable a further 3.5 Gt CO2e in emissions abatement. The overall ICT-enabled reduction in emissions would be nearly 3.6 Gt CO2e, which is equivalent to 9% of projected world GHG emissions in the relevant IEA scenario.

Alongside emissions, the ICT sector must consider the other potential negative externalities of its growth, which include increasing resource consumption, the furthering of inequalities, and anti-social impacts of consumption. Considerations surrounding resource consumption involve the initial mining of both abundant and rare materials, and the impact of further activity across the value chain. Growth of the sector has to date had an inflationary impact on resource consumption, although this could be offset by re-use, recycling, and behaviour changes resulting in less demand for resources. Inequalities can be exacerbated both directly, e.g. through maintaining an unbalanced gender mix in sector employment, and indirectly, e.g. by creating greater divisions between those who have access to digital technologies and those that don't.

Finally, digital technology could also provide a platform for other negative social impacts, such as the adverse impacts on mental health caused by cyberbullying. The global understanding of context, cause, and effect is still evolving in these areas, but digital technologies can undoubtedly be used to ill effect and have unintended negative consequences. Cross-sector commitment and investment is needed to understand how such unintended consequences can be avoided, alongside changes in governance. These actions are crucial in order to ensure the full potential of the ICT sector in driving progress to the 2030 Agenda.

8 Actions to Deliver a SMARTer2030

To maximise the potential of digital technologies and to diminish the downsides, there needs to be a common purpose both within the ICT sector and more widely throughout partner sectors.

Across each of the Goals and through each of the four impact functions, digital technologies can, and do already, contribute by accelerating positive impacts and mitigating negatives. However, as indicated by the forecast numbers weaved throughout this report, a significant challenge remains. On current trajectories, even the expected increases in the adoption of digital technology will not be sufficient to support full realisation of the SDGs by the 2030 target date, especially in regard to the growing crisis associated with climate change.

This report outlines the wide variety of ways in which digital technologies can be deployed to support the achievement of the SDGs, detailed in the chapter on Actions to Deliver a SMARTer2030.

To maximise the potential of digital technologies and to diminish the downsides, there needs to be a common purpose both within the ICT sector and more widely throughout partner sectors. As such, to secure a positive future – one that may be described as a ‘SMARTer2030’ – this report proposes a small number of universal commitments, together with a set of commitments for the ICT sector and other related stakeholder groups.

To be clear, this is not a request for altruism. This is, rather, a request to recognise the powerful challenges the world faces. To recognise the way those challenges are influencing the stakeholders who dictate the success of the organisations they engage with. A request to understand the need to place societal value at the core of the organisation to secure longer-term success, whatever the nature of your organisation.

Universal commitments

The ICT sector and all stakeholders to **recommit to the common purpose of the SDGs**; understand them; promote them; use them as context to all activity and decision making. Supplement this with a specific commitment to reduce GHGs by 50% by 2030.[2]

Each actor to **call out their own role in delivering the SDGs**; explaining how this is embedded in the business model; how it drives success; and enshrining it as their organisation’s purpose.

Embrace the principles of impact transparency and collaboration. Invest in the measurement and management of intended impact called out in the organisational purpose, and communicate progress to all stakeholders. Share knowledge assets and collaborate extensively to further impact.

Drive an **enhanced, organisation-wide understanding of how digital technologies can be deployed for positive impact**, and influence development. Move from digital transformation to purpose-led transformation powered by digital.

ICT Sector specific commitments

Lead on the universal commitments: as a large and influential sector of the global economy, the ICT sector has the opportunity to act as an exemplar; collectively supporting and actively pursuing the 2030 Agenda.

Operate responsibly: ICT companies have a responsibility to call out their commitment to the common purpose, and be seen as the responsible sector, working together to address common environmental, social and governance (ESG) challenges in a comparatively progressive way across all recognised dimensions.

Call out the areas of greatest risk and opportunity: with the help of its trade bodies, the sector should identify, understand, and call out the areas of greatest risk and opportunity in terms of its contribution to the SDGs, beyond operations and through core products and services. For example, the sector should call out the opportunity to eradicate the 'digital divide', and enable the drive towards net zero-carbon through digital technologies to enable greater growth and deployment of renewable energy sources.

Enable the development and deployment of digital technologies in countries without a mature ICT sector: it will be challenging to operate in countries that lack the infrastructure to support a transition to a sustainable, digitally-enabled economy. To drive achievement towards the SDGs, ICT companies should work precompetitively to consider how technology can be deployed in partnership with governments in these countries and how the sector can engage with public policy to address identified critical sustainable development challenges. Underachieving against the central tenet of 'leave no one behind' is a very real threat related to further entrenchment of a digital divide.

Harness its unique role in enabling impact transparency: only digital technology can, at scale, monitor and track how organisations impact the wider world and gather the information required to help them take responsibility for their impact and enable decision making for sustainable development. Indeed, understanding an increasingly connected system is a precondition to understanding what is needed to drive impact. The ICT sector must help organisations understand how to adopt impact transparency as a means of enhancing impact and strengthening business models. This requires new data, massive computing power, and new forms of distribution, deployment, and application.

Urgently seek to decouple economic growth from environmental degradation: the sector will be at risk if it cannot find ways to ensure that the energy required to manage increasing volumes of data transfer and computing power does not further contribute to carbon emissions. Circular economy approaches must be taken forward to ensure that the proliferation of IoT devices and smartphones does not lead to an exponential growth in e-waste and depletion of natural resources. Only by working together with a broad range of stakeholders and investing in better understanding the context, cause, and effects of impact, can the ICT sector ensure that its growth does not hinder, but instead 'turbocharges', sustainable development.

Lead on cyber security and cyber ethics, both individually and collectively: the greater adoption of cognitive technologies and reliance of services on digital infrastructure is associated with increasing existential threats around cyber security and new ethical challenges. ICT companies are frequently the first adopters of new technologies, and thus must ensure they implement exemplary cyber security safeguards into their business practices and services. Collectively, the ICT sector has a critical role to play in working with government to develop cyber security and cyber ethics business norms, standards, and codes of conduct, and lead the way in demonstrating good practice. They have to take responsibility to ensure trust.

Other stakeholder group commitments

Critical stakeholder groups include Governments, NGOs, Institutional Investors, Businesses and Partner sectors, and Citizens. Each group needs to embrace the Universal Commitments, and for each this report proposes some specific additional commitments, with the single most important for each being:

- **Governments:** work with the ICT sector and other stakeholders to develop precompetitive approaches to more equal access to the benefits of digital technology, both inter- and intra-economy;
- **NGOs:** hold stakeholder groups to account for their use of digital technologies, and help form multi-sector partnerships with the ICT sector to drive impact;
- **Institutional Investors:** demand evidence concerning commitment to the 2030 Agenda as well as transparency of impact from investee companies. Utilise the capability of ICT sector to help evolve impact transparency together;
- **Businesses and partner sectors:** deploy digital technologies with an understanding of their impact, and recognise and help manage negative externalities;
- **Citizens:** become educated on the role of digital technologies in the 2030 Agenda, take responsibility for positive and negative impacts of personal usage and use power as a consumer to promote impact.

GeSI's role

GeSI exists to bring the ICT sector together to deliver against a vision of a sustainable world through responsible, ICT-enabled transformation. This means working across the industry and with key stakeholder groups to make Digital with Purpose a reality.

This report has outlined the huge potential for digital technology to contribute to the SDGs, but also the significant gap that still exists for the achievement of the 2030 targets.

To that end, there are a series of next steps that GeSI hopes to progress, with the support of its members on the back of this report.

- **Make the case for the 2030 Agenda:** GeSI will continue to call upon its members and all businesses to commit to the common purpose of the SDGs and recognise the interdependence of a commitment to sustainable development and long-term success.
- **Enable inclusive digital transformation:** GeSI will continue to work with its members and wider stakeholders to identify and plug gaps in the development and deployment of digital infrastructure to enable sustainable development for all and leave no one behind.
- **Understand and address negative externalities:** GeSI will continue to work with its members to understand, in depth, the potential negative impacts of the increased adoption of digital technology and the necessary mitigating actions that will enable the sector to realise a radical ambition to drive the transformation needed to realise the SDGs.

Digital with Purpose - Delivering the SMARTer2030 Agenda: GeSI will continue to work with its members and broader civil society, to address the critical externalities, take forward the opportunities, and address the challenges laid out in this report.

Introduction

The Sustainable Development Goals represent, for the first time in history, a consensus-driven agenda for human progress. Framed by the UN's 2030 Agenda for Sustainable Development and ratified by all nation states in 2015, the SDGs comprise 17 Goals and 169 targets that detail the critical challenges facing humanity and against which all have a responsibility to contribute.[1]

Despite considerable progress, poverty, hunger, water scarcity, unemployment, and inequality plague too many people across the world. CO2e emissions and the associated adverse impacts of climate change continue to increase dramatically. According to the Social Progress Imperative, current global trajectories put us on the path to failure by the 2030 target date.[2]

Bold commitments are needed from all parts of society if the ambition of the 2030 Agenda is to be delivered, with partnerships at the core of these commitments. The Goals and associated targets simply cannot be delivered alone, not by government, nor business, nor philanthropists. Stakeholders must work together towards a common purpose to achieve real impact, and digital technology is a vital enabler for this.

The Global Enabling Sustainability Initiative (GeSI) pursues a vision of a sustainable world enabled by digital technology. Its guiding mission is to encourage and corral the ICT sector, policymakers and partner industries to develop, adopt, and deploy digital technology for the greater good.

This report, developed by Deloitte on GeSI's behalf, sets out the power of digital technologies to accelerate action on the SDGs. It builds on GeSI's extensive previous work on the potential for digital solutions to reduce global CO2 emissions[3] and to draw correlations between the use of digital technology and achievement of the SDGs.[4]

The purpose of this report is to extend previous analyses by considering the causal relationship between adoption of digital technologies and the consequent impact on the SDGs, whether this be positive or negative. The Goals have been grouped into three themes that reflect the intertwined systems that must be transformed to enable sustainable development.[5] 'Biosphere' represents the natural environment and the challenge posed by the SDG Agenda to conserve our planet and its natural resources. 'Society' represents the fundamental need to protect the most vulnerable in society and to support all individuals and communities to flourish. Finally, the 'Economy' theme targets our shared prosperity, but acknowledges the imperative for this prosperity to be delivered with the utmost consideration for human welfare and the biosphere.

This report is intended to be read either as one narrative, or by dipping into its constituent parts across six chapters and 17 SDG deep dives.

The chapters include:

01 Digital technologies
An introduction to the technologies explored in the report and an overview of the opportunities they provide to develop and deploy for maximum impact on the SDGs;

02 Impact on the SDGs
The impact these technologies have now and in the future, supported by a deep dive which details the opportunities for each SDG individually;

03 Impact on the SDGs – Sectors
An exploration of the scope for partner sectors to deploy digital technologies for impact on the SDGs;

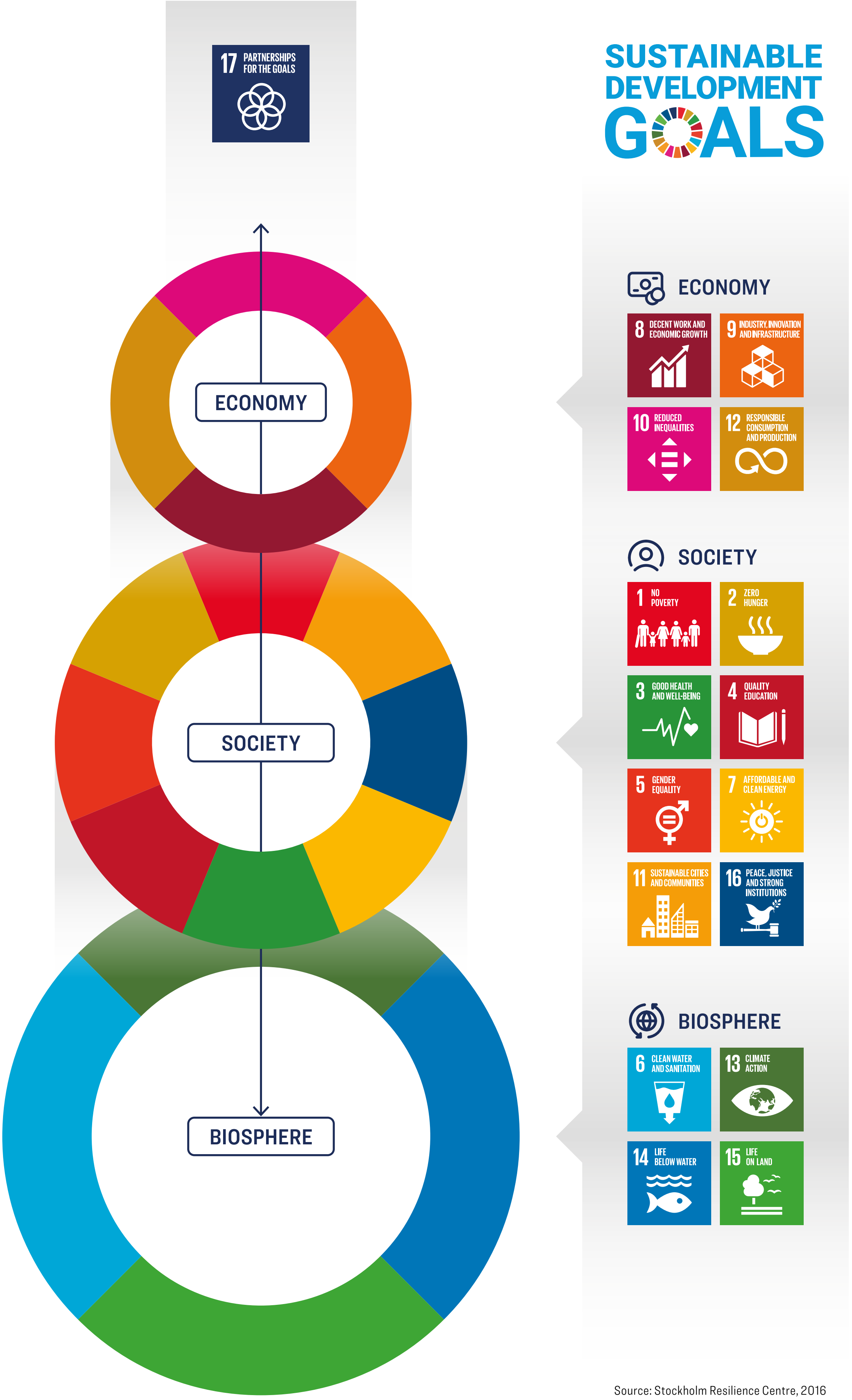
04 Impact on the SDGs – Geography
Reflections on the most immediately relevant Goals for six major global regions, progress against these, and the comparative impact of digital technologies;

05 The ICT sector – the Catalyst for Sustainable Development
Estimations on the scale and current impact of the ICT sector, as well as projections to 2030; and

06 Actions to Deliver a SMARTer 2030
Delineation of the critical roles for both the ICT sector and other stakeholders in developing and deploying digital technologies to maximise positive impact and minimise negatives.

The analysis of impact on the SDGs that drives the main body of the report and the 17 SDG deep dives has been conducted both qualitatively and quantitatively. A qualitative assessment clusters SDG targets and considers these through the lens of four ‘impact functions’. The potential impacts of different digital technologies are then assessed with use case examples. A quantitative assessment has also been undertaken to assess a selection of SDG targets and forecast the potential adoption rate of relevant digital technologies in order to deliver a set of projected impacts by 2030. These priority targets have been identified for analysis on the basis of both their relevance to digital technologies and wider data availability. The methodology was built on a review of existing literature and was supplemented by expert input through a crowdsourcing platform.[6]

This report is intended to act as a clarion call for all who engage with it. For the ICT sector, partner sectors, policymakers and individuals, time is running out to commit and contribute to the sustainable development agenda. The world faces a race to prevent an irreversible cataclysm caused by climate change, and it is imperative that positive and ambitious action is taken to prevent a deterioration in the well-being of our planet and the people who inhabit it. The time to act is now, and this report should be seen as a clear and comprehensive call for all to participate.



Source: Stockholm Resilience Centre, 2016

01

Digital technologies

Digital technologies increasingly permeate human activity, not least those activities that promote sustainable development. In his speech to the 73rd UN General Assembly in September 2018, UN Secretary General Antonio Guterres described digital technology as having the ability to “turbocharge” progress towards the SDGs.[1]

A new understanding of the connection between the adoption of digital technologies and the consequential impact on the SDGs will catalyse progress towards the 2030 Agenda. This chapter sets out how these digital technologies are defined, how they bridge to the SDGs through ‘impact functions’ and how they are being developed, deployed and delivered.

Whilst digital technologies drive innovation and can create positive economic, social and environmental impact, they can also constrain or retard development. This can either be **intentional**, e.g. assisting illegal exploitation of those who are vulnerable, **as a consequence**, e.g. emissions resulting from the electricity needed to recharge a phone, or **unintended**, e.g. job losses from enhanced operational efficiency. Both positive and negative impact will be discussed in later chapters.

Digital technologies are constantly converging and evolving, so being overly definitive has limited benefit. What is beyond doubt though is:

- Digital technologies will increase in influence and impact on the world;
- These technologies can deliver positive or negative impact, depending upon their development and deployment; and
- To deliver positive impact consistently, development and deployment needs to happen within the context of a more sophisticated, system-level understanding of the linkage between use and impact.

1 The seven digital technologies

For the purposes of this report, seven digital technologies have been selected to represent the short and medium term evolution of the ICT sector. These technologies are:

1. Digital Access: connectivity between people and of people to the internet via telecommunications infrastructure (fixed or mobile), devices (handheld devices and computers) and software.

2. Fast Internet: next generation connectivity that provides speed, capacity and reliability at fundamentally higher levels including high speed fixed broadband, 4G and 5G.

3. Cloud: the provision of highly scalable, advanced IT capabilities as hosted services. Typically on-demand and pay-as-you-go and including an ever widening breadth of capabilities including infrastructure, network, storage, computing power, applications and data.

4. IoT (Internet of Things): the suite of technologies enabling the connection of physical objects to the internet, and enabling communication from, and to, the object about the object's condition, position and surroundings.[2]

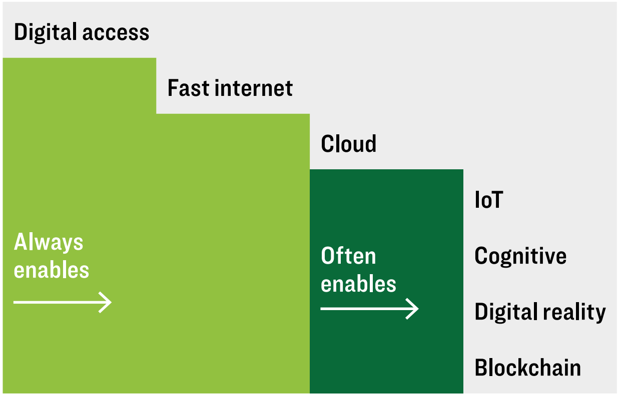
5. Cognitive: the application of advanced analytics, machine learning (ML) and artificial intelligence (AI)[3] approaches to big data[4] to develop insight.

6. Digital Reality: virtual digital worlds or systems (Virtual Reality), or mixed virtual and physical worlds (Augmented Reality).[5]

7. Blockchain: digital, distributed ledgers of transactions maintained on multiple computer systems controlled by different entities and accessible by all participants without the need for intermediaries enhancing accuracy, verifiability and security.[6]

These technologies typically work together both in their development and deployment. AI for instance is crucial to the effective development and operation of the networks that underpin fast internet, whilst scaled deployment of AI by an organisation will often involve cloud services.

The diagram below illustrates how the seven digital technologies work together when deployed. In later chapters, we have called out the distinguishing technology for each use case rather than list out each of the seven involved. Innovative combinations and evolutions of core technologies continually push back the digital frontier of possibilities.



1.1 Digital access

Definition

Digital access describes the capacity of different stakeholders across the globe to engage, interact and carry out transactions within digital environments, or simply, the overall ability of individuals in a country to access and use digital technology.[7] GeSI has developed the Digital Access Index to provide global visibility to the impact of access to digital technology to the achievement of the 2030 Agenda using two foundational components: connectivity (including infrastructure, affordability, and use) and technologies.[8]

Application

Digital access enables any transfer of information and data from one point to the other, connecting people to each other and to information. It allows the provision of digital products and services that improve quality of life and connects the unconnected – enabling people to connect to global digital marketplaces and to participate in today's economies and societies. Digital access democratises information, facilitates transactions and digital business models, promotes innovation, and enables human interactions.

A range of technologies can provide digital access, such as satellite reception, mobile communications and the internet, and these are transmitted through an array of devices, such as mobile phones and tablets. The task of enhancing and extending digital access lies primarily with the telecommunications infrastructure providers, the handset manufacturers, and the mobile network operators.

Scalability

An estimated 96% of the global population now have access to a mobile telecommunications network.[9] At the end of 2018, 51.2% of the global population had access to the internet. In developed countries, the percentage of the population using the internet has seen steady growth from 51.3% in 2005 to 80.9% in 2018. Whilst the overall trend is positive, huge disparities of adoption rates across nations, populations, and communities persist. For example, digital access in Africa has grown from around 2% in 2005 to more than 24% in 2018, but this is still less than half the global average.[10]

The division between those who benefit from digital access and those who don't is often referred to as the "digital divide"; as highlighted by the GESI #DigitalAccessIndex[11] this is characterised by a lack of infrastructure, affordability, knowledge/readiness to use, or quality of service.[12] For digital access to be truly universal, individuals must not only have access to a sufficiently high quality connection, but be able to manage, understand, communicate and create information safely and appropriately through digital devices and networked technologies.[13]

To prevent exclusion, digital access must be addressed both through the value chain and by governments and institutions in tandem with other development policy objectives and regulations.[14] Higher levels of digital access is likely to require reduced access costs to the internet market and more funding around infrastructure capabilities and digital inclusion initiatives.[15] Higher levels of access will also increase the market size for big tech firms and other ICT stakeholders, and can stimulate and be stimulated by the development of more accessible products and services.[16]

1.2 Fast internet

Definition

Fast internet refers to different types of broadband internet connection and high speed connection to the cellular mobile network through next gen networking, e.g. 4G or 5G that offers fast download and upload speeds, wide coverage, and stable connections. As interactions between humans, businesses and objects (via IoT) become more entrenched in our daily lives, the volume and frequency of data exchanges is expected to increase exponentially. Fast internet not only enables the promise of higher volumes of quicker data, but crucially becomes a gateway to the promise of digital technology itself.

Application

A majority of the use cases and ways in which digital technologies impact the world noted in this report could either be enhanced by, or are dependent upon, fast internet.

5G is the signature development for fast internet, expected to act as a unifying technology, combining networking capabilities to underpin a seamless, smart networked, communication environment of people and objects. Although the incremental benefit between 4G and 5G for consumers is minimal, the scope for industrial 5G to support deployment of other digital technologies is significant. This provides massive data processing ability and transport at low levels of latency and high levels of reliability.[17]

Whilst an established technology, roll out is at a comparatively early stage and so large-scale use cases are currently few and far between.

Scalability

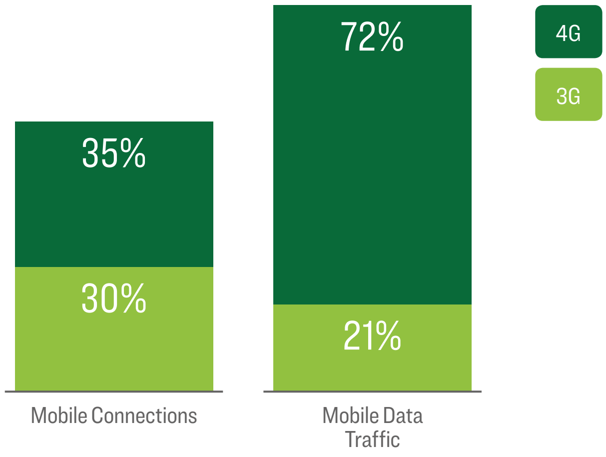
Fast internet has seen rapid and accelerating rates of adoption: 4G has taken five years to cover 2.5 billion people, in comparison to eight years for 3G. Currently, 3G and 4G reach 80% of the global population, compared to 96% receiving basic access.[18]

Many governments have initiated 5G trials, while strategies for 5G deployment have been established in many parts of the world,[19] with 72 operators testing 5G in 2018, and 25 expected to launch by the end of 2019. [20]

By 2025, 5G is forecasted to account for half of mobile connections in the US, with the number of 5G connections globally expected to reach 1.4 billion by 2025, accounting for 15% of the total global mobile market.[21]

In tandem, international, national, and regional regulations and policies need to be adopted and applied to enable the effective roll out of 5G.[22] Roll out will also depend upon the availability and cost of devices, and the evolving business case, i.e. the ability to save cost by retiring legacy networks and the opportunity to share in the monetisation of the new capabilities and applications.

Current usage of fast internet



1.3 Cloud

Definition

Cloud technologies enable global on-demand access to a shared pool of configurable computing resources, such as networks, servers, storage, applications, data and services. This provides multiple advantages in terms of efficacy (access to better capability), efficiency (only pay for what you use) and management (faster set up times).[23] Organisations and individuals are increasingly benefiting from cloud either intentionally, or because the product or service they are consuming has it incorporated.

The major cloud providers, e.g. Amazon (AWS), Google (GCP), Microsoft (Azure) and Alibaba (Alibaba Cloud), are rapidly adding to the scope of the services they provide as they seek to provide fully-equipped ecosystems, offering a single source of diverse services, solutions and applications which support organisations to grow, innovate and develop.

Application

Cloud is transitioning from an infrastructure-orientated, cost-based proposition to a significant driver of business transformation[24] and digital innovation. Most of the other six digital technologies use cloud services in some way in their development and deployment. Depending upon the commercial model, cloud promises the democratisation of access to digital services by removing the fixed cost, stepped consumption model of traditional IT.

Offering multi-faceted capabilities, cloud technologies are being used by all types of organisations and bodies in various industries, from consumer products and services to life sciences. Cloud supports faster and more efficient product development, expedites drug development and genomics analytics, boosts productivity and communication, and streamlines business processes.

Scalability

Globally, public cloud services revenue is projected to reach $411 billion by 2020, compared with $260 billion in 2017.[25] The rate of cloud adoption, measured by the volume of organisations hosting their workloads and applications on the cloud, has grown significantly over the last two years. 23% of businesses had more than 20% of their workloads on the cloud in 2018, in comparison to 3% in 2016.[26]

Levels of wholesale adoption by business i.e. the transition of significant proportions of their IT capability to the cloud, differ radically by geography. The US is significantly ahead, whilst Europe is slightly more limited in adoption rate, with other regions much further behind.

The benefits of cloud usage might not necessarily imply sophisticated end-consumer access, for example a text-based, medical triage application is likely to be driven off cloud-based servers and processing. Even so, business uptake does depend on the quality of the local infrastructure and also on data laws and policies, e.g. GDPR which may restrict where and how sensitive data is held. An additional potential barrier to roll out is vendor lock-in which has always been a concern of CIOs, exacerbated by the consolidated set of global vendors.

1.4 Internet of Things

Definition

IoT refers to the suite of technologies enabling the connection of physical objects to the internet which allows communication from, and to, the object concerning its condition, position and surroundings. This requires the device to be equipped with some form of sensor and a communication device, e.g. SIM card. The device is reliant on the network through which the electronic signal is transmitted, e.g. cellular, WiFi, satellite and Bluetooth.[27]

IoT technologies typically also include the data processing capability through which the data received is analysed and understood. The connection may be coupled with an interface which translates data into a user-friendly form, and/or performs actions automatically.[28] In this way, IoT creates value through the collection and analysis of location-specific information to generate insight and enhance decision making.[29]

Application

Currently, IoT technologies are primarily deployed in consumer products, utilities, and industrials and in environmental management. IoT is used to enable Industry 4.0, or a transformational improvement in the efficiency and effectiveness of processes in manufacturing and related sectors. To achieve this, IoT is used to communicate, analyse and utilise real-time data to drive intelligent action[30] into manufacturing, operations, and product development. Utilities were early adopters with smart meters, though roll out is still underway. IoT for the environment is deployed with the purpose of tracking and understanding environmental changes and phenomena, which can be particularly useful to the agricultural industry.

The envisioned smart future foresees near ubiquitous IoT as each functioning device embodies some level of intelligence or information that provides insight to others, e.g. in the context of the smart city and smart mobility.[31]

The implementation of IoT relies on a number of partners to work in collaboration. These include the hardware manufacturers, who can develop smart products such as sensors and circuits that will collect information, and software providers who will act as system integrators to increase interoperability of IoT capabilities. Further to this, carriers and telecommunications providers are needed to host the network technologies that will transmit the information, and platform and cloud providers will be required to provide a secure user interface and the necessary on-the-ground applications to translate the information.[32] Partnerships between these groups will be crucial given the continued evolution of the technology.

Scalability

The global IoT market is expected to double from $235 billion in 2017 to $520 billion in 2021.[33] This will be accelerated by the deployment of industrial 5G. Costs associated with transferring, storing, and analysing data have reduced as bandwidth, data storage, and computing prices are becoming more accessible,[34] thereby improving the business case. However, adoption rates may be hindered by concerns regarding data privacy, cyber risk,[35] and digital inclusion, as well as the difficulties associated with retooling legacy operations with emerging technologies.[36]

1.5 Cognitive

Definition

Cognitive is one way of referring to the application of advanced analytics, machine learning (ML) and artificial intelligence (AI)[37] approaches to big data[38] to develop insight. Big data can be structured or unstructured data, from diverse sources in volumes too large for traditional technologies to capture, manage, and process in a timely manner.[39] ML is the running of algorithms that automatically improve their function through self-directed adaptation. AI is analysis of data to perform and/or augment tasks, help better inform decisions, and accomplish objectives that have traditionally required human intelligence.[40] These all add up to vastly improved and actionable insights.

Cloud providers, together with some other technology firms, e.g. ERP and telecommunications providers, are the main providers of cognitive technologies, often providing data or a fully outsourced service. In parallel, reflecting both the promise of the market and its relatively early stage, there are many smaller companies, such as specialised application companies, offering their own analytics capabilities often specific to particular industries, data domains, or types of analytics.[41]

Application

Cognitive has vast potential to enhance or effectively replace any judgement or decision that humans make. Reflecting this broad opportunity, the applications of cognitive range in scope and ambition and can be combined with one another to enhance the final output,[42] which includes:

- **Computer vision:** the automatic extraction, analysis and insight generation from images;
- **Language technologies:** the analysis, understanding and generation of human languages to facilitate interfacing with machines in written and spoken contexts, including natural language processing and speech recognition;
- **Robotics, or Robotic Process Automation (RPA):** rule-based machines programmed to perform particular tasks, or automate processes. Typically combining hardware, such as mechanical parts, sensors or screens, with intelligent technologies to perform a task for which a certain level of human intelligence is required, e.g. orientation, motion, interaction; and
- **Smart machines:** autonomous systems that make contextually-informed decisions by themselves, without human input.[43]

Scalability

Industries are increasingly deploying cognitive technologies in their products, processes and services. The percentage of businesses that have deployed AI has grown from 4% in 2018 to 14% in 2019.[44] Between 2017 and 2021, global spending on AI-focused systems, including AI-focused hardware, software and services, is expected to grow by 50%. In 2021, AI augmentation is anticipated to generate $2.9 trillion in business value, reflecting spending across an array of sectors including life sciences and health care, consumer products and services, financial services, and manufacturing.[45]

Organisational challenges still remain that may slow AI adoption, particularly concerning technology, processes and people. Aligning strategic purpose, data management processes, and operational models including people and governance, are requirements for preparing an organisation to take full advantage of cognitive technologies. Similarly, ethical concerns around privacy and societal impact prevent the widespread adoption of AI and other forms of cognitive technologies.

1.6 Digital reality

Definition

Digital reality encompasses the wide spectrum of technologies and capabilities that enable simulation of reality through engaging, multi-sensory experiences.[46] This includes virtual reality (VR), augmented reality (AR) and mixed reality (MR). Virtual reality immerses users in artificial surroundings that replace the users' real world environment, whilst AR overlays contextual information on the physical environments users see. MR is a combination of the two, overlaying the artificial surroundings of VR onto the physical environment used in AR.

Digital reality is typically based on three key elements: a real-time source of data, the presentation of data to the user, and user interaction with the data. Data sources may include real-time information from IoT and other sensors. The data is then presented to the user via visual overlay, auditory cues or video. The user then interacts with the data through gestures, voice commands, or gaze and attention.

As such, this digital technology builds on the other noted technologies, requiring for example the contextual input provided by IoT, the processing power of cloud and the connectivity and distribution of fast internet. Devices for user interaction may be bespoke for more sophisticated applications, e.g. flight simulation, or generic, e.g. using a mobile phone for a guided city tour.

Application

The digital reality offering is a result of the collective activities of three specific groups of providers over and above those providers linked to the digital technologies that underpin it. These are application providers, content providers, and the infrastructure providers who facilitate the development and provision of bespoke devices for use, e.g. headset devices.

Digital reality aims to deliver seamless interaction between human and machines within a specific domain or system; improving decisions, enhancing communication and coordination, and reducing costs by swapping live environments for virtual ones, applicable in areas such as training or tourism. Whilst still evolving, these properties add up to a significant value proposition and as such digital reality has already been deployed in industries as diverse as aerospace and defence, policing, automotive, health care, and consumer products and services.

Scalability

The digital reality market is expanding rapidly. The global AR and VR market was estimated at $6.1 billion in 2016, and is expected to reach $16.8 billion by 2019, supported by the increasing penetration of 4G and 5G. [47]

The most significant barrier to widespread adoption is the lack of innovative applications underpinned by a clear support infrastructure, e.g. head-mounted displays.[48] This is likely to change as the market evolves. The computing power and connectivity required to create high-quality graphics and engaging user experiences poses further challenges. Cyber risks, regulatory constraints, and privacy concerns also create friction in adopting digital reality technologies. In order to provide a secure immersive experience, security protocols, data management programs and other appropriate controls are required.[49]

1.7 Blockchain

Definition

Blockchain is a digital distributed ledger technology, allowing for the secure management of shared ledgers where transactions are verified and stored on a network without a governing central authority.[50] "Block" describes the way this ledger organises transactions into blocks of data, which are then organised in a "chain" that links to other blocks of data.[51] Blocks are comprised of a header, which includes the time the block was created and a link to the previous block, and the content itself, usually a list of validated digital assets and instructions.[52]

The technology offers a way of recording transactions or any digital interaction in a way that is designed to be secure, transparent, reliable and efficient.[53] Data stored on the blockchain is immutable and irrevocable; it is nearly impossible to make changes to a blockchain without detection because transactions are visible and agreed upon by a proportion of the participants, depending on the consensus mechanism.

Application

Blockchain is deployed either as a public or private network. The distinction rests upon who is allowed to participate in the network, execute the consensus protocol, and maintain the ledger.[54] Public blockchain is completely open, and anyone can participate. An example of this is a coin offering. Private blockchain is only open to participants who meet a set of criteria, for example, a business using blockchain in its internal supply chain may restrict participants.

As a digital technology, blockchain has a wide range of applications. It can be used to store digital records securely, particularly digital identities of individuals, assets, rights and any other digital documentation. Users can also conduct digital transactions through blockchain without third party intermediaries (peer-to-peer), avoiding fees and ancillary costs and reducing time of execution. Blockchain also allows the operation of smart contracts, which are digital codes that enable the automatic execution of specified actions based on contractual conditions as validated by all parties. Blockchain concepts, prototypes, and investments are emerging in every major industry,[55] particularly in areas such as finance, supply chains and land rights. These applications can be used to further the 2030 Agenda by reducing the costs of remittances to developing countries, allowing the traceability of products through supply chains, ensuring small-holder farmers have ownership over the land they cultivate, and giving refugees a secure identity to access critical services.

Scalability

Blockchain is still a nascent technology, with only 1% of CIOs indicating any kind of blockchain adoption and 8% currently considering short-term planning and execution.[56] Blockchain initiatives targeting social impact are also in their early stages, with 34% started in 2017 or later, and 74% are still in the pilot or idea stage.[57] However, momentum around the technology is beginning to grow. 53% of senior executives believe blockchain technology has become a critical priority for their organisations.[58] Looking further forward, blockchain is expected to deliver $176 billion dollars of business value by 2025, and over $3 trillion dollars in value by 2030.[59]

The lack of widespread understanding of the business case for blockchain remains a barrier for adoption, along with energy usage, regulatory uncertainty, and lack of trust among public network users.[60] Energy usage is of particular concern when deploying blockchain given the electricity required to power the underlying consensus mechanisms. Estimates vary, but Bitcoin alone is reported to use approximately 0.25% of the world's entire electricity consumption.[61]

2 Impact functions

Each of the seven selected digital technologies affect the world in a multitude of different ways. To help navigate these effects, this report uses a new framework laying out a set of impact functions. These four impact functions represent the different ways in which digital technologies come together to deliver impact and support the achievement of the SDGs. The impact functions build upon each other and increase in complexity and sophistication, each with a series of sub-functions.

The framework has been used in three ways, as a diagnostic to reflect on how digital technologies can impact the SDGs, their targets and indicators; as a vehicle for classifying the noted use cases we have found; and in the communication of our findings.

Connect & Communicate: Digital technologies can make a significant impact in the world even through basic transmission of data. Digital technologies foster connections between people, enabling the sharing of information between each other, or on the internet more broadly, either for public awareness messages and campaigns, or for targeted content to specific audiences. This connectivity provides widespread access to marketplaces, improving the efficacy and efficiency of global and local markets. Furthermore, digital technologies provide the networks needed to conduct financial transactions online, removing the need for physical interaction for financial services.

Monitor & Track: Digital technologies can be used to enable robust, real-time and extensive observation of the world and everything in it. This information can be used to direct interventions for individual and collective good. Digital technologies can be deployed to monitor and track both the natural environment and our human environment, including populations, people and activities. Additionally, they can be deployed to monitor and track economic activity, including organisational activities and supply chains, and personal circumstances, including both assets and rights.

Analyse, Optimise & Predict: By collating, processing, manipulating and interpreting large volumes of data from multiple sources, digital technologies can be deployed to reach new analytical conclusions that enable the optimisation of processes and predict future outcomes. This capability can be deployed to improve a plethora of processes, to analyse socio-ecological phenomena, to enable rapid innovation, and to determine future state predictions.

Augment & Autonomate: Digital technologies can be deployed to simulate the world and form an ‘active bridge’ between the physical and digital. This bridge can provide immersive experiences to aid decision making. It can provide humans with augmented capabilities, opening up new mechanisms for observing and interacting with the world around them. Finally, this bridge can be deployed to create (largely) autonomous systems: or to coin a new phrase, “autonomate”.

Impact functions	Impact functions definitions	Impact sub-functions
Connect & Communicate	Connecting people to each other and to critical information/ the internet.	• Public awareness messages • Targeted content • Digital marketplaces and business models • Digital payments and finance
Monitor & Track	The real-time, extensive observation of the world and its natural and man-made systems.	• The environment • Populations, people and activities • Organisations and supply chains • Individual assets and rights
Analyse, Optimise & Predict	The development of insights from data, and the use of those insights to drive process efficiency and infer the future.	• Process optimisation • Socio-ecological analysis and targeting • Rapid data analysis for innovation • Future state prediction
Augment & Autonomate	Provision of an "active bridge" between digital and physical, from simulation through augmentation to the creation of autonomous systems.	• Immersive experiences to aid decision making • Augmented humans • Autonomous processes and machines

Whilst there is not a direct one-to-one relationship between the seven focus digital technologies and the impact functions, there are stronger links between some than others. As discussed already, each technology is evolving, and therefore combinations are evolving too. The commentary below presents current observations rather than a set of absolute conditions.

Connections and communications are directly enabled by digital access, fast internet, cloud, and IoT devices, with AI playing a limited role in this space. Nearly all the digital technologies explored in this report enable monitoring and tracking, except digital reality applications. AI, machine learning and big data have a singularly direct part to play in analysis, optimisation and prediction. Finally, augmentation and autonomation are directly enabled by AI, IoT and digital reality, and more indirectly enabled by the other digital technologies.

However, given the description on scalability earlier, a more prevalent use of AI can be expected, particularly in combination with IoT, blockchain and digital reality, and holds the greatest promise of impact in the medium term.

3 Delivery

Digital technologies are combining to drive a transformational transition towards a digital economy and society. This is stimulating an evolution in value propositions, business models, markets, channels, and customer relationships globally. For example, subscription based business models are generating new revenue streams; digital direct-to-consumer interactions are eliminating intermediaries from the value chain; and many of the costs of doing business and transacting are dramatically decreasing.[62]

These shifts are already delivering impact against the SDGs, accelerating economic growth and improving quality of life and efficiency of activities. However, significant further developments are required in order to deliver impact against the SDGs. This includes the digital provision of services and products, widespread transparency, the democratisation of data, and the rapid demonetisation of technology in relevant contexts which will allow for ubiquitous access. Of equal importance is the careful management of increasingly data-centric processes, large-scale efficiency, fast learning, and automation. For example, the digital provision of services makes mMoney and e-Education[63] possible, and data-centric processes enable improved and personalised health care pathways.

ICT companies and IT departments are being challenged to retool and upgrade their functions in order to deliver these digital shifts and the capabilities that their organisation needs in order to succeed in a digital economy, and to deliver a positive social and environmental impact. However, in practice deployment of new digital technologies and services is often carried out in siloes by IT departments and service providers, with little or no interaction with other business departments or partners. As a result, deployment often lacks alignment with wider organisational goals, products and services, and any social or environmental impact delivered gains little recognition or scale.

Going forward, it will become increasingly critical to reorient ICT and technology teams around wider product and business goals and crucial impact. In order for this to happen, companies must integrate both positive impact and digital technologies into their strategy involving deep CEO and board-level engagement and alignment. In this new configuration, business and technology teams can work together to quickly deliver more impactful products, services and outcomes, in a manner that is scalable and maintainable.[64]

4 Shaping the future

Individual applications of digital technologies can, and are, driving progress. But to properly support the transformation required by the SDGs, digital technologies need to be developed and deployed with impact in mind from the outset, in a way that ensures positive impact is maximised and negative impact and footprint is well understood and mitigated.

The ICT sector plays a clear role in developing such digital technologies. The small concentration of large players in this sector have a responsibility to provide core digital infrastructure, platforms, and services that support many others, yet there is still a role for the large number of smaller players. Their focus on specific impacts and smaller addressable markets provides the opportunity to take advantage of the exponential reduction in the cost and performance of digital technologies and cloud in order to create equally impactful digital products and services.[65] Deployment of digital technologies to deliver impact is then an important role for the ICT sector and partner sectors; for example ICT and agricultural sectors together implementing digital solutions to agricultural monitoring and productivity.

The ICT sector, along with partner sectors, is in a position to deploy digital solutions with purpose that can and will achieve transformational impact against the 2030 Agenda. The sector itself makes a significant contribution to economic growth, employment and R&D, both inherent to the economic SDGs and to environmental SDGs through pioneering and efficient use of resources, circular business models to reduce e-waste, and the accelerated use of renewable energy. Despite this existing contribution to the SDGs, the transformational impact of the ICT sector will come from successful deployment of digital products and services. These range from digital disease diagnosis and early warning text messages for disasters, to intelligent traffic management and autonomous irrigation systems.

In order for deployment to be truly effective, there needs to be change at both macro and micro levels:

- At a macro level, ICT companies must ensure they are working towards a common shared agenda both within the industry and with key stakeholders. That agenda is the 2030 Agenda. They must also work in effective partnerships, capitalising on the opportunity provided by collaboration to maximise impact. Above all, transparency will be key to understanding and attributing the impact that each solution has against the SDGs, as well as regulating activities and democratising solutions, both local and systemic.
- At a micro level, technology and positive impact must be integrated into individual business purpose and strategy, and ethical and cyber security measures embedded into the operationalisation of such strategies. ICT companies must also work towards modernising and retooling legacy systems and technology architecture, in order to implement new, flexible systems that enable faster and more efficient growth and scalability.

However, the deployment of digital technologies to achieve a positive impact also comes with negative externalities and implications that fall into three categories: i) intended, ii) consequential and iii) unintended:

- Intended externalities occur when individuals or organisations distort the use of technologies to achieve an intended outcome that is either deliberately malicious or deliberately robs individuals of their rights. For example, governments can use digital technologies to provide constant surveillance of their populations or individuals can deploy digital technologies to spread radical sentiment or to take part in online sex trafficking.
- Consequential externalities are unavoidable impacts of using digital technologies themselves, such an increase in e-waste and carbon emissions, e.g. the energy required to power the underlying consensus mechanisms of blockchain. Additionally, the use of rarer raw materials, such as cobalt, can lead to both societal and environmental exploitation.
- Unintended consequences are consequences that occur due to a combination of qualities inherent to technologies and/or pre-existing social structures. For example, as more and more services become digital, the services inherently become more susceptible to cyber attack. Automation, although driving large-scale efficiencies, threatens millions of jobs;[66] and basic digital access often is not accessible to the poorest and most vulnerable in society who need it the most, widening the "digital divide".

These externalities must be carefully mitigated, with ethical and safe control structures put in place, in order for the technologies to have a truly positive and transformational impact.

In order for positive impact against the SDGs to be realised through the delivery and deployment of digital technologies, there are a number of recommended ICT sector, partner sector, and stakeholder actions. The ensuing chapters provide further detail on how this impact can be achieved against each SDG as well as the footprint of the ICT sector more broadly, as follows:

- **Digital technologies:** an introduction to the technologies explored in the report and an overview of the opportunities they provide to develop and deploy for maximum impact on the SDGs;
- **Impact on the SDGs:** the impact these technologies have now and in the future, supported by a deep dive which details the opportunities for each SDG individually;
- **Impact on the SDGs – Sectors:** an exploration of the scope for partner sectors to deploy digital technologies for impact on the SDGs;
- **Impact on the SDGs – Geography:** reflections on the most immediately relevant Goals for six major global regions, progress against these and the comparative impact of digital technologies;
- **The ICT sector – the Catalyst for Sustainable Development:** estimations on the scale and current impact of the ICT sector, as well as projections to 2030; and
- **Actions to secure the delivery of a SMARTer2030:** delineation of the critical roles for both the ICT sector and other stakeholders in developing and deploying digital technologies to maximise positive impact and minimise negatives.

02

SDG impact

Biosphere

If we do not achieve the Biosphere SDGs, the world will fail to achieve the remaining goals, and societies and economies will be at risk of collapse.

The biosphere refers to all regions on the surface of the Earth occupied by living organisms. It extends from the deepest root systems of trees and the dark environment of ocean trenches, to the highest mountaintops and the layers of atmosphere used by birds in flight.[1]

The prosperous society and economy envisaged by the SDGs is entirely dependent on the natural resources and ‘ecosystem-services’ the biosphere offers. Without continuing to sustainably accrue the benefits of the natural world, current and future generations will live in a society that cannot function and with an economy that cannot prosper. To ensure the health and prosperity of our planet, the biosphere requires careful management.[2]

Nine processes, commonly referred to as ‘ecological ceilings’ or ‘planetary boundaries’,[3] have been identified as critical for regulating the biosphere and to achieve the SDGs. The planetary boundaries include the following processes, which can be linked to specific SDGs: climate change (SDG 13), atmospheric aerosol loading (SDG 13), stratospheric ozone depletion (SDG 13), chemical pollution and the release of novel entities (SDG 13), loss of biosphere integrity (SDG 14, 15), ocean acidification (SDG 14), freshwater consumption (SDG 6), land system change (SDG 15), and nitrogen and phosphorous flows to the biosphere and oceans (SDG 6, 14). Overshooting these ceilings increases the “risk of generating large-scale, abrupt or irreversible environmental changes,” ultimately putting the development and safety of all life at risk.[4]

Of the ecological ceilings, climate change, nitrogen and phosphorus loading, biodiversity loss, and land conversion are already overshot.[5] Reversing these overshoots, preventing others and thus protecting the biosphere from irreparable damage can be achieved through meeting the four core biosphere SDGs and the targets they lay out for 2030. These SDGs comprise the ecosystems that sustain biological life, and are categorised into two thematic groups: climate action (SDG 13) and the provision of natural resources (SDG 6, 14 and 15).

Climate action: SDG 13

Climate change is arguably the most serious challenge currently faced by humanity. Humans are estimated to have caused 1.0 °C of warming already,[6] and as a result, have already set in motion damage to the natural world, leading to far-reaching impacts across the biosphere, society and economy. Climate change is already triggering unexpected and negative impacts on our ecosystem and increasing the rate of biodiversity loss. As a result of unpredictable weather triggered by climate change, agricultural yields become less certain, and water becomes increasingly scarce in areas where it is already limited, which triggers greater probability for conflict and negative economic growth.

Whilst urgent action to combat climate change is captured as an aim within SDG 13, 15 targets across other SDGs explicitly call for the reduction of CO2 emissions in more specific contexts. These targets are also considered here. Digital technologies have the opportunity and obligation to contribute to climate action through helping to measure and track carbon emissions, communicating the gravity of the crisis, and analysing and optimising all manner of emitting processes across industries to reduce emissions. They also play a major role in monitoring, tracking and managing natural disasters and building capacity to deal with the effects of climate change.

Natural resources: SDG 6, 14 and 15

Breaching ‘ecological ceilings’ as a result of intense industrialisation is threatening the stability of the ecosystems which produce the natural resources that sustain life. These include freshwater (SDG 6), marine (SDG 14) and terrestrial (SDG 15) ecosystems. These SDGs are concerned with the sustainable use of resources for the long-term benefit of all. SDG 6 aims to ensure the availability and sustainable management of water. SDG 14 focuses on conserving and sustainably using the oceans and marine resources; whilst SDG 15 calls for the protection, restoration, and sustainable use of terrestrial ecosystems.

Digital technologies have an important role to play in enabling interventions to protect ecosystems and ensure the sustainable use of natural resources. In particular, digital technologies can be deployed to help reduce damage to the environment and maintain biodiversity by monitoring environmental conditions, natural resources and species populations.

Looking forward

However, the deployment of digital technology needs to be taken forward with due consideration to the potentially exacerbating impacts on emissions and resource usage. For example, the increasing spread of internet-capable devices, supported by appropriate networks, will cause a significant increase in resource consumption to produce these devices and emissions from electricity usage, unless the electricity is generated from renewable energy sources. A build-up of e-waste and the mining of precious and semi-precious metals could have disastrous consequences for the biosphere, leaching toxins into water supplies and terrestrial and marine ecosystems, threatening their stability.

Despite these risks, failure to act would be considerably more devastating. Individuals, and public and private sector organisations, have a responsibility to work together to use digital technology in a way that safeguards the biosphere, whilst mitigating exacerbating impacts.

SDG Progress overview

Significant progress has been made against some core biosphere SDG targets – in particular expanding access to drinking water and increasing the proportion of protected land and sea areas. However, many more targets are tracking in the wrong direction, including a number of targets aimed at protecting ecological ceilings. Climate change is an area of particular concern.

Climate change

13 CLIMATE ACTION

- ✗ **Act to reduce CO2 emissions:** CO2 emissions have hit an all-time high, and are rising at an accelerating pace, with an increase of 1.6% in 2017 and 2.7% in 2018, primarily led by increased economic output.[7]
- ✗ **Ensure resilience to natural hazards:** rising sea levels, extreme weather conditions and extreme temperature continue: the year 2018 was one of the four warmest on record, with the other four falling in 2015-2017.[8] 2017 also saw the cost of natural disasters hit $306 billion worldwide, nearly double the cost in 2016.[9]
- ✗ **Improve education, awareness and capacity to act:** so far developed nations have only committed $3.5 billion of the $10.3 billion pledged to the UN Green Climate Fund.[10]

Natural resources

6 CLEAN WATER AND SANITATION

- ✓ **Clean water and sanitation for all:** the proportion of the global population using at least a basic drinking-water service increased from 81% in 2000 to 89% in 2015.[11]
- ✗ **Reduce freshwater pollution and conserve ecosystems:** over 80% of wastewater is discharged into water bodies without pollution treatment.[12]
- ✗ **Efficiently manage freshwater reserves:** approximately one third of countries have medium or high levels of water stress,[13] with more than two billion people living in countries experiencing high water stress.[14]

14 LIFE BELOW WATER

- ✓ **Conserve and sustainably manage oceans and coastal ecosystems:** the percentage of ocean waters covered by protected areas increased from 12% in 2015 to 17.2% in 2018.[15]
- ✗ **Improve ocean health and reduce all marine pollution:** ocean acidity has increased by about 26% since the start of the Industrial Revolution.[16] Ocean eutrophication is expected to increase in 20% of large marine ecosystems by 2050.[17]
- ✗ **End destructive fishing practices and encourage sustainable fishing:** the global share of marine fish stocks that are within biologically sustainable levels declined from 90% in 1974 to 67% in 2015.[18]

15 LIFE ON LAND

- ✗ **Conserve, restore and sustainably manage terrestrial biomes:** currently more than 75% of Earth's land areas are substantially degraded, having become deserts, polluted or deforested, undermining the well-being of 3.2 billion people.[19]
- ✓ **Conserve biodiversity and ecosystems and combat invasive species:** the global percentage of each key biodiversity area covered by protected areas increased from 33.1% in 2000 to 46.1% in 2018.[20]
- ✗ **Prevent extinction, poaching and trafficking of species:** the global Red List Index of threatened species has fallen from 0.82 to 0.74, indicating an alarming trend in the decline of animals. Illicit poaching continues, with ~7,000 species of animals and plants reported in illegal trade in 120 countries.[21]

Impact of digital technologies

Digital technologies have a critical role to play in protecting the biosphere and reversing negative progress against the four biosphere SDGs and their targets. All four impact functions will be critical for success, but the most relevant impacts are particularly concentrated within monitoring and tracking the state of the natural world (SDGs 6,14, 15), and analysing and optimising energy usage across-sectors to reduce climate change (SDG 13). There will be increasing opportunities in the future for emissions savings under 'Augment and Autonomate', as the automation of processes across agriculture, industry and manufacturing becomes increasingly sophisticated and automated, helping in the fight against climate change.

Connect & Communicate

Digital technologies drive public engagement in the major challenges facing the biosphere, particularly through the widespread distribution of increasingly vivid information on anthropogenic impact, e.g. through documentaries. Social media and online repositories can be used to inform those interacting closely with the biosphere to spread sustainable practices and to provide advance warning of hazards. Digital connections have introduced incentives and opportunities to minimise our impact on the biosphere, for example through telecommuting and carbon trading.

Monitor & Track

As the biosphere goes through immense distress, it is vital for humans to have an accurate insight into both when and where damage is occurring. Collecting and gathering data regarding key environmental indicators provides insights into how each ecosystem, biome and natural resource is changing and why it is changing. In turn, this helps inform decision makers and consumers of the immediate and long-term actions that can be taken to prevent harm. Digital technologies also enable the continuous monitoring of people and organisations to ensure the adoption of sustainable behaviours, practices and decision making. For example, supply chains can be monitored more closely to track the flow of resources from the biosphere.

Analyse, Optimise & Predict

Adaptive AI algorithms, sometimes in combination with IoT sensor data, can optimise the efficiency of water and energy usage across a variety of sectors, reducing stress on freshwater systems and the climate. Algorithms can analyse vast amounts of geographical data and satellite or drone imagery in order to both identify and target emerging problems in the biosphere, as well as to predict future problems, e.g. by tracking illegal fishing vessels. AI can help with understanding complex ecological interactions and trade-offs, which improves the accuracy of these predictions. Finally, AI can be combined with various biological technologies in order to drive bio-innovation, which can protect biodiversity efforts.

Augment & Autonomate

Autonomous machines enable rapid and informed interventions to manage the biosphere, in particular by maximising and automating the efficiency of core-sector activities such as reducing pollution in water bodies. Automated processes can prevent damage being inflicted in the first place, particularly by improving the efficiency of activities in sectors including agriculture, manufacturing, and waste; and in cities, reducing energy consumption, carbon emissions and reducing harm to the climate.

Impact projections to 2030

A selection of biosphere-related SDG targets has been identified for modelling, selected on the basis of data availability and empirical impact evidence. The numbers presented serve as an illustration of the potential impact that digital technologies could have on achieving the Goals – giving a comparison of the business-as-usual scenario against how the outcome could look if some of the digital opportunities identified in this chapter were more widely adopted.

This does not, however, illustrate the full potential of digital technology. The estimated impacts are based on use cases which currently exist, and do not take account of potential gains from further R&D to develop new use cases. In addition, the numbers are based on expected adoption levels, and hence there is potential for much greater impact with an accelerated penetration of digital technology.

13 CLIMATE ACTION

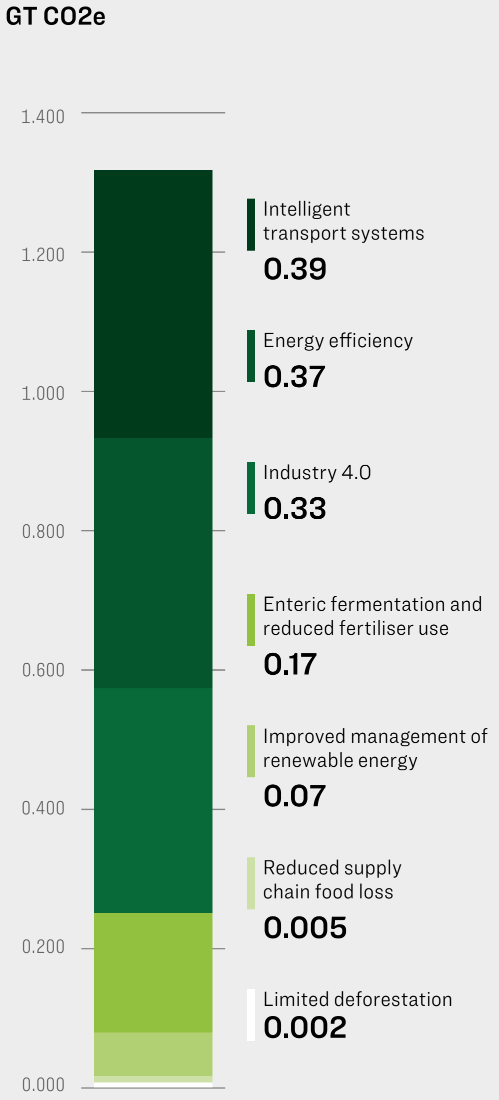
Target 13.2

Reduced GHG emissions

The use cases studied in this report demonstrate a number of ways in which ICT can reduce the GHG emissions contributing to climate change. In aggregate, these examples could lead to abatement of 1.34 Gt in 2030 against the business-as-usual scenario, delivering emissions savings estimated to be seven times the growth in the ICT sector's own footprint between 2019 and 2030. The total abatement is made up of:[22]

- Intelligent transport systems in smart cities could reduce emissions by 0.39 GT CO2e by 2030.
- Smart grids, to increase energy efficiency and the management of renewable energy, could reduce annual emissions by 0.43 GT CO2e in 2030, compared to the business-as-usual scenario.
- Industry 4.0 and more efficient manufacturing processes could result in abatement of 0.33 GT CO2e.
- Precision agriculture, to improve efficiency in the use of nitrogen-based fertilisers and livestock management could lead to lower annual emissions of 0.17 GT CO2e by 2030.
- Reduced food waste in the supply chain could reduce the total amount of food produced and lead to lower annual emissions of 0.005 GT (5.4 MT) CO2e by 2030.
- Limiting deforestation could improve net emissions from biomass in forests of 0.002 GT (2.3 MT) CO2e by 2030.

This is not an exhaustive list. Many other digital technology-enabled use cases also have the potential to lead to significant CO2e abatement though are not quantified for this report. For instance, there is evidence to show that solutions such as smart logistics to reduce distances travelled in delivering goods or telecommuting to reduce business travel can both lead to lower GHG emissions.



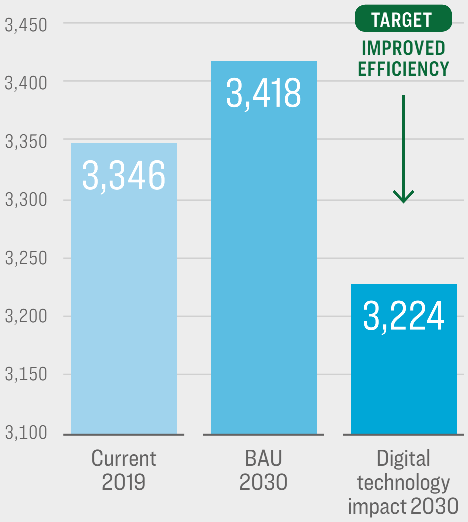
6 CLEAN WATER AND SANITATION

Target 6.4

Water use

Growing populations are increasing the future demand for clean water, both on an everyday basis and due to its use in the production of food. Agriculture and municipal water withdrawals make up around 80% of total withdrawals, and based on predicted trends in demand are expected to increase from 3,346 billion m^3 per year currently to 3,418 billion m^3 per year in 2030. However, digital technology in smart water infrastructure and smart agriculture has the potential to reverse some of this increase. In smart water infrastructure, IoT can automate demand management and maintenance, and in smart agriculture predictive modelling of the weather and environment could make irrigation more efficient. The impact of these use cases could reverse the projected increase in municipal and agricultural water withdrawals to 3,224 billion m^3 for 2030.[23]

Agriculture and municipal water withdrawals (10^9 m^3 per year)

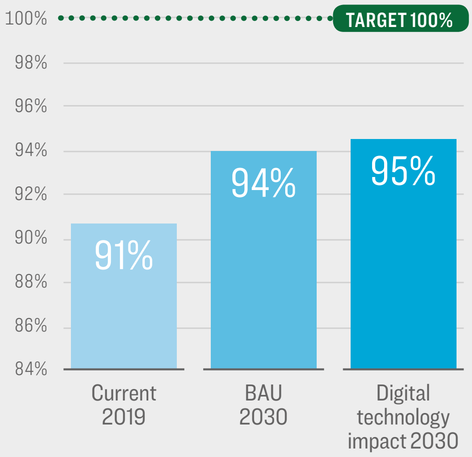


Target 6.1

Clean drinking water

Currently, 91% of the global population have access to at least basic drinking-water services (for which the collection time is not more than a 30 minute round trip). Given historic trends, this figure is set to improve to 94% by 2030, but more can be done: installation of smart water infrastructure to detect leaks and monitor water quality could increase the proportion of people with access to at least basic drinking-water services to 95%.[24] This change would improve the lives of around 93 million more people over the business-as-usual scenario.

Proportion of the population using at least basic drinking-water services



14 LIFE BELOW WATER

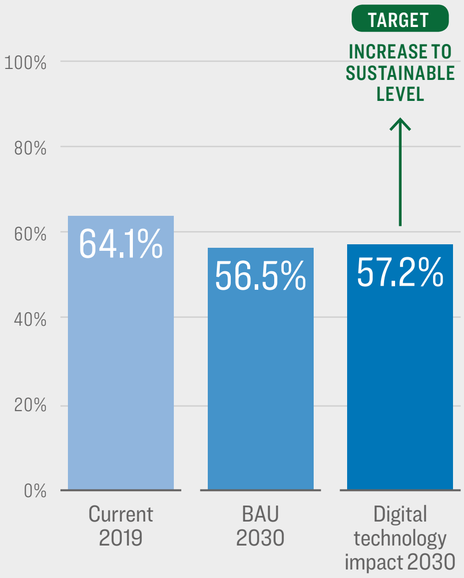
Target 14.4

Sustainable fish stocks

The proportion of fish stocks fished within biologically sustainable levels has fallen consistently from 91.5% in 1978 to 66.9% in 2015. Based on the historic trend, by 2019 this is expected to have fallen further to 64.1% and by 2030 the proportion could fall to below 56.5%. The sustainability of fisheries is essential to the livelihood of billions of people in coastal communities around the world, especially in developing communities where 97% of fishermen live.[25]

Using digital technologies, such as smartphones to collect data from vessels and AI to detect illegal activities, could help tackle unregulated and unreported fishing. Adoption of such technologies could slow the depletion of fish stocks so that in 2030, the proportion of fish stocks within biologically sustainable levels falls to a slightly higher 57.2%.[26]

Proportion of fish stocks within biologically sustainable levels



15 LIFE ON LAND

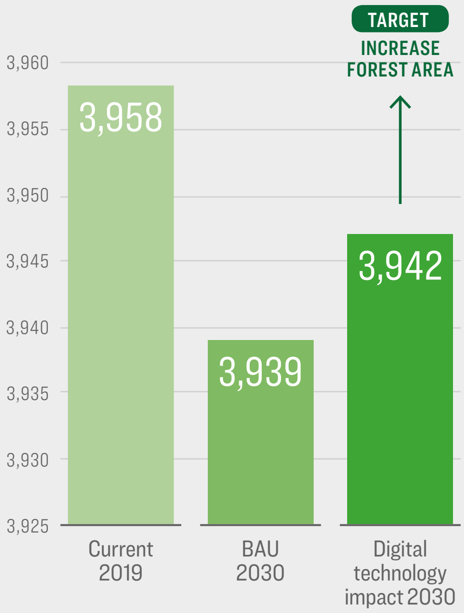
Target 15.2

Global forest area

Some parts of the world are experiencing acute deforestation: in the ten years to 2016, Africa and Latin America lost 4.6% and 1.4% of forest area respectively, totalling 51 million hectares. Based on historic trends, an estimated 19 million hectares of forest could be lost globally between now and 2030, with total global forest area decreasing from 3,958 million hectares to 3,939 million hectares. Forests are important for absorbing greenhouse gases, and have important economic and social benefits too: a study by the Woodland Trust put the value of UK woodlands at around £270 billion, stemming from impacts such as recreational visits, aesthetic value and health benefits.[27]

Digital technology has the potential to slow the rate of deforestation, for instance through the targeting of illegal logging using AI-enabled audio monitoring systems and research using big data facilitated by cloud technologies. Targeted adoption of such technology could save around 3.4 million hectares of forest area in 2030 compared to the business-as-usual scenario, meaning total global forest area in 2030 could be higher at 3,942 million hectares.[28]

Global forest area (million hectares)



Digital technologies drive public engagement in the major challenges facing the biosphere.

Connect & Communicate

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030...
Public awareness messages Digital access is fundamental for raising public awareness of both the damage being done to the biosphere and the mitigating actions required. Widespread distribution of information through digital channels can enable global engagement on issues from climate change to plastic pollution and drive action. For example, BBC nature documentary Blue Planet II induced 88% of viewers to change their plastic consumption habits.[29] Digital Reality technologies can also communicate powerful messages to drive action to protect the biosphere, whether by allowing the public to experience threats to animals[30] and marine life[31] through VR experiences, or through AR games that aim to raise knowledge of, and empathy for, endangered species.[32]	**Clean water VR documentary** WaterAid produced a VR documentary, 'Aftershock' that illustrates the struggles of a community to regain access to clean water after an earthquake.[33] The documentary connects viewers to the water challenges much of the world faces and has been used to encourage donations towards improving access to basic WASH (Water Supply, Sanitation and Hygiene) services.[34] VR films are powerful instruments for charities; for example, a VR film shown at UNICEF's annual fundraising conference influenced one in every six viewers to donate to UNICEF (twice the normal rate).[35]	**Companies, governments, and NGOs are able to deliver sincere, powerful and engaging messages explaining both the issues relating to the biosphere and how they are helping**
Targeted content Digital technology, including websites, SMS communications and social media, can be used to share messages with specifically targeted audiences. Evidence and research for protecting and improving the biosphere can be shared over the web. Text messages and emails can provide specific best practice knowledge to individuals with responsibility for protecting the biosphere. For example, fishermen and construction workers who encounter protected species can be trained to manage ecosystems responsibly.[36] Targeted messages can bolster resilience to climate-related hazards, with SMS and social media used as early-warning systems to provide vital information for communities most at risk of natural disasters.[37]	**Fishery management advice** FishPath is a decision support tool for fisheries management, created by The Nature Conservancy. It aims to reduce overfishing, given that more than 60% of global fisheries are overfished or in decline. After completing a questionnaire, the tool provides fishery management advice, specific to the environment and status of the fishery, to guide local users towards sustainable management of their marine life.[38]	**Digital access will enable information, advice and guidance to be shared directly with the people who need it most, so they can protect, support and repair the natural world. Training will support those using digital tools and solutions**

Digital marketplaces and business models

Digital access and the increasing data capacity of mobile networks allows consumers and organisations to connect, interact, and trade online, which supplants physical interaction. By enabling face-to-face meetings to be replaced by videoconferencing, digital technologies can enable a reduction in the carbon emissions caused by travel, protecting the biosphere.[39] More advanced technologies, such as 3D printing, may also reduce emissions in some instances, through localised manufacturing that reduces the distance product parts need to travel.

Further, the emergence and refinement of new, virtual, marketplaces, such as blockchain-hosted carbon trading[40] and carbon offsetting platforms, provide mechanisms for incentivising responsible treatment of the biosphere.[41]

Videoconferencing reducing emissions

T-Systems, Deutsche Telekom's B2B provider of digital services, offers an integrated communications platform (Unified Communication and Collaboration) allowing flexibility and access to the workplace through a range of devices, including phones and tablets. This system encourages employees to telecommute more frequently and reduce their travel. Using the platform, clients with 35,000 employees can abate up to 16,000 tons of CO2 emissions per year.[42]

Businesses of all types will be able to conduct their affairs in a primarily digital environment, increasing efficiency and reducing the transport of people and goods, thereby reducing emissions

Digital payments and finance

E-payment models provide an opportunity to leapfrog existing, and often ineffective, systems. Credit cards can encourage us to reduce our carbon footprint via mobile apps.[43] E-water payments provide local communities more effective and efficient local water distribution; similarly, Pay-As-You-Go solar power can connect off-grid communities to renewable energy.[44]

Online micro-payments for fresh water

In developing countries, water collection is a time-consuming process, requiring lengthy trips to find a vendor.[45] eWaterPay allows users to pre-pay for water on NFC tags, using their mobile phones. The tags can be scanned on eWater taps (equipped with IoT sensors) to dispense water at any time of day, without requiring a vendor, thereby saving users significant amounts of time.[46] The payment mechanism provides evidence that the system is working, and enhances revenue collection.

No matter how remote their location, all people have access to the basic financial services that enable them to purchase utilities at point of need

Monitor & Track

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030…
The environment Monitoring the natural environment is essential to understanding the biosphere. Collecting and gathering data regarding key environmental indicators can provide insights into changes in climate and carbon dioxide emission, and environmental resources such as water and flora. For example, IoT sensors can be deployed to provide real-time, continuous monitoring of water quality reserves[47] or track who is drawing upon water supplies in water-scarce areas.[48] Monitoring has been extensively used to sense natural hazards and inform hazard warning systems. Similarly, connected sensors can provide insights into ecosystems and biomes, including protected areas and endangered species.	**Real-time monitoring of marine conditions** Fujitsu, Microsoft and Digicel under the Institute of Marine Affairs (IMA)'s initiative built IoT-connected sensors, specifically targeted to measure changes and the impact of oil spills in real time. This provides the information and insight to improve response times to local spills, and attribute accountability for incidents.[49]	**All elements of the natural world are precisely monitored to allow governments, NGOs, companies and citizens to allow direct intervention, or further analysis and decision making**
Populations, people, and activities Digital technologies allow the continuous observation and monitoring of humans and their activities, which can have a positive impact on the biosphere, but may also create privacy issues if not managed correctly. Particularly, IoT and digital access can be used to identify harmful behaviours, illegal activities, and irregularities in protected areas. Live video monitoring, streaming through the cloud and IoT-enabled cameras, can be used to detect multiple types of illegal activities, such as dumping around waterways, poaching, and illegal fishing. Similar technologies can be used to track areas with endangered species as a means to ensuring they follow normal migration patterns, and protect populations against poaching.	**Early warning system for poaching activity** Cisco partnered with Dimension Data to create a solution that would protect rhinos from poaching. Their project Connected Surveillance helps identify suspicious activity, protecting the rhino without disturbing its natural state of being. The solution uses a combination of technologies—WiFi, scanners, CCTV, and sensors—to provide early warnings about intruders. Rangers are then able to act as soon as the perimeter of a protected area is breached.	**Animal populations are precisely mapped and tracked to inform conservation efforts; human behaviour that damages the biosphere is observed to inform intervention and prevention**
Organisations and supply chains Digital technologies, such as digital access and blockchain, create greater transparency, make data management more efficient and improve accountability of organisations. Digital solutions such as RFID, watermarks, and quick response codes can be deployed to track the natural resources flowing from the biosphere. Organisations are beginning to experiment with peer-to-peer networks to implement traceability systems. Recording data on a consistent basis on the ledger allows closer monitoring of medical supplies following natural disasters, as well as food production and delivery.[50]	**Tracking of fish catches to ensure they are of sustainable origin** Provenance has piloted the "bait to plate" approach for managing fish catches. It facilitates the registration of local fishermen and catches through text messages on a blockchain, up to the point of purchase from consumers. At purchase, the fish's origin is indicated through smart stickers and a mobile application.[51]	**All supply chain actors accruing benefits from the biosphere incorporate digitally-enabled tracking systems to ensure sustainable sourcing**

Analyse, Optimise & Predict

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030...
Process Optimisation Adaptive AI algorithms, sometimes in combination with IoT sensor data, have the ability to optimise the efficiency of water and energy utilities, thus preserving two important elements of the biosphere: climate and fresh water.[52] Algorithms drive these efficiencies by collecting and assessing large amounts of data from millions of IoT sensors and a range of factors such as weather, utility demand, performance, and prices.[53] Rapid analysis of this data enables algorithms to provide real-time recommendations to optimise resource allocation, efficiency, and water and energy usage.[54]	**Utility efficiency and cost savings** The smart grid provides suppliers with real-time information on electricity consumption. Suppliers then use demand-side management strategies to shift end-user demand to times where energy can be supplied more efficiently, or by renewables. It is estimated the smart grid could directly provide a 12% reduction in CO2 emissions in the energy sector in the US by 2030.[55] For consumers, being able to analyse their energy use can also lead to behavioural change to reduce emissions.	**All utility providers adopt AI and IoT technologies to optimise water and energy efficiency, combatting climate change and preserving water**
Socio-ecological analysis and targeting Trained AI algorithms can be deployed to target emerging problems in the biosphere by analysing vast amounts of topographical and geographical data as well as satellite and drone imagery. This technology has been applied in a wide variety of ways including to enable precision conservation by mapping land and ocean terrain[56]; to identify species on the brink of extinction, to identify illegal fishing[57]; and to assess the extent of damage post disaster to ensure that aid goes to those who need it the most.[58]	**Mapping the distribution of ocean plastic** Ellipsis uses the latest in data scanning technology, drone surveying, and machine learning to gather robust and accurate data of plastic pollution around the world. Their scalable approach allows them to compare different ocean regions, and build up a detailed and accurate heat map of the worst areas of plastic pollution, as well as their change over time. Using the heat maps, they offer advice on where to target clean-up and prevention resources more efficiently - saving thousands of hours of manpower and dramatically reducing levels of ocean plastic.[59]	**NGOs integrate smart algorithms into their conservation efforts, enabling precision conservation and rapid targeting of problem at the source as they emerge**
Rapid data analysis for innovation AI, when combined with genomics, robotics and gene editing, can be deployed to analyse biological assets[60], e.g. metabolic pathways, animal and plant genes, and the chemical or material products they produce. [61] This analysis can then be used to develop 'bio-inspired innovations' that can be applied to protect and improve the biosphere. As biological assets are often found in developing countries, innovation of this type can deliver both ecological and economic value simultaneously. [62]	**Catalysing bio-innovation** The Amazon Third Way initiative is developing the Earth Bank of Codes, a project to create an open digital platform that registers nature's assets, records their spatial provenance and codifies the associated IP rights. An AI-driven "biological search engine" will build on the Bank to allow users to understand more fully the planet's web of life, optimising scientific discovery, catalysing bio-inspired innovations and improving conservation outcomes by creating new sources of economic value for the region where the asset is registered.[63]	**Pharma and consumer-packaged goods companies use bio-innovation to create new types of medicine and sustainable products, with bio-assets creating new sources of value for countries**
Future state prediction AI-enabled predictive models use complex historical and current datasets to predict natural events or human activities that impact the biosphere, in both the short and long term. This technology is used to make predictions across a range of issues, from freshwater withdrawals and areas of water scarcity to instances of poaching or illegal fishing. For climate change specifically, AI is improving the prediction of extreme events and their potential impact, enabling proactive disaster management.[64] AI is also enabling the prediction of the future effects of climate change over the longer term and on a larger scale, through improved understanding of cause and effect.[65]	**Tsunami prediction and risk reduction** Fujitsu, The Earthquake Research Institute at the University of Tokyo, the International Research Institute of Disaster Science (IRIDeS) at Tohoku University and the City of Kawasaki are collaborating on a project to advance the utilisation of disaster-prevention technologies, including AI and supercomputers. The organisations plan to use these technologies to predict tsunamis and take pre-emptive measures aimed at mitigating tsunami disaster risk in the Kawasaki coastal zone.	**Climate scientists can predict natural hazards with precision, and have a deep understanding of climate change cause and effects, enabling better policy decisions and allowing organisations to understand and manage climate risk**

Augment & Autonomate

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030...
Augmented humans N/A	N/A	N/A
Autonomous processes and machines Through sensors and AI, autonomous processes and machines can understand what is happening in the biosphere, use that data to make decisions, and then intervene to achieve a set of defined objectives. This technology can be applied across the biosphere, for example, to clean up ocean[66] and river[67] pollution, to provide irrigation where it is needed[68] or to plant trees in deforested areas.[69] The increased efficiency of automated processes over other forms of slower, more error prone activity also contributes to the protection of the biosphere. Efficiency gains can reduce emissions from human activity, for example through smart street lighting[70] and traffic management[71]. See SDG9 for manufacturing, SDG2 for agriculture and SDG11 for cities.	**Autonomous machines assist with ocean clean-up** Founded in 2013, The Ocean Cleanup is a non-profit aiming to rid the world's oceans of plastic through a fleet of independent clean up systems best described as a 'floater and skirt coastline'. The systems transmit and receive data through sensors, radar and satellite communications and are guided by algorithms to target optimal areas for collecting plastic waste that can then be extracted and recycled. Starting with the Great Pacific Garbage Patch, the Ocean Cleanup aims to remove 90% of ocean plastic by 2040.[72]	**Governments, NGOs and companies with large environmental impacts deploy intelligent autonomous machines to prevent degradation and to clean up and restore elements of the biosphere**

SDG 13

Take Urgent Action to Combat Climate Action

SDG 13 focuses on taking "urgent action to combat climate change," and groups targets into three categories of actions: reduce CO2 emissions (target cluster 1: 13.2), ensure resilience to natural hazards (target cluster 2: 13.1), and improve global capacity to ensure all populations can adapt to and mitigate the impacts of climate change (target cluster 3: 13.3). It is notable that whilst SDG 13 calls for the integration of climate change measures into national policies, it is actually a range of targets throughout other SDGs which specify the mechanics and sectors by which CO2 will be reduced. However, given the centrality of these SDGs to abating climate change and protecting the biosphere, an overview is also presented here.

The impact of anthropogenic activity is being felt intensely throughout the biosphere as we enter a period of unprecedented and rapidly accelerating change. This change, caused by the rising greenhouse gas emissions which drive global warming, is increasing the numbers of extreme weather events and escalating levels of chemical and air pollution.[73] Humans have breached global planetary limits on climate change,[74] and as a result are now beginning to see devastating impacts throughout society and the economy.[75]

Digital technologies will enable a reduction in CO2 emissions as they allow the optimisation of a range of energy or input intensive processes, from agriculture to the electricity grid to manufacturing. Digital technologies also contribute to ensuring hazard resilience, enabling populations to be warned of impeding disasters, and alerting authorities of when disasters are likely to unfold. Improving capacity to act against climate change is driven by improved long-range forecasting, and also through improving public understanding and education on the issue.

In the future, the wider introduction of 'smart' systems in cities and the electricity grid will further reduce emissions through autonomously controlling and optimising the allocation of resources for maximum efficiency. Improved short-term prediction of disasters is likely to improve resilience to climate-related hazards, and improved long-range forecasting to more clearly inform where there are capacity gaps.

Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Reduce CO2e emissions					
13.2 / Multiple: 2.4, 7.2, 7.3, 8.4, 9.4, 11.2, 11.6, 12.2, 12.3, 12.5, 15.1 cross-sectoral efforts to reduce CO2e emissions	3	4	1	2	Use of teleconferencing reduces the need to travel, and has saved Vodafone more than 5,000 tonnes of carbon annually per year since committing to the technology[76]
2. Ensure resilience to natural hazards					
13.1 Strengthen resilience to natural climate-related natural hazards	1	2	3	4	Machine learning improves the ability of climate models for both long-range forecasting[77] and short-term hazards, e.g. storm path forecasting, bringing insight to local levels
3. Improve education, awareness and capacity to act					
13.3 Improve human / institutional capacity to mitigate and adapt	2			1	AI improves long-term climate model projections, increasing the accuracy of climate change projections versus the average model prediction, which is the default practice in climate science, and advising on potential actions [78]

1	2	3	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate

SDG 6

Clean Water and Sanitation

SDG 6 focuses on the conservation of water systems. Core to the goal, is the attainment of clean and safe WASH (water, sanitation and hygiene) services for all (target cluster 1: 6.1 and 6.2). This can be achieved by reducing freshwater pollution and conserving ecosystems (target cluster 2: 6.3 and 6.6), efficiently managing freshwater reserves (target cluster 3: 6.4 and 6.5) and supporting developing countries and local communities with WASH-related efforts (target cluster 4: 6.A and 6.B).

Challenges to meet SDG 6 remain acute. Demand for water is intensifying, and the water resources currently used are not managed effectively in order to provide clean fresh water in many areas of the planet. As it stands, over 80% of wastewater is discharged into water bodies without pollution treatment, hindering progress in ensuring universal access to clean water.[79] Progress made against SDG 6 will help protect the natural environment, support the growing global demand for food, lift communities out of poverty, and reduce deaths caused by waterborne diseases.[80]

Digital technologies contribute to clean water and sanitation through the monitoring and tracking of resources and through spreading key messages on best hygiene and sanitation practices and connecting and monitoring water points. Monitoring and tracking freshwater supplies is also critical to reduce freshwater pollution and conserve ecosystems. Efficiently managing these resources is also enabled by more advanced analysis of water-use efficiency.

In the future, there are two key opportunities for digital technology to further contribute to SDG 6. First, existing and innovative forms of communication will be likely required to both improve global hygiene practices and encourage greater water-use efficiency. Second, to move closer towards a circular water economy, advanced and autonomous water management systems will play an increasing role, particularly in urban centres.

Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Clean water and sanitation for all					
6.1 Achieve universal access to safe and affordable drinking water	2	1	3		Sensors installed in hand pumps can reduce the downtime of water pumps caused by failures or empty wells[81]
6.2 Achieve access to adequate sanitation for all, especially women and girls	1	2	3	4	Oxfam and UNICEF developed a platform that provided access to surveys and interactive learning modules to spread hygiene best practice in remote communities[82]
2. Reduce freshwater pollution and conserve ecosystems					
6.3 Improve water quality by reducing pollution, treating wastewater and minimising dumping		1	2		AT&T and Ericsson installed IoT sensors in the Chattahoochee river to allow local organisations to monitor the water quality along the river remotely and in real time[83]
6.6 Protect and restore freshwater-related ecosystems (wetlands, rivers, lakes etc.)		1	2		Descartes Labs developed a platform to analyse satellite imagery of water bodies to predict where water scarcity may emerge; this can be used to guide conservation efforts[84]
3. Efficiently manage freshwater reserves					
6.4 Increase water-use efficiency across all sectors and address water scarcity	4	1	2	3	Suez has developed a smart water meter that both tracks household consumption and provides tips to consumers to manage their water consumption[85]

1	2	3	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate

14 LIFE BELOW WATER

SDG 14

Life Below Water

The ocean is vital to all life on Earth, and has multiple provisioning, regulating and supporting functions. The ocean supports our resilience to climate change, the security of our food supply and our ability to trade. Human activities need to be carefully managed to maintain the health and productivity of the ocean's ecosystem.

To achieve this, the targets underneath SDG 14 are aimed at: reducing marine pollution and improving ocean health (target cluster 1: 14.1, 14.3), enhancing the conservation and sustainable use of oceans and marine resources (target cluster 2: 14.2), and ending illegal fishing, over-exploitation of fish stock and encouraging sustainable fishing practices (target cluster 3: 14.7, 14.4 and 14.B).

The oceans cover 71% of the Earth's surface and contain 97% of the Earth's water.[86] But, they are struggling. Marine pollution is worsening due to the global dependency on plastic, oil and fertiliser, and inadequate recycling facilities. The proportion of fish stocks within biologically sustainable levels is declining, which is particularly problematic for the significant percentage (10-12%) of the world's population who depend on fisheries and aquaculture for their livelihoods.[87] Failure to protect the oceans will not just affect these livelihoods, but the health and well-being of all those who depend on the oceans for marine resources and the natural environment.

Digital technologies will have a key role to play in reducing marine pollution by improving the monitoring and tracking of ocean acidification, as well as analysing data to map the areas of greatest concern and predict future challenges. Connecting individuals to others through social media, and connecting them to information and knowledge on ocean conservation issues will continue to encourage a greater global interest and information sharing in preserving the ocean. Free, digital advice to empower and educate fishing groups will help encourage sustainable fisheries, and vessel tracking through satellite data and AI will help reduce illegal fishing.

The most promising use cases for the future include the deployment of real-time monitoring to improve the speed of responses to marine pollution and debris incidents and to improve the understanding of marine conditions and ocean health. As information becomes more accurate and accessible, humans will be able to take better care of the oceans. Finally, as illegal fishing practices become more closely and automatically monitored, marine biodiversity can get closer to sustainable levels.

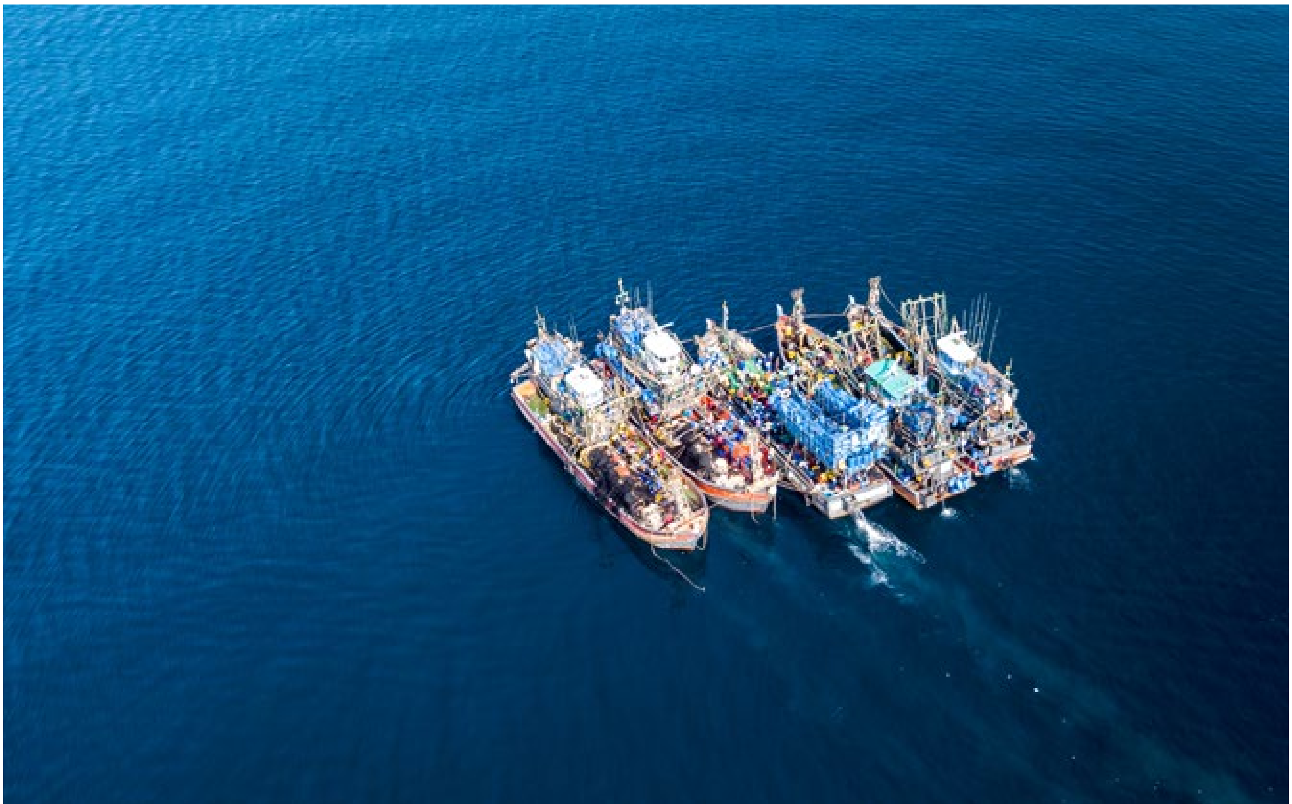
Target level impact function mapping

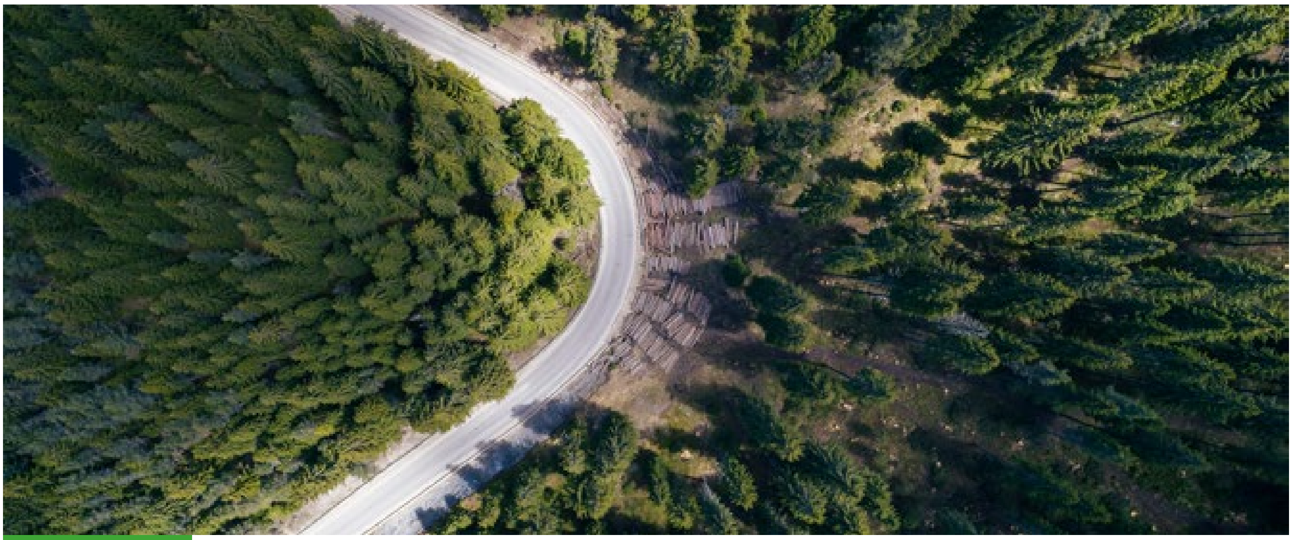
TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Reduced marine pollution and improved ocean health					
14.1 Significantly reduce all marine pollution, including plastic debris and nutrient pollution	3	2	1	4	Fujitsu, Microsoft and Digicel collaborated to deploy IoT-connected sensors to monitor oil spills[88]
14.3 Minimise and address the impacts of ocean acidification	3	1	2	▨	Ocean Networks Canada has been using IoT sensors to gather data on ocean heath[89]
2. Enhance the conservation and sustainable use of oceans and marine resources					
14.2 Sustainably manage and protect marine and coastal ecosystems	1	3	2	▨	Nature Conservancy created an AI-powered web application mapping natural resources for their Mapping Ocean Wealth project[90]
3. End illegal fishing practices					
14.4 End overfishing, illegal and unreported fishing, and all bad fishing practices; restore fish stocks	2	3	1	4	Ocean Mind track fishing vessels and illegal fishing activities using satellites and artificial intelligence[91]
14.7 Encourage sustainable fisheries, aquaculture and tourism in SIDs/ LDCs	1	2	3	▨	Nature Conservancy has built FishPath to educate on fisheries management[92]
14.B Provide access for small-scale fisheries to marine resources and markets	1	2	▨	3	Dock to Dish by the United Nations Foundation built a platform to connect small-scale fisheries to their nearest communities[93]

1	2	3	4
MOST			**LEAST**

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate





15 LIFE ON LAND

SDG 15

Life on Land

Healthy ecosystems protect the planet and sustain livelihoods. Terrestrial ecosystems such as forests, wetlands, mountains and drylands, are the main source of vital environmental resources and 'eco-services' including clean air and water, biodiversity, and for mitigation of climate change and natural disasters. To protect Life on Land, the core of SDG 15 aims to conserve, restore and sustainably manage terrestrial biomes, particularly forests (target cluster 1: 15.1, 15.2, 15.3, 15.4, and 15.5). To support this, the SDG calls for the prevention of extinction, poaching and trafficking of species (target cluster 2: 15.5 and 15.7), and to conserve biodiversity and ecosystems and combat invasive species (target cluster 3: 15.8, 15.9 and 15.A). Finally, it promotes access and sharing of genetic resources (target cluster 4: 15.6).

More than 75% of Earth's land areas are substantially degraded, having become deserts, polluted or deforested, undermining the well-being of 3.2 billion people.[94] Progress made against this SDG will improve the stability of livelihoods and food security, as many of those currently living in extreme poverty live in forest and savannah areas.

Digital technologies will improve the conservation, restoration and management of terrestrial biomes. Monitoring and tracking terrestrial ecosystems is critical to understanding their current status, and analysis and prediction allows for effective interventions, for example through the remote detection of illegal activities. Monitoring and tracking species through remote sensors gives indications of population health, and the presence of poaching. Image recognition expedites the collection of conservation data.

In the future, there will be full visibility into the status of terrestrial biomes and ecosystems on a global scale through the accurate collection and analysis of data. The opportunity exists to monitor the condition and behaviours of environmental habitats and species automatically through connected sensors and AI. Real-time, relevant data will empower humans to restore and protect life on land.

Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Conserve, restore and sustainably manage terrestrial biomes					
15.1 Conserve, restore and sustainably use terrestrial and inland freshwater ecosystems	3	1	2	4	The Food and Agriculture Organization (FAO) and the National Aeronautics and Space Administration (NASA) developed Collect Earth, giving visibility to terrestrial landscapes through Google Earth[95]
15.2 Sustainably manage all forests, halt deforestation & restore degraded forests	3	2	1	4	Microsoft and SilviaTerra built a solution to measure changes in forests using cloud and machine learning[96]
15.3 Combat desertification, and restored degraded land and soil	3	2	1	4	European Space Agency (ESA) has been using satellite imaging to monitor land degradation over time[97]
15.4 Conserve mountain ecosystems, including their biodiversity	3	1	2	4	EUBrazilOpenBio is an open access platform offering a suite of tools used to further understand biodiversity[98]
2. Prevent extinction, poaching and trafficking of species					
15.5 Reduce the degradation of natural habitats & prevent species extinction	3	2	1	4	Huawei partnered with Rain Forest Connection to build AI-enabled sound recognition systems to detect (in real time) when species are under threat[99]
15.7 End poaching of flora and fauna and address supply & demand of illegal wildlife products	2	1	3	4	Vulcan developed Earth Ranger, a software platform designed to collect information on protected areas
4. Promote access to and sharing of genetic resources					
15.6 Promote equitable sharing of the benefits arising from utilising genetic resources	2	3	1		Earth Bank of Codes is building a data repository of biological assets to be used for bio-based economic development[100]

1	2	3	4
MOST			**LEAST**

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C Connect & Communicate
M&T Monitor & Track
AOP Analyse, Optimise & Predict
A&A Augment & Autonomate

System interactions

Achieving the biosphere-focused goals is likely to incur some trade-offs for the economy and society, potentially constraining economic growth and the reduction of social inequalities. For example, conserving large areas of intact virgin forest and biodiverse regions in developing regions is essential for the preservation of the biosphere,[101] yet may restrict populations in developing countries from extracting natural resources and creating arable farm land, depriving them of the same opportunities previously afforded to wealthier nations.[102] Likewise, restrictions on fishing in marine and coastal ecosystems may restrict economic activities, limiting economic growth and job creation.

More broadly, the decarbonisation of the global economy needed to achieve SDG 13 will involve major transformations, toward re-centring industries around renewable sources of energy. Fossil-fuel dependent business models need urgent transformation, and large-scale upfront investment will be required from both public and private sector stakeholders. Central to this investment must be the deployment of digital technologies for the greater good.

Negative externalities: impact of digital technologies

Unless there is a shift to a circular, renewable-powered economy, the widespread adoption of digital technologies in a traditional, linear economy will create emissions and e-waste that will contribute to the degradation of the biosphere. The emissions created through the deployment of digital technologies such as blockchain must be compared and assessed with the savings digital technologies create to ensure there is no intensification of climate change. E-waste can leach into waterways and ecosystems, increasing the levels of toxins in the environment and impacting terrestrial and marine life. Moreover, digital technologies are likely to drive economic growth, which will subsequently lead to increased resource extraction, emissions and consumption that will have negative impacts on the biosphere.

As digital technologies are increasingly deployed to improve management of the biosphere, attention must be given to their ‘in situ’ potential negative impacts. For example, IoT sensors are required to monitor and track ecosystem changes in atmosphere, temperature, and species and to provide data to predict future states. However, a proliferation of IoT sensors would create further e-waste, as would the uptake of solar-panels required to achieve SDG 13. For example India, a country where the uptake of solar-panels has been successful, is likely to deal with 1.8 million tonnes of solar panel e-waste recycling by 2050.[103] The importance of implementing circular material flows is apparent.

Moreover, as natural resources become increasingly scarce, digital technologies which measure and track commodities could also become a means of state or corporate control, further restricting indigenous populations from accessing resources they have traditionally depended on and raising issues of civil liberties.

Despite the potential challenges of implementing the biosphere SDGs, digital technologies will play an essential part in the overall attainment of the SDGs, acting as a stable foundation for shared and continued prosperity. Every human has some inevitable impact on the biosphere, but it is not inevitable that this impact will be perpetually harmful. Using the SDGs as a guide, partnerships across civil society, industry and government must form to take urgent action to mitigate our impact on the environment, and to bring it once more below the safety of the ecological ceiling. The UN reports that there are only 11 years left to prevent irreversible damage from climate change; the time to act is now.[104]

2.2
SDG impact

Society

A healthy biosphere lays the foundation for equitable and peaceful societies, and in turn, such societies lay the foundation for inclusive economic growth.

Society is the aggregate of people living together in a more or less ordered community. The 2030 Agenda places a significant focus on creating an equitable, peaceful and sustainable global society through tackling systemic social challenges such as poverty, hunger and conflict.

These challenges are present throughout the world, and are on the rise due to a combination of rapid population growth, climate change urbanisation, globalisation and uneven social development.[1] These issues act as barriers to achieving sustainable development where "no one is left behind", and a society where all human beings have equal opportunities to fulfil their potential with dignity.

Achieving an equitable, peaceful and sustainable society will depend on ensuring universal fulfilment of basic human needs, access to sustainable amenities and utilities and promoting societies and governance systems that are fair and just. A healthy biosphere lays the foundation for such a society, and in turn, equitable and peaceful societies lay the foundation for inclusive economic growth and effective partnerships for sustainable development.

Fulfilment of basic human needs: SDGs 1, 2, 3 and 4

Central to achieving an equitable society is ensuring that basic human needs are met for all people, everywhere. Core to this, is the eradication of poverty (SDG 1) in all its forms and dimensions, an "indispensable requirement" for sustainable development.[2] Poverty is multidimensional, comprising of low income, but also hunger, and poor health and educational outcomes; its eradication relies on fulfilling other basic human needs: ending hunger and malnutrition (SDG 2), and achieving universal access to both healthcare (SDG 3) and education (SDG 4).[3] Achieving these goals and creating a world free of poverty, hunger, and disease, sets the precondition for fair societies where all human beings can thrive.[4] Today around 9% of humanity is trapped in extreme poverty, concentrated in sub-Saharan Africa and parts of Asia and Latin America. This represents over half a billion people who are prevented from fully participating in society. [5]

Digital technologies can improve health and educational outcomes for all by providing new channels to services for the previously unconnected, as well as by optimising delivery methods and mechanisms. Digital technologies can assist with targeting areas of hunger or poverty more efficiently and effectively. Basic digital access fosters financial inclusion and education, and has a large positive correlation with poverty uplift. However, some of the most vulnerable do not have such access, and the growing 'digital divide' must be tackled going forward, so that digital technologies can support the delivery of critical services to those who need it most.

Sustainable amenities and utilities: SDGs 7 and 11

Societies rely on equal access to sustainable utilities and amenities. This includes access to modern energy services (SDG 7), safe drinking water (SDG 6 – included within the biosphere) and other amenities crucial to the functioning of cities and communities (SDG 11), including public transport, housing and green space. All of these services must be managed sustainably, in ways that protect or even enhance the biosphere. Urbanisation and population growth are currently exerting significant pressure on these amenities, jeopardising their sustainability and exacerbating social exclusion of groups without access.[6]

Digital technologies can drive large-scale efficiencies and energy savings in the provision of utilities and building management, and can optimise and co-ordinate the provision of such services in an urban setting. They can enable digital payments for such services, and help individuals use and engage with services such as public transport, in an efficient and inclusive way.

Fair and just society: SDGs 5 and 16

In addition to providing access to basic human necessities and amenities, societies must be fair, just and stable.[7] This involves promoting the rule of law, good governance and equal access to justice (SDG 16) throughout all societies, as well as ending corruption, violence and crimes, particularly against women and children (SDGs 16 and 5). Societies must promote equal opportunity and non-discrimination against women (SDG 5), as well as against all races, abilities and marginalised groups. Realising the equality and empowerment of women in particular, will be crucial to achieving the SDGs. Sustainable development is impossible to achieve in societies where equal human rights and access to opportunity are denied.[8] Conflicts over natural resources or religious or political ideologies often exacerbate discrimination and human rights violations.

Digital technologies can connect and empower marginalised groups, as well as provide access to justice and legal information and systems and biometric identities. They can be deployed to monitor threats to society, such as serious organised crime or human trafficking, in order to catch instigators and prosecute them. Digital technologies can augment and simulate situations for audiences, to help populations sympathise with each other, accelerating progress towards peace.

Looking forward

If left unchecked, population growth and urbanisation may further negatively impact the biosphere, through increasing demand for and depletion of natural resources. Inequalities of access to human necessities, utilities and amenities can also affect the economy and shared prosperity, through widening the gap between the rich and the poor, and stagnating industrialisation in developing countries. Therefore, societies must ensure they grow sustainably and manage amenities and utilities in a way that does not further damage the biosphere. They must also become more fair and peaceful, and ensure that all basic human needs are met, so that all people are able to live with dignity, and participate and positively contribute to the economy.

Digital technologies will have a catalytic role to play, although their development and deployment must be carefully managed and distributed to achieve maximum impact. A widening digital divide could prevent the most vulnerable from accessing the services and information they need. Urban services and amenities that are increasingly reliant on digital technologies become more vulnerable to cyber attacks, putting citizen privacy and safety at risk. Digital technologies can also be used maliciously, through spreading radicalism and extremist sentiment, and instigating acts of terrorism. These externalities, if not mitigated, put the peacefulness and inclusivity of society at risk.

SDG Progress overview

Significant progress has been made towards some of the societal targets, particularly those that involve provision of basic human necessities and those that have already been impacted by digital technologies, such as agricultural productivity and energy efficiency.

However, other targets that would ensure sustainable societies and improve persistent inequalities, remain in stagnation or are tracking in the wrong direction. For example, the provision of renewable energy, protection of the poor and vulnerable, accessible healthcare and women's empowerment have not progressed fast enough, and require accelerated action.

Fulfilment of basic human needs

1 NO POVERTY

- ✓ **Eradicate poverty:** the share of the world population living in extreme poverty declined to 8.6% in 2018, down from 16% in 2010 and 36% in 1990. However, climate change and conflict over resources may reverse this trend[9]
- ✓ **Ensure equal rights to basic services:** access to basic resources, including electricity, clean cooking fuels and improved water sources, is steadily increasing, although 30% of the global population do not hold a bank account[10], and 70% do not have access to land registration[11]
- ✗ **Ensure protection and resilience of the poor:** disasters often exacerbate poverty. From 1998 to 2017, 90% of deaths due to disasters were in low- or middle income countries, and climate change is increasing the frequency of such events. Additionally, in 2016, 55% of the world was not covered by any social protection cash benefits[12]

2 ZERO HUNGER

- ✓ **Improve agricultural productivity:** agricultural productivity has been increasing steadily year on year, with a global value add per worker of $3,540 in 2016, compared to $1,410 in 1991[13]
- ✗ **End hunger and malnutrition:** after a prolonged decline, world hunger has been on the rise for three years, with undernourishment rising to 10% in 2017[14] and expected to increase to 20% by 2040[15]
- ✗ **Promote sustainable agriculture:** agriculture accounts for 70% of global freshwater withdrawals.[16] Global nitrogen fertiliser usage has increased by 800% over the past few decades[17]

3 GOOD HEALTH AND WELL-BEING

- ✓ **Improved health outcomes:** maternal and under-five mortality ratios have fallen 37% and 49% respectively since 2000.[18]. Deaths by communicable diseases, such as HIV, have also been declining. However, deaths by non-communicable diseases remain relatively flat, and are expected to increase[19]
- ✗ **Better, more accessible healthcare:** coverage of essential health services has been slowly increasing, however, at least half of the global population still does not have access to essential medical care, and nearly 40% of all countries have less than 10 medical doctors per 10,000 people[20]

4 QUALITY EDUCATION

- ✓ **Access to quality education:** globally, the participation rate in early childhood and primary education was 70% in 2016, up from 63% in 2010. Enrolment rates in tertiary education are also increasing[21]
- ✗ **Build digital skills and lifelong learning:** since 1980, global literacy and numeracy rates have been steadily increasing, ranging at about 85% and 90% respectively, with rates increasing since 2015. [22] However, digital literacy is also necessary for participation in a digital society, and rates remain far lower than basic literacy[23]
- ✗ **Inclusive access to quality education:** most of the 262 million children that lack access to education today belong to vulnerable groups[24]

Sustainable amenities and utilities

7 AFFORDABLE AND CLEAN ENERGY

- ✓ **Increase access to energy:** access to electricity rose from 83% in 2010 to 89% in 2017. However, some 840 million people around the world are still without access to electricity[25]
- ✓ **Improve energy efficiency:** energy intensity (defined as the global total primary energy supply per unit of GDP) is declining and fell 10% between 2010 and 2016. However, the estimated rate of improvement in 2018 (1.3%) is below the 2.7% required to meet the goal by 2030[26]
- ✗ **Increase provision of modern, sustainable energy:** only 17.5% of final energy consumption is from renewables, which needs to be rapidly increased to meet the 2030 Agenda[27]

11 SUSTAINABLE CITIES AND COMMUNITIES

- ✗ **Sustainable and inclusive urbanisation:** between 2000 and 2014, areas occupied by cities grew 1.28 times faster than their populations, with large environmental sustainability repercussions[28]
- ✗ **Access to safe & affordable urban amenities:** the proportion of urban residents who have convenient access to public transport remains low, and absolute number of people living in slums has increased from 807 million to 882 million[29]
- ✗ **Reduce environmental impact of cities:** In 2016, 91% of the world's population breathed air that did not meet the WHO's air quality guidelines for particulate matter, the majority of whom lived in cities[30]

Fair and just society

5 GENDER EQUALITY

- ✓ **End harmful practices:** child marriage has continued to decline, largely driven by progress in South Asia. Female genital mutilation is also declining; prevalence declined by 25% between 2000 and 2018[31]
- ✗ **Better access to sexual and reproductive health:** only 57% of women aged 15 to 49 who are married or in a union make their own decisions about sexual relations and the use of contraceptives, although access to contraceptives has been slowly increasing[32]
- ✗ **Promote economic empowerment and independence:** women continue to be largely underrepresented, with 24% representation in national parliaments and 27% in managerial positions[33]

16 PEACE, JUSTICE AND STRONG INSTITUTIONS

- ✓ **Inclusive societies:** despite the enactment of freedom of information laws and policies by 125 countries in total, including 31 since 2013, their implementation is a challenge. At least 1,019 human rights defenders and journalists have been killed in 61 countries since 2015[34]
- ✗ **Peaceful societies:** since 2005, the number and intensity of armed conflicts has risen. Intentional homicides have risen slightly, whilst violence against women and children remains fairly constant[35]
- ✗ **Just societies:** an estimated 5.1 billion people worldwide, two thirds of the world's population, continue to live outside the protection of the law[36]

Impact of digital technologies

Digital technologies, if carefully managed, have an important role to play in ensuring sustainable and equitable societies. All four impact functions will be critical in delivering progress against the societal SDGs. However, three major opportunities have been identified: i) continuing to connect the unconnected and vulnerable to basic digital access, to enable financial inclusion, education and women's empowerment; ii) taking advantage of ML/AI and computing power to accelerate drug and crop development, and to assist in understanding complex datasets in order to improve targeting of areas of crime, poverty and hunger, education and health outcomes, and disaster impact; and iii) autonomous machines to transform agriculture, and city utility, service and security provision. The impact generated by specific sub-functions is explored later in this chapter.

Connect & Communicate

Digital technologies provide a platform for raising global awareness of societal issues. Pressing issues affecting humanity receive widespread and immediate attention through social media and new digital channels, ultimately inspiring greater action and commitment to change. New digital channels are also being used to share targeted messages covering topics such as farming advice, health check-up reminders and emergency alerts. Business models are being transformed, as digital networks and digital marketplaces increase the ability to exchange knowledge, practices and assets - opening global economic participation to more cohorts of society.

Monitor & Track

As populations and human activities grow, they place growing stress on natural resources. As digital technologies are deployed to monitor human usage of basic services, such as energy and water, there is greater opportunity to improve efficiency in both consumption and supply. Digital solutions can further be utilised to monitor harmful human activity, such as human trafficking and areas of conflict, and stimulate preventative or mitigating actions. Digital tracking systems, often stored in the cloud, ensure accountability across society, by tracking supply chains and corporate transactions and making the management of people, and of legal and public affairs, transparent.

Analyse, Optimise & Predict

Vast amounts of data can be collected, stored, analysed and assimilated to produce valuable insights to address societal issues. Machine learning based algorithms can identify errors in human-led activities and produce recommendations to optimise processes from resource allocation, e.g. teachers, to service provision, e.g. intelligent traffic services. Optimised service provision will be greatly enabled by 5G networks, and increased cloud capacity. Rigorous analysis of geographical and topographical data ensures areas and people in need are identified and supported. Increases in computing power and other digital capabilities unlock the potential of accelerated innovation and shorter development cycles, in areas of utmost importance to healthy societies, such as drug development or discovery of weather resilient crop varieties. At the same time, digital technologies enable societies to make predictions around areas of hunger or crime, transport demand or energy supply, enabling better management and prevention of unexpected outcomes.

Augment & Autonomate

Advanced digital technologies enable the active empowerment of humans by bridging the limitations of the tangible world and the potential of the digital world. For example, augmented reality applications can help people with disabilities conduct day-to-day tasks, and virtual reality can be used to simulate scenarios to aid decision making, improve city-wide disaster preparedness, and improve education and vocational training outcomes. Autonomous machines are also able to conduct various activities more efficiently than humans, including farming activities, security and patrolling duties and automatically controlling the flow and distribution of various services within smart cities, such as mobility, waste collection and utilities.

Impact projections to 2030

A selection of society-related SDG targets have been identified for modelling, selected on the basis of data availability and empirical impact evidence. The numbers presented serve as an illustration of the potential impact that digital technologies could have on achieving the Goals, giving a comparison of the business-as-usual scenario against how the outcome could look if some of the digital opportunities identified in this chapter were more widely adopted.

This does not, however, illustrate the full potential of digital technology. The estimated impacts are based on use cases which currently exist, and do not take account of potential gains from further R&D to develop new use cases. The impacts are also estimated on the basis of the world as it is today, and hence are unable to take account of the potential impact of climate change on the frequency of natural disasters, for example, and the subsequent impact on the societal SDGs. In addition, the numbers are based on expected adoption levels, and hence there is potential for much greater impact with an accelerated penetration of digital technology.

Fulfilment of basic human needs

1 NO POVERTY

Target N/A

The causes of poverty are complex, and a number of dependencies can prevent people and communities from escaping the poverty trap. Factors outside of individuals' control, such as conflict, natural disasters or access to sufficient employment can be key drivers, which are often exacerbated by limited access to education, healthcare, bank accounts, and basic services that are often taken for granted by many.

In this report, we have modelled how digital technology can impact a number of contributory factors to eradicating poverty: mMoney to provide access to bank accounts, data access to provide basic information to smallholder farmers in developing countries, and mHealth to increase access to skilled birth attendants are all accessible ways which have been shown in the academic literature to reduce poverty levels.

2 ZERO HUNGER

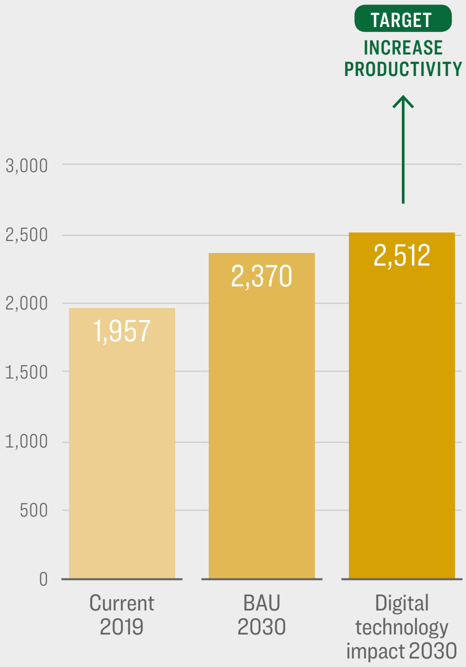
Target 2.3

Agricultural productivity

Increased agricultural productivity has the potential to improve the incomes of many smallholder farmers, particularly in developing parts of the world. Smallholder farms are defined by the FAO as farms that operate an amount of land falling in the bottom 40% of the cumulative distribution of land size at national level. Currently, global cereal yields (which make up around 45% of calories per capita per day globally and include important crops such as wheat and rice)[37] for smallholder farms are around 1,957 kilograms/hectare (kg/ha).

By 2030, based on expected changes in production and harvested land area it is estimated that yields for smallholder farmers will be around 2,370 kg/ha (21% growth). Digital technology in the form of data access can improve the productivity of smallholder farms, for instance by providing information on the weather and basic advice on how to improve practices. With no deviation in harvest area from the business-as-usual scenario, these practices could increase global yields for smallholder farmers in 2030 to 2,512 kg/ha (increase of 6% on the business-as-usual scenario).[38]

Cereal yield for smallholder farms (kilograms per hectare)



3 GOOD HEALTH AND WELL-BEING

Target 3.1

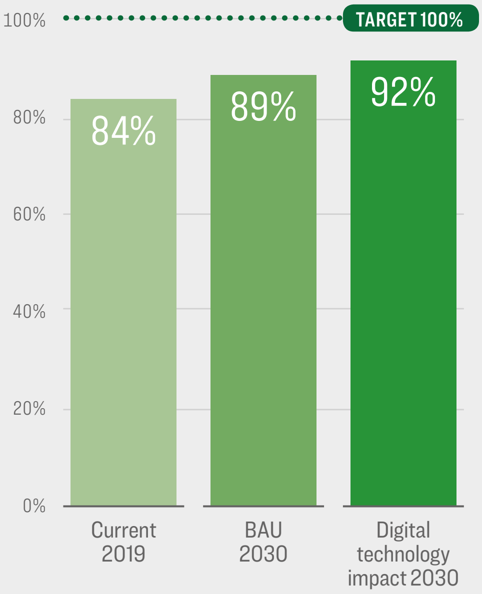
Skilled birth attendance

Historically, there is a steadily increasing trend in the proportion of births attended by a skilled health professional. The measure is important as there are multiple studies showing the link between births attended by skilled health professionals and maternal mortality ratio. For example, in Cambodia, a reduction in the maternal mortality ratio from 472 to 170 per 100,000 livebirths between 2005 and 2014 is largely attributed to increased access to skilled birth attendants (increase of 44% to 89% over the same period) and facility-based births (increase of 22% to 83%).[39]

The majority (around two-thirds) of countries achieving high rates of births attended (>99%) by skilled health professionals are in developed countries. By 2030, it is estimated that the global average of the proportion of births attended by a skilled health professional could reach 89%, from 84% today.[40]

Digital technology-enabled interventions have been shown to positively increase the proportion of births attended by a skilled health professional, for instance by sending notifications to raise awareness and provide two-way communication between mothers and healthcare providers. Targeted adoption of these technologies could increase the proportion of births attended by a skilled health professional in 2030 to 92%.[41]

Proportion of countries with 100% of births attended by skilled health professionals



4 QUALITY EDUCATION

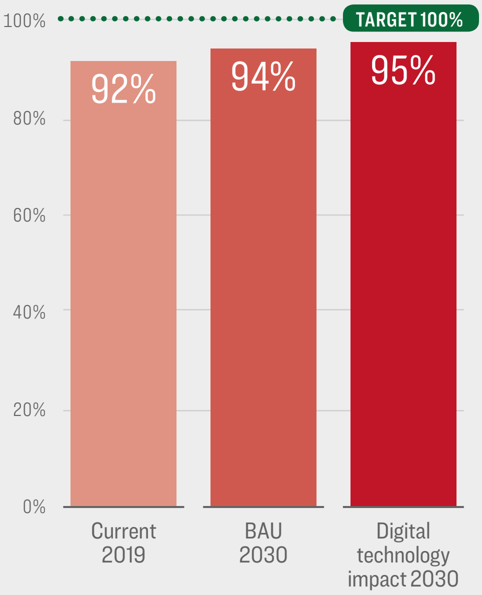
Target 4.6

Youth literacy

Today, the global youth literacy rate, defined as the proportion of the population aged 15-24 who can both read and write a short simple statement about their everyday life is around 92%. The measure is important as it gives an indication not just of the quality of education, but also of the quality of the future labour force. A study by the OECD demonstrated that the possession of higher levels of literacy could increase hourly earnings on average by around 8-10%.[42]

Globally, the application of digital technologies in the classroom such as interactive literacy software or e-readers for students could improve literacy. If historic trends continue, under the business-as-usual scenario in 2030 global literacy rates could increase to 94%. With the application of relevant digital technologies, this could further increase to 95%, which is equivalent to an additional 17 million young people attaining basic literacy skills.[43]

Literacy rate, youth total (% of people ages 15-24)



Sustainable amenities and utilities

7 AFFORDABLE AND CLEAN ENERGY

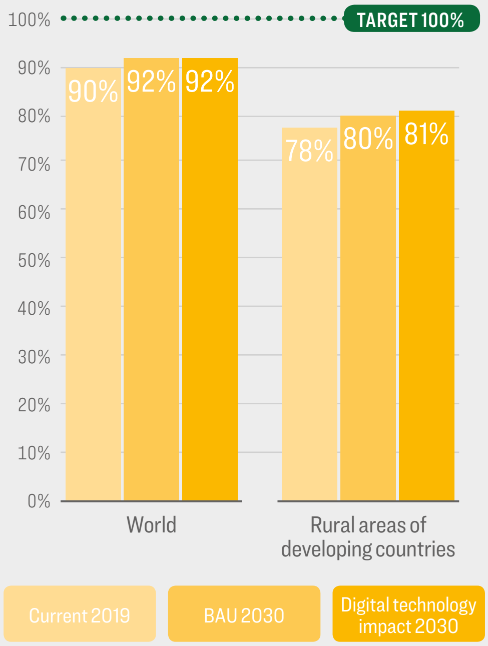
Target 7.1

Access to electricity

Reliable electricity supplies are becoming increasingly important for countries as an enabler for economic growth and community prosperity, particularly considering the use cases discussed in this report. Currently, almost 90% of the global population are estimated to have access to electricity. Focusing on rural areas of developing countries, only around 78% of the populations have access to electricity.

Targeted adoption of microgrids supported by pay-as-you-go (PAYG) models enabled by digital access has the potential to connect the unconnected to a renewable energy source. Under this digital technology adoption scenario, the proportion of the populations in rural parts of developing countries with access to electricity could increase to 81% compared to 80% in the business-as-usual scenario in 2030.[44] This is the equivalent of an additional 31 million people with access.

Proportion of the population with access to electricity



11 SUSTAINABLE CITIES AND COMMUNITIES

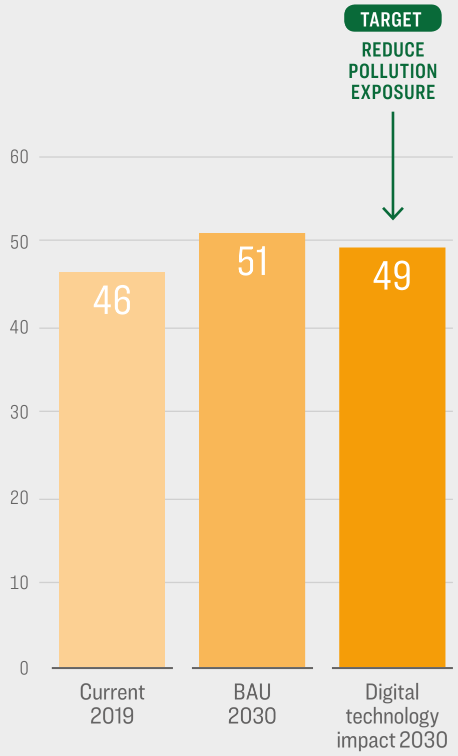
Target 11.6

Mean levels of PM2.5

By 2030, it is estimated that 60% of the global population will live in urban areas compared with 54% today.[45] Increased concentration of the population in cities has the potential to exacerbate the negative impacts of cities, such as urban emissions and levels of particulate matter, PM2.5, which is an important measure of atmospheric air pollution. PM2.5 can affect human health, and the WHO estimated that average life expectancy in the most polluted cities could be increased by approximately 20 months if the long-term PM2.5 concentration was reduced to the Air Quality Guideline (AQG) of less than an annual average of 10 micrograms per cubic metre.[46]

A large share of particulate matter in cities is caused by road transport. Today, mean global levels of PM2.5 are around 46 micrograms per cubic metre, and trends projected in the Global Burden of Disease study suggest this figure is predicted to increase to 51 micrograms per cubic metre by 2030. Intelligent road transport systems could prevent some of this increase by improving efficiency, for instance real-time traffic flow management or predictive maintenance of infrastructure. In this case, mean global levels of PM2.5 could reduce to 49 micrograms per cubic metre.[47]

Mean annual exposure to PM2.5 (micrograms per cubic metre)



Fair and just society

5 GENDER EQUALITY

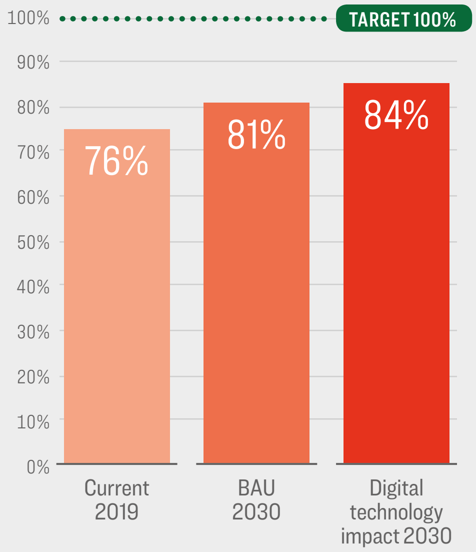
Target 5.6

Reproductive rights

Universal access to sexual and reproductive health is key to both gender equality and fair healthcare access. Across countries for which data is available (128, c.20% of developed countries and c.64% of developing countries), the proportion of women who have their family planning needs satisfied is currently around 76%.[48] By 2030, some progress is expected to have been made and the global average is projected to reach 81%. However, this figure could be improved upon with the targeted adoption of digital technology-enabled interventions such as mHealth services that provide family planning information via text message or smartphone apps to raise awareness and increase effective use of contraception.

Adoption of such interventions in the communities where the largest gains are to be made could increase the proportion of females who have their family planning needs met to 84% globally.[49] This translates to an additional 70 million women with access to sexual and reproductive health services relative to the business-as-usual scenario.

Proportion of women of reproductive age (15-49 years) who have their need for family planning satisfied with modern methods



16 PEACE, JUSTICE AND STRONG INSTITUTIONS

Target 16.9

Birth registrations

The proportion of children under 5 years of age whose births have been registered with a civil authority currently sits at 73% globally. The figure is significantly lower for some developing countries, driven by barriers on both the supply and demand side.[50] On the supply side, there are often issues with administrative infrastructure and fragmented government departments across regions. On the demand side, there is a lack of awareness of the process or difficulties in getting to the office where the registration takes place.

In some countries, the proportion of children under 5 years of age with their births registered is still below 30%.[51] Mobile birth registrations could be used to improve on this, as an affordable solution to capture this information in parts of the world where it is not commonplace to have births registered. The GSMA reports that in the first six months of a mobile birth registration pilot in Tanzania, the birth registration rate increased from 8.9% to 30.3% in the region.[52] If all countries who currently have a birth registration rate of below 30.3% were to achieve this rate of registrations by 2030 through the use of mobile birth registrations, that could mean almost 12 million more children have their births registered compared to the status quo.[53]

Connect & Communicate

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030…
Public awareness messages With improved digital access and new digital channels, important information can be communicated to huge audiences with great ease and speed. This helps to create greater global awareness of key societal issues such as malnutrition, harmful practices against women, basic and sexual health, and education. Improved awareness will lead to greater global commitment to these issues which will help to drive improvements across society.	**Human trafficking campaign** In 2018, Kyrgyzstan launched a nationwide campaign called "100 Days against Trafficking in Persons" in order to encourage youth activists and government representatives to take action against human trafficking. Over 10,000 people, including 5,000 young activists, participated through press conferences, regional launch events, live TV shows, round table discussions, bicycle marathons, outreach meetings and free legal consultations.[54] The campaign had a significant impact, reaching over 60,000 people.[55]	**Companies, governments and NGOs share truthful, sincere and engaging messages with the wider public in order to raise awareness, on important topics especially for particularly vulnerable groups**
Targeted content Digital technologies such as web platforms, SMS communications and social media channels enable targeted content to be shared with specific groups of society. For example, SMS messages are an effective way to send treatment reminders or family planning advice, legal advice, early warnings for disasters, or advice on improving farming techniques. Additionally, disease spread and outbreak can be communicated digitally to improve emergency preparedness and response.	**Farming advice to improve productivity** In Tanzania, The International Fund for Agricultural Development (IFAD) used mobile phones and emails to provide rural farmers with information and advice, as well as connections to others in the market chain. After one agricultural season, the initial investment of $200,000 contributed to a gross increase in income of participants of more than $1.8 million.[56]	**Universal digital access enables key messages, advice and warnings to be communicated directly to the people who need it most so they can be a positive force in society**
Digital marketplaces and business models Digital technologies are enabling consumers to buy and trade online, as well as to benefit from new, digital products and services. This has transformed service provision across a variety of industries central to societal development such as public sector services, healthcare, education and energy. Digitalised public sector services, such as birth registration, improve access and ease of engaging. Interactive learning software and e-reading tools provide an alternative to traditional classroom-based learning. Introduction of microgrids supported by pay-as-you-go (PAYG) models helps improve access to electricity. Agricultural marketplaces, peer-to-peer energy trading and ride sharing all work as marketplaces, connecting buyers to consumers.	**Insurance to help smallholder farmers** EIT Climate-KIC supports 'WINnERS' to offer risk management services through digital access to create sustainable supply chains from the small holder all the way to the global retailer in food production and supply chain operations. The scheme was first rolled out in 2016 in Tanzania[57] where insurance has reached 25,000 farmers, and has since expanded to other countries including Zimbabwe, Uganda and Ghana.[58] The programme has been so successful that the United Nations World Food Programme has been able to buy at least $120 million agricultural product each year from smallholder farmers.[59] This solution is addressed in more detail within the EIT Climate-KIC case study. See EIT Climate-KIC case study for more (pg 206).	**Individuals and businesses throughout society operate more effectively in a digital environment, helping to overcome various societal issues concerning accessibility, inequality and sustainability**
Digital payments and finance Digital technologies offer faster and inclusive access to finance, and help keep finances safe. For example, mMoney can empower women and can give the poor access to bank accounts they wouldn't be able to access traditionally. Digital payments facilitate direct transfers to those in extreme poverty rather than going through intermediary charities. Furthermore, blockchain enables fast, direct cash transfers for the purchasing of food helping to reduce hunger for vulnerable communities like refugees.	**Mobile savings and loans for women** 24% of married women in Tanzania are using M-Pawa, a mobile savings and loan service, without their husbands' knowledge, giving them the power to make financial decisions without having to ask their husbands for consent.[60]	**All members of society have access to basic financial services, giving them the resources they need to overcome substantial barriers they face in society**

Monitor & Track

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030...
The environment Population growth, agriculture and urbanisation are all exerting significant pressures on the environment, through increased usage of water and energy utilities, and rising levels of waste, pollution and emissions. Digital technologies, such as IoT sensors, can monitor human usage of utilities, prompting usage to be reduced. They can also monitor various parameters on farms, such as water or fertiliser usage, in order to reduce usage to minimum amount required. Finally, they can monitor urban issues such as air pollution, in order to take mitigating actions, such as closing roads.	**Smart meters improve sustainability of utilities** Smart meters allow individuals and organisations to monitor and track energy usage, prompting behavioural change. Taiwan Mobile uses remote detecting devices to monitor base station energy consumption and gather real-time information. This reduces reliance on human meter-reading (reducing travel emissions) and allows anticipation and prediction of energy consumption. So far, CO2 savings have totalled 25.4 tonnes per year, and 8,439 human meter-reading trips have been saved per year.	**Societies' utilisation of the world's natural resources and impact on the biosphere is precisely monitored, to enable optimised resource efficiency and protection of human health**
Populations, people, and activities Digitally-enabled monitoring of the condition, activities and movement of people can enable effective intervention. IoT wearables can monitor the safety of individual humans, such as changes in health, exposure to air pollution or level of alertness while driving. Digital technologies can monitor the movement of humans on a larger scale. For example, they can monitor and alert to human and arms trafficking, underage border crossings, and the spread of disease or distribution of poverty.	**Monitoring accidents and emergencies** Verizon's Real-Time Response System is designed to help first responders and their coordinators monitor emergency incidents and improve decision making. It collects data from a number of sources, using fibre-optic 4G LTE and 5G networks, to provide a real-time view of events occurring across a city. The solution can improve the response time to emergency incidents, reducing fatalities in cities by up to 10% and upholding safety in communities. This solution is addressed in more detail within the Verizon case study.[61] See Verizon case study for more (pg 214).	**Governments and service providers all deploy monitoring technologies to ensure the safety of all their citizens, and to prevent health epidemics and malicious activities**
Organisations and supply chains Digital technologies, such as digital access, QR, RFID and Blockchain, can improve the transparency of organisations and supply chains. Digital technologies enable the tracking of human necessities, such as food and healthcare products, to ensure that the supply is not disrupted or counterfeit,[62] improving access to healthcare and food, and ensuring farmers receive payment for their goods. Blockchain will also enable transparent tracking of organisations' transactions, reducing instances of bribery and fraud.	**Monitoring the supply of contraceptives** The Performance Monitoring and Accountability 2020 programme collected data on the supply of contraceptives in 11 countries. The programme was based on a unique annual data collection model capable of tracking trend data on family planning, such as contraceptive use, in order to improve the provision of sexual healthcare.[63]	**Corporates and governments alike ensure that the supply of lifesaving goods as well as organisational transactions are tracked to minimise disruptions and risk of fraud**
Individual assets and rights Blockchain can create secure and immediate registrations of legal titles and other transactions through a secure ledger. It can be used to provide individuals with digital identities and records of land titling, births, deaths and IP rights. This can lead to societal improvements, by giving vulnerable individuals and farmers land and farm titles, or enabling refugees to pay for food using digital identities. Governments can also use this technology to collect taxes and manage public services, which can improve transparency and accountability within societies.	**Securing property rights for vulnerable groups** The World Bank and the government of a Pakistani province launched a digital land titling project to transform the way the province manages land records. In just five years, the project scanned 10 million pages of old records, digitised all land records for over 55 million landowners across the province, and made the land title information easily accessible online. As a result, the time needed to complete a transaction drastically decreased from 2 months to just 50 minutes.[64]	**Governments provide all individuals, especially the most vulnerable, with secure digital identities and other basic rights, in order to enable essential public services to be delivered more efficiently**

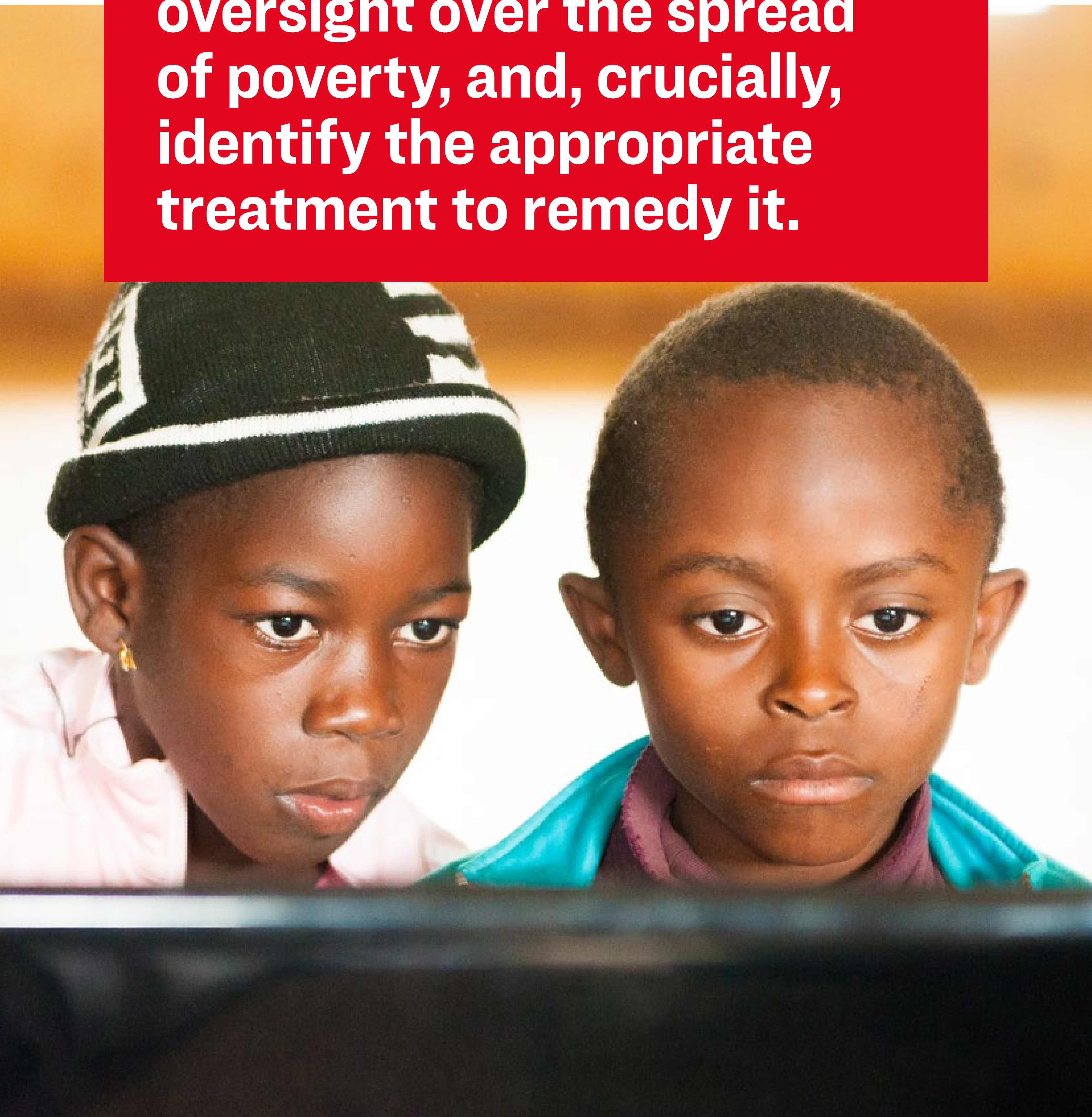
Analyse, Optimise & Predict

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030...
Process Optimisation Digital technologies, often including AI, are able to collect and assess large quantities of data from IoT sensors and other sources. Rapid analysis of this data enables real-time recommendations and optimisation of various systems implemented in society such as healthcare, education, security, utilities, cities and agriculture. For example, the technology can optimise energy efficiency, resource allocation on farms, the distribution of teachers for improved education outcomes and security staff for improved security outcomes; and also optimise various urban features such as city design, waste collection routes and intelligent transport systems.	**Intelligent parking space service** A significant proportion of urban congestion is caused by drivers searching for parking. Deutsche Telekom's Park and Joy is a digital parking service that allows users to easily find, park and pay for parking spaces. Park and Joy uses a combination of mobile data analytics and data from in-road IoT sensors to provide drivers with accurate, real-time information on available spaces, and as well as optimised routing towards their chosen space. Park and Joy reduces average distance travelled to a space by 875 metres, and CO2 / NOX emissions by 63%. This solution is addressed in more detail within the Deutsch Telekom case study.[65] See Deutsche Telekom case study for more (pg 202).	All stakeholders make use of relevant digital technologies and open source data from a variety of sources, including IoT sensors, to achieve optimised outcomes and overcome societal challenges
Socio-ecological analysis and targeting Digital technologies can analyse vast amounts of social and geographical data, as well as satellite and drone imagery, in order to identify vulnerable groups in society which need specific targeted intervention. This technology can help to address key problems facing society. For example, by mapping slums and identifying areas of poverty, officials can better direct programmes that help lift people out of poverty. The same drone and satellite technology can be applied to targeting crime, such as trafficking, climate displaced people, as well as identifying evacuation routes for natural disasters.	**Mapping refugee movements** Turk Telekom created a big data challenge in 2018. It opened a large dataset of anonymised mobile phone usage to researcher groups to provide better living conditions to Syrian refugees in Turkey. The premise was to understand refugee movements and help authorities provide better conditions to more than 3.5 million Syrian refugees in Turkey. This challenge was aided by AI technology, which processed the huge swathes of data. Turk Telekom partnered with non-profit organisations and governments to guarantee the sustainability of the proposed solutions.[66]	Governments and NGOs deploy smart algorithms in their efforts to tackle poverty and national emergencies including refugee crises and natural hazards
Rapid data analysis for innovation AI and machine-learning technologies have the capacity to analyse vast amounts of technical data to unlock new insight and knowledge. This enables the discovery of new drugs to offer more effective treatment of diseases in order to improve health outcomes. This technology also enables rapid data analysis of genes in order to identify nutrient-producing genes which can be used to develop new crops with higher nutrient content, helping to reduce malnutrition.	**Immune-related drug development** CytoReason turns human clinical data (genomic, proteomic, microbiomic etc.) into biology, by rebuilding missing data, integrating directionality into the model and identifying disease modulating signals to uncover novel targets, indications, combinations and biomarkers - critical components in bringing new drugs and vaccines to patients faster. This technology identified which patients are likely to respond to therapy, before starting treatment, through discovery of novel, pretreatment biomarkers of response to anti-TNFa therapy in Inflammatory Bowel Disease.[67]	Innovation will be critical to positive societal outcomes as digital technologies enable a shorter development cycle and global distribution of the returns
Future state prediction Big data and predictive analytics are able to generate models which can predict future outcomes of human activity as well as health and safety risks, which will have significant implications on society, to deliver effective risk management. For example, this technology allows city governments to detect unsafe buildings before they deteriorate to the point of collapse, farmers to predict crop yields and schools to predict key attendance rates in order to help students who need it most. Predictive maintenance also helps to ensure the renewable energy supply is functional at its most optimal level with maximum supply to the grid.	**Prediction of potential student dropouts** Civitas Learning's platform uses predictive modelling to identify students at risk of dropping out of school. It focuses on student engagement, persistence and completion to improve college attendance, retention, and graduation rates. Del Mar College in Texas reported a 34% increase in graduation after using Civitas.[68]	Predictive ability will become open to all, enabling the prevention of harmful societal risks and the design of optimal systems and processes throughout society

Augment & Autonomate

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030...
Augmented humans Digital technologies, such as augmented reality, computers and mobile apps, can assist humans with certain tasks by augmenting what they see, hear or do. In a societal context, this can lead to improvements in health outcomes, through enabling remote surgeries or diagnoses to become a reality. Digital technologies can also help people with disabilities use public services or take part in education thus reducing inequalities and improving education outcomes.	**Augmented doctors for remote surgery** A surgeon at St Joseph's Hospital in Hamilton, Canada, is able to control a robot surgeon in another part of the country to treat patients. The robot itself is located in a community hospital that lacks the same facilities and expertise as the hospital in Hamilton. The human and robot duo have performed a variety of operations so far including colon operations and hernia repairs, improving the health outcomes for individuals previously unable to access the level of care needed.[69]	Digital technologies have been developed that assist once marginalised groups with taking part in society and the economy. Healthcare and other services are able to be delivered remotely, everywhere
Immersive experience for decision making Virtual reality headsets and portals provide immersive simulations of a variety of situations, enabling humans to interact with the situations and improving human decision making. For example, urban planners and citizens can immerse themselves in a proposed urban project, to land on a location or configuration that works best for the city. City-wide disasters or epidemics can also be simulated, to enable city governments and planners to prepare accordingly. Simulated scenarios can also be used in education and vocational training, and to facilitate peacemaking by illustrating the experiences of conflicting communities and promoting empathy and understanding.	**Disaster simulation for city evacuation planning** EON Reality was selected by the Singapore Civil Defence Force (SCDF) to promote emergency preparedness through the use of immersive VR technology. EON's technology simulates various emergency scenarios such as typhoons, earthquakes, tsunamis, and fires. It can be used to prepare all citizens, from first responding safety officers to school children, on how to safely react and make decisions in the face of disaster.[70]	Immersive experiences become a fundamental part of urban design, education, disaster preparedness and peacemaking, in order to improve awareness, empathy and crisis readiness in all cities and communities
Autonomous processes and machines A combination of digital technologies is enabling the rise of autonomous processes and machines, that can analyse situations, make decisions and act without human intervention. This has large implications for improving the provision and efficiency of utilities and amenities. For example, autonomous traffic lights and vehicles will improve traffic flow and road safety; and smart buildings, lights and grids can automatically optimise energy usage. Autonomous machines can also improve productivity and resource usage on farms, by deploying themselves to areas where they are most needed, and by automatically watering crops only when it is needed. In healthcare, smart software can automatically triage patients, ensuring help is given first to those most in need.	**Autonomous farm vehicles** Deutsche Telekom's Telematics on the Farm solution autonomously enhances the coordination of farm vehicles. Status information about all connected agricultural machines is transmitted to the cloud in real time and is then logically linked and analysed on a central web platform.[71] The platform collates and analyses fleet data, and automatically sets fleets on the quickest routes, avoiding unneeded fleet movements and protecting the farmland. This solution can boost productivity by up to 15% resulting in reduced fuel consumption, associated CO2 reduction, more efficient deployment of machinery, quicker harvesting and larger yields.[72]	Autonomous machines, where beneficial, become ubiquitous throughout society, improving resource-use efficiency and productivity, and provision and safety of public and corporate services; removing the strain on such services and resources, and enabling humans to take part in higher value tasks

In the future, it is expected that cloud technology and AI will enable greater oversight over the spread of poverty, and, crucially, identify the appropriate treatment to remedy it.



1 NO POVERTY

SDG 1

No poverty

The core aim of SDG 1 is to eradicate poverty (target cluster 1: 1.1 and 1.2). This is enabled by ensuring equal rights to basic services (target cluster 2: 1.4), such as health and education. Access to basic services also contributes to improving the protection and resilience of the poor (target cluster 3: 1.3 and 1.5), which can in turn help drive the eradication of poverty, for example, through social security payments. Finally, progress will be further enabled by accelerating investments in poverty eradication actions (target cluster 4: 1.A and 1.B), such as international aid to the least-developed countries.

Today, 8% of people around the world live in extreme poverty and the UN reports that on the current trajectory, 6% of the global population, or over half a billion people, will still be facing severe hardship in 2030.[73] Addressing poverty is not only important ethically and intrinsic to the core SDG aim of leaving no one behind, but poverty also has subsequent impacts on the rest of the world, causing instability, inequality and mass-migration.[74]

For individuals, digital technologies can assist those in, or close to, poverty to save money, establishing a security net in the case of unexpected economic or climatic events. Blockchain solutions can improve the utility and security of basic services through expediting essential insurance payments and securing once-vulnerable land rights. At a higher level, cloud technology helps to identify the spread and dimensions of poverty across regions, informing tailored and specific interventions.

In the future, it is expected that cloud technology and AI will enable greater oversight over the spread of poverty, and, crucially, identify the appropriate treatment to remedy it. In addition, while blockchain technology will help secure rights for the remote and impoverished, mobile solutions will still be critical for connecting the unconnected to financial services.

Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Eradicate poverty					
1.1 Eradicate extreme poverty (those living on under $1.90 a day)	1	2	4	3	Juntos is a mobile 'financial coach' that encourages Colombian families to save money in their bank accounts. It sends personalised text messages to members to remind them when to save or to prompt them to save more. It aims to assist the "newly banked" members of society who may have not saved much historically.[75]
1.2 Reduce by at least half the number of those living in poverty					
2. Ensure equal rights to basic services					
1.4 Ensure equal rights to economic / tech resources and basic services	1	2			Aon and Oxfam are using Blockchain to deliver affordable insurance to rural populations in Sri Lanka. The technology automates insurance products and simplifies the claims process for farmers.[76]

1	2	3	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate

2 ZERO HUNGER

SDG 2

Zero Hunger

SDG 2 can be subdivided into three interrelated clusters that together embody the social, economic and environmental dimensions that must be achieved in order to eradicate hunger.[77] Core to the aim of SDG 2 is the social dimension, ending hunger and malnutrition in all forms (target cluster 1: 2.1 & 2.2) which must be achieved through both the economic dimension of improving agricultural productivity and increasing farmer incomes (target cluster 2: 2.3, 2.A, 2.B & 2.C) and the environmental dimension of promoting sustainable agriculture (target cluster 3: 2.4 & 2.5). Managing interdependencies and trade-offs amongst these clusters will be key to SDG 2.

Since 2015, world hunger has risen year-on-year due to increases in conflict, drought and disasters, reversing a decade of progress , and is predicted to continue to rise.[78] Although agricultural productivity has been steadily increasing, population projections indicate that global food output will need to increase by 70% by 2050.[79] This challenge will be further exacerbated by rapid land degradation and urbanisation, agriculture-induced freshwater withdrawals, and climate change. [80] In order to ensure nutritious food can be provided to all for generations to come, SDG 2 demands the world to quickly rethink the way food is grown, distributed and consumed; and digital technologies have the ability to catalyse this shift.

Digital technologies are currently contributing to ending hunger and lessening malnutrition through communicating information, and connecting the hungry to nutritious food using food matching platforms, or more innovative blockchain-enabled food voucher payments. In agriculture, basic digital access has played the largest role in improving the incomes of small-scale farmers, by connecting farmers to digital marketplaces where they can buy cheaper inputs and sell goods to a wider market, and connecting farmers to instantaneous credit, farming and food pricing advice and weather alerts. On more connected farms, IoT, cloud and autonomous machines are currently automating processes and optimising the delivery of resources to improve farm productivity and sustainability.

In future, AI-enabled rapid data analysis and modelling is expected to be most beneficial in ending hunger, as such technology can understand complex interrelationships between conflict, weather, and other factors to predict and target areas of hunger most effectively. The better use and analysis of data will also be of great importance on the farm, to enable valuable insight into weather, farm, and market trends to optimise farm output and farmer income – as autonomous machines, though helpful with productivity, will not be able to predict such events. Data analysis will also be of increased importance to designing crops that produce a higher yield, are more nutritious, and are more resilient to climate change, as well as to designing new types of foods with a lower environmental impact. Autonomous machines and systems will, however, have perhaps the highest impact on sustainable farming, through automatically optimising the use of water, fertiliser and other inputs, and through enabling automated indoor and vertical farms to scale rapidly.

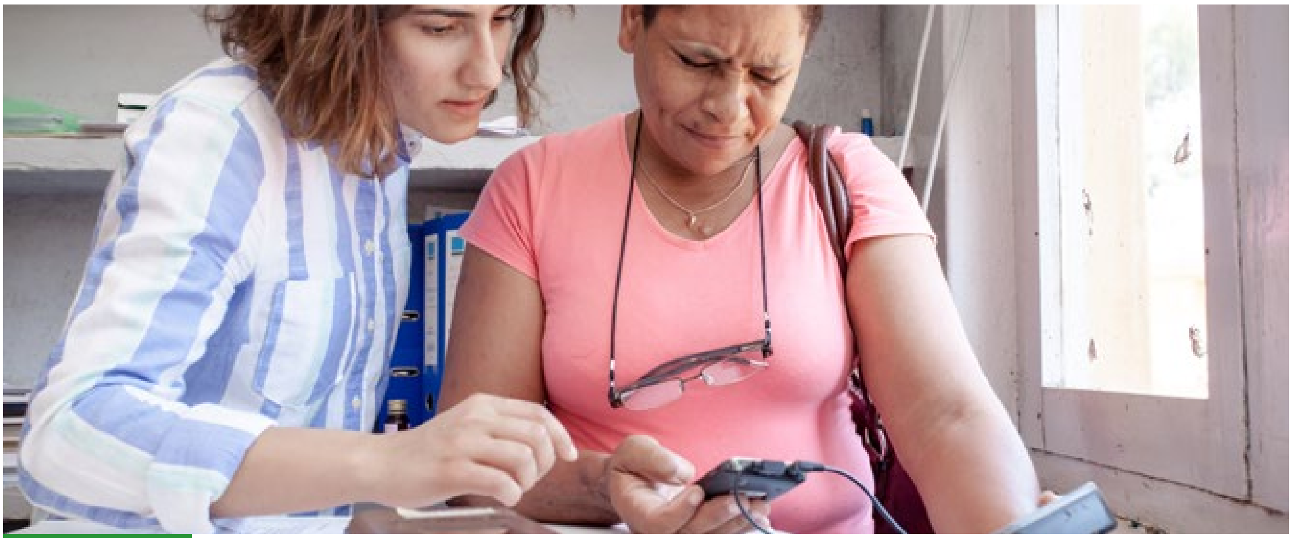
Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. End hunger and malnutrition					
2.1 End hunger and ensure access to sufficient food all year round	1	3	2		The WFP implemented Blockchain in two refugee camps, enabling 100,000 refugees to purchase food by scanning an iris at checkout, instead of having to pay with easily losable food vouchers.[81]
2.2 End malnutrition and address the nutritional needs of certain groups	2		1		Child Growth Monitor is an AI-power smartphone app that scans children to determine height, body volume, and weight ratio as well as arm circumference, to instantly diagnose malnutrition.[82]
2. Improve agricultural productivity and increase farmer income					
2.3 Double productivity and increase incomes of small-scale food producers	1	3	2	4	The Grameen Foundation and Musoni developed Kilimo Booster, a mobile-based loan designed for smallholder farmers, provided within 72 hours and with flexible repayment terms.[83]
3. Promote sustainable agriculture					
2.4 Ensure sustainable and resilient food production systems	4	3	1	2	AT&T's PrecisionKing IoT solution connects water-level sensors to water pumps, enabling automated irrigation of rice paddies, and saving 80,000 US gallons of water per acre of farmland.[84]
2.5 Maintain genetic diversity of farmed and wild species		1			EMPRES analyses satellite imagery to monitor and alert rural populations to desert locust swarms, as infestations threaten animal health and biodiversity.[85]

1	2	3	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate



3 GOOD HEALTH AND WELL-BEING

SDG 3

Good Health and Well-Being

SDG 3 aims to ensure health and promote well-being for all at every stage of life. This goal can be attained by improving a wide range of health outcomes (target cluster 1: 3.1, 3.2, 3.3, 3.4) and delivering better quality, more accessible healthcare (target cluster 2: 3.5, 3.7, 3.8, 3.B). Better health can be further supported by enabling policies (target cluster 3: 3.D) which can increase healthcare coverage as well as the management of health risks.

Healthy people are essential for economic and societal development yet more than five million children still die before their fifth birthday,[86] and whilst access to healthcare is a basic, essential human right, only half of women in developing regions receive the recommended amount of health care they need.[87] The achievement of SDG 3 will help to improve the chances of poverty reduction, increase school attendance, deliver better education outcomes, and contribute to an inclusive and productive economy.

Digital technologies act as an important enabler to SDG 3 by monitoring and tracking a variety of health indicators, supplies and outcomes. Digital technologies primarily help to improve health outcomes by analysing large quantities of technical data to identify new, relevant insight which can help manage the spread of diseases or discover new medicines to treat illnesses. More accessible healthcare can be supported by digital technologies which help to monitor and track the supply of vaccines. Blockchain can also be used to securely share and store patient data in real time in order to improve insurance coverage, thereby ensuring health policies which have the capacity to effectively manage health risks can be aided by connected devices which help to monitor diseases.

In the future it is likely that 5G and AI will transform healthcare, helping connect different applications, people, devices and robots to improve hospital systems and procedures and enable innovative technology applications. For example, 5G, along with AI, will enable remote surgery to become more commonplace allowing patients in remote areas to be treated for a wide range of illnesses and diseases.

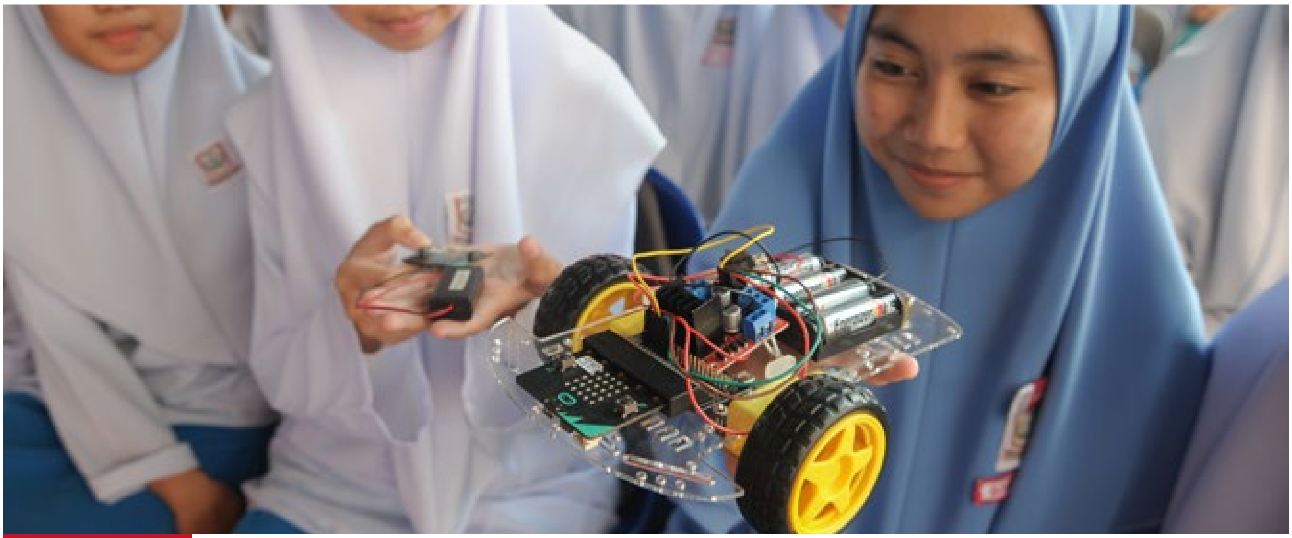
Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Improved health outcomes					
3.1 Reduce maternal mortality	🟩 1	2	3	▨	Mobile phone applications increase facility access and uptake, increasing the proportion of births attended by a skilled health professional which drives reduced maternal mortality.
3.2 Reduce neonatal and under-5 mortality	3	2	1	🟩	Fujitsu developed a foetal heart screening system which uses AI to detect complex heart abnormalities.[88]
3.3 End epidemics of communicable diseases	1	3	🟩 2	▨	HealthMap analyses real-time information to map the outbreak and spread of diseases.[89]
3.4 Reduce non-communicable disease mortality and promote mental health	3	🟩 2	1	4	Connected devices can be used to monitor a range of health indicators of individuals, helping to improve self-management of non-communicable health conditions.
2. Better, more accessible healthcare					
3.5 Strengthen prevention and treatment of substance abuse	1	▨	▨	🟩	Mobile phone apps can be used to send out treatment reminders and encourage self-assessments.
3.7 Ensure universal access to sexual and reproductive health care services	🟩 2	1	▨	▨	See SDG 5
3.8 Achieve universal health coverage	2	1	▨	🟩 3	5G-enabled remote surgery allows patients in remote locations to be treated.
3.B Support R&D of and affordable access to medicines and vaccines	3	2	🟩 1	▨	Sensors installed in refrigerating units help to monitor the supply of medicines and vaccines to improve access and distribution.
3. Ensure enabling policies					
3.D Strengthen early warning, risk reduction and management of health risks	2	1	🟩	▨	USAID introduced IoT-enabled Stamp2 sensors into “smart Band-Aids” and Ebola endemic areas. The Band-Aids collect a wide range of data, and alert physicians to any abnormal results, helping to contain the epidemic.[90]

1	2	🟩 3	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate



4 QUALITY EDUCATION

SDG 4

Quality Education

Increasing access to education is the core of SDG 4 (target cluster 1). This includes broadening access to primary, secondary (4.1), early childhood (4.2) and further education (4.3) with quality teacher training (4.A). In order to effectively receive, and benefit from, a quality education, skills needed for lifelong learning are required (target cluster 2). This involves possessing basic literacy and numeracy (4.6), and digital skills (4.4) needed for the workforce. Finally, increasing access to education must be paired with an ambition to ensure that education is inclusive (target cluster 3). Inclusivity means ensuring equal access for vulnerable groups (4.5), by providing the necessary infrastructure and funding (4.A, 4.C).

Despite increasing school enrolments worldwide, child labour is currently preventing 152 million children from receiving an education[91]. Even for those who receive an education, learning outcomes are poor in many countries. There are 125 million children that attend school and yet are unable to read or write. To achieve universal access to education by 2030, nearly 70 million new teachers will need to be trained and recruited.[92]

Digital technologies will have a crucial role in increasing access to quality education. Online educational platforms are connecting vulnerable groups to quality education. Digital technologies can indeed be deployed to improve quality of educational content, enabling the most effective material to be shared at scale to improve literacy, numeracy and digital skills.[93] Digital access can also broaden the availability of training materials, helping to improve the number and quality of teachers. Digital technologies including immersive virtual reality increases education access for children with disabilities.

In the future, it is expected that connectivity will continue to be the main driver of education access and teacher training. As the technology becomes more affordable, virtual reality will become increasingly used for immersive learning. Predictive analytics will play a larger role in monitoring students and their progress, and creating more effective content and tailored interventions.

Target level impact function mapping

1. Extend access to quality education

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
4.1 Access to primary and secondary education	1				Microsoft's Skype in the Classroom provides remote access to a wide range of educational content and digital teaching tools. It is a free global community which connects students, guest speakers and more than 100,000 teachers from 235 different countries.[94]
4.3 Access technical, vocational and tertiary education	1			2	Eduncle is a learning platform for students in India seeking to pursue further education, including the local Engineering Entrance exam (JEE). Eduncle has over 32 million site visitors, and provides many free courses.[95]
4.C Increase the supply of qualified teachers and teacher training	1		2		BetterLesson offers one-on-one virtual coaching for teachers. 92% of teachers report that they are able to leverage technology in more thoughtful and strategic ways as a result of working with their coach.[96]

2. Building digital skills and lifelong learning

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
4.4 Increasing skills for employment	1		2		Skillshare is an online learning community with thousands of classes in design, business, tech, and more. Skillshare has over four million students and 22,000 classes.[97]
4.6 Universal literacy and numeracy	1	3	2		Ubongo, based in East Africa, gives "edutainment" lessons via mobile phone, radio, print, internet, and TV. Kids who watch Akili and Me outperform their peers by 24% in counting compared to control groups watching other cartoons.
4.7 Citizenship and sustainable development	1				The Climate Pioneers Initiative offers schoolchildren from pre-school to secondary school the opportunity to realise their own climate protection projects. In 2011, 1,500 climate pioneers implemented a total of 100 climate projects.[98]

3. Enable inclusive access to quality education

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
4.5 Ensuring equal access to education, e.g. gender, disability	1		2	3	Pearson launched Tomorrow's Markets Incubator to innovate new products for underserved communities. Ideas include digital and blended learning for workforce training for US prison inmates, and language learning for refugees in Germany.[99]
4.A Building safe, inclusive learning environments				1	VOISS developed a Technology Innovation Adoption Model that will be applicable to helping school staff to successfully implement evidence-based technologies into the lives of students with disabilities.[100]

1	2	3	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate

SDG 7

Affordable and Clean Energy

SDG 7 focuses on the universal provision of access to modern sustainable energy (target cluster 1), including clean household energy, electricity access (7.1) and increasing the share of renewable energy in the global mix (7.2). This is supported by improving the rate of energy efficiency (target cluster 2: 7.3) to reduce the pressure on supply , as well as policy to promote access to modern energy services (target cluster 3: 7.A and 7.B)

Improving access to energy will be critical to the fulfilment of basic human needs (SDGs 1,2,3, and 4), and increasing the share of renewable energy is imperative to act against climate change (SDG 13). Energy efficiency supports both these aims, but it is particularly critical to help reduce CO2 emissions to the levels required to limit global temperature rise.

Digital technologies will provide the means of financing the expansion of solar energy sources through pay-as-you-go (PAYG) business models, which is an increasingly popular option to electrify rural areas where extending grid access through decentralised means is likely to be the least-cost option[101]. Energy efficiency is being improved by smart meters, which give the means to monitor and track energy usage.

The smart grid is the future of energy, and will be considerably impacted by digital technologies as the world moves toward 2030. The smart grid will allow the integration of small-scale, decentralised renewable sources into the grid, improving the share of renewable electricity. A proliferation of data across the grid will also enable autonomous management of end consumption, improving energy efficiency.

Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Increase access to modern, sustainable energy					
7.1 Universal access to affordable, reliable and modern energy	1		2		SolarAid provides not-for-profit access to renewable solar energy to the poorest customers in SSA. After piloting PAYG, they found purchase rates for entry-level solar solutions increased from 10-15% of targeted customers to 20-50%.[102]
7.2 Increase share of renewable energy in global energy mix	2		1	3	The Brooklyn (NYC) micro grid is a pilot where participants are able to buy and sell locally generated renewable energy over a peer-to-peer network, via smart contracts.[103]
2. Improve energy efficiency					
7.3 Double the improvement in energy efficiency		1	2	3	In the UK, research shows that 86% of people take energy-saving actions once their smart meter is installed,[104] including the 40% of people who install energy-efficient lightbulbs immediately after.[105]

1	2	3	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C Connect & Communicate
M&T Monitor & Track
AOP Analyse, Optimise & Predict
A&A Augment & Autonomate

11 SUSTAINABLE CITIES AND COMMUNITIES

SDG 11

Sustainable Cities and Communities

Core to achieving SDG 11 is achieving sustainable and inclusive urbanisation, through effective urban planning and city management (target cluster 1: 11.3, 11.4 & 11.A). This is supported by ensuring equal access to safe and affordable urban amenities such as housing, transport, and green and public spaces (target cluster 2: 11.1, 11.C, 11.2 & 11.7), and by encouraging cities to both mitigate their current environmental impact and adapt to the future impacts climate change (target cluster 3: 11.6, 11.5 & 11.B). Effective urban planning directly enables the other targets, and in turn achieving aspects of the other targets reinforces the implementation of sustainable, smart cities.

SDG 11 is crucial to achieving sustainable development, as the future will be increasingly urban: with the world's urban population predicted to grow from 55% in 2007 to over 70% by 2050.[106] Rapid urbanisation is already contributing to various challenges, including stark socioeconomic inequalities, poverty, crime, air pollution, and large environmental impacts, with the world's cities occupying just 3% of the Earth's land, but accounting for 60-80% of global energy consumption and 75% of global carbon emissions.[107] However, cities also lend themselves well to discovering, testing and scaling physical and digital solutions to these pressing issues, due to their density, economies of agglomeration and developed governance systems.[108,109]

Digital technologies have already become integrated into urban life in many cities. For example, mobile and digital platforms allow citizens to engage with urban planning, find housing, optimise their public transit routes or time to find parking, and take faster action during disasters. IoT-monitoring technologies are also already being deployed to monitor utility usage and quality, and air pollution levels and traffic flows, enabling city managers to make decisions to reduce adverse impacts.

In the future, it is expected that augmentation and automation will largely drive progress towards sustainable urbanisation and urban transportation. For example, AI-powered smart city management platforms will automatically control various urban services, such as transport, waste collection, and security, from the same platform. Autonomous vehicles are also predicted to transform the safety and sustainability of urban mobility, and make transport more accessible to those with disabilities. Predictive modelling and image analysis, for example to predict disasters or identify housing units in need of repair, will also be important in providing safe accommodation to all and reducing the impact of natural disasters in cities.

Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Sustainable & inclusive urbanisation					
11.3 Enhance inclusive and sustainable urbanisation and planning capacity	1		3	2	UCL's 'Palimpsest' is using VR to help citizens explore how HS2, a planned high-speed railway, will potentially impact their neighbourhood, which will be fed back to the project planners.[110]
2. Access to safe, affordable & sustainable urban amenities					
11.1 Ensure access to adequate, safe and affordable housing and upgrade slums	3	2	1	4	Taiwan Mobile offers real-time home monitoring using high-quality video surveillance and broadband. The service sends emergency notifications if family members need support and detects burglaries.
11.2 Provide access to safe, accessible and sustainable transport & improve road safety	1	4	2	3	Verizon's traffic management service uses sensors and cloud-based data collection to optimise traffic flows, resulting in 25% less travel time and 22% fewer emissions in cities.[111]
3. Climate change mitigation and adaptation in cities					
11.6 Reduce the adverse per capita impact of cities (inc. air quality and waste mgmt.)		1	3	2	Ecube Labs have installed fill-level bin sensors in Seoul, South Korea. Data from the sensors is gathered on a big data platform, which uses applied machine learning to optimise waste collection routes based on the data.[112]
11.5 Reduce the number of deaths and loss to GDP caused by disasters	1	3	2	4	Fujitsu's 'smart drain' solution uses a network of sensors and cloud technology to monitor drains in real time, significantly reducing the risk of flooding due to storm drain overflows.[113]

1 2 3 4

MOST **LEAST**

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate

Tôi có đam mê với việc kinh doanh này.

Doanh nghiệp của tôi giải quyết vấn đề thật sự.

Sản phẩm / dịch vụ c
tôi khác biệt so với các đối thủ.

Tôi có đủ thời gian cho việc kinh doanh này.

Tôi có thể duy trì khả năng tài chính 6 đến 12 tháng.

5 GENDER EQUALITY

SDG 5

Gender Equality

SDG 5 focuses on achieving gender equality and empowering all women and girls. Ending all forms of discrimination against women and girls is at the core of this goal. This target and the overall goal can be achieved by ending harmful practices (target cluster 1: 5.2, 5.3), promoting economic empowerment and independence of women (target cluster 2: 5.4, 5.5, 5.B), and ensuring better access to sexual and reproductive health (target cluster 4: 5.6).

Gender equality is a fundamental human right, however, 40% of the world's girls and women live in countries failing on gender equality.[114] According to the 2019 SDG Gender Index, the world is furthest behind on SDG 5,[115] which is perhaps unsurprising given that 49 countries still have no laws that specifically protect women from physical and sexual violence.[116] However, the achievement of the 17 SDGs will not be possible without securing gender equality.[117] For example, gender equality helps to achieve overall equality, promote peaceful societies and enable inclusive and sustainable economic growth.

Digital technologies play a vital role in helping to achieve SDG 5 as they help to communicate important messages to a wide audience in order to change deeply-rooted social norms and alter the perceptions of the rights and appropriate treatment of women. The empowerment of women can be greatly supported by digital technologies which help to connect women to each other as well as connecting them to new opportunities, such as job prospects or online learning tools, to improve their economic and political participation and representation.

In the future, there will likely be increased focus on gathering more data, and developing more machine learning and computing power in order to help understand why gender inequalities, which are particularly apparent in the workplace for example, still persist. This will help to uncover the underlying drivers of gender equality and their interlinkages in order to deliver tailored responses that will drive progress towards SDG 5.

Target level impact function mapping

1. End harmful practices

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
5.2 Eliminate violence against women	2	1	3		Moldova have implemented a blockchain solution using digital identify verification to prevent underage border crossing and detect trafficking networks.[118]
5.3 Eliminate all harmful practices	1	2			SMS messages were sent out in Uganda to alert children and youths of the illegality of female genital mutilation (FGM).[119]

2. Promote economic empowerment and independence

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
5.4 Recognise and value unpaid care and domestic work	1				The gig economy, enabled by digital access and mobile technology, gives women greater recognition and reward for their work.
5.5 Full participation at all levels of economic and political life	1				eLearning tools and mobile technology create new platforms for women to learn and acquire skills which can enable greater economic participation.
5.B Enhance use of enabling technology to empower women	1				Business Women, a mobile service launched in Nigeria, sent SMS messages to over 70,000 women with tips and training on business skills, helping to empower them.[120]

3. Better access to sexual and reproductive health

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
5.6 Ensure universal access to sexual and reproductive health	1	2			M4RH, a mHealth service in Kenya provides family planning information via SMS messages.[121]

1	2	3	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate

16 PEACE, JUSTICE AND STRONG INSTITUTIONS

SDG 16

Peace, Justice and Strong Institutions

SDG 16 aims to build peaceful, just and inclusive societies eliminating fear and violence. The achievement of this goal is underpinned by three interrelated key characteristics: peace, justice and inclusivity. For example achieving peaceful societies (target cluster 1: 16.1, 16.2, 16.4) requires ending harmful practices and reducing illicit financial and arms flows. Inclusive societies (target cluster 3: 16.6, 16.7, 16.10) can be attained by protecting fundamental freedoms and developing accountable and transparent institutions, whilst just societies (target cluster 2: 16.3, 16.4, 16.5, 16.9) are free from corruption, ensure equal access to justice for all and enforce non-discriminatory policies.

Achieving peace, justice and strong institutions is of vital importance. However, time acts as a major barrier to fulfilling this goal as delivering institutional change and resolving conflicts represent slow processes, beyond the 2030 timeline. For example, fast moving countries take on average 27 years to bring corruption under reasonable control, while it has been estimated that it would take Haiti 600 years to achieve the institutional quality of Singapore.[122] The attainment of SDG 16 would help to end extreme poverty and improve overall quality by boosting prosperity for the poorest 40% of people in developing countries.[123]

Digital technologies are fast becoming embedded in public institutions and organisations. They are contributing to more peaceful societies by monitoring online forums to identify child abuse and organised crime, and analysing public data to determine crime patterns and prevent future incidents or attacks. Digital access is also contributing to just societies, by disseminating information on bribery and corruption, and connecting individuals to low-cost, digitalised public services such as birth registration and legal advice. Digital technologies are contributing to inclusive societies by ensuring instantaneous public access to information, and ensuring citizens can engage with decision making processes online.

In future, blockchain technology is expected to play a large role in maintaining peaceful and just societies. For example, blockchain and IoT technologies are able to ensure auditable traceability across a supply chain, from sourcing raw materials to end product, and will enable identification of child exploitation and trafficking as well as assurance that code of conducts and human rights are respected along the supply chain. Analysis of data gathered by monitoring technology is also expected to play a more important role in predicting crime, terrorism and trafficking, enabling peacekeeping services to be dispatched accordingly.

Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Peaceful Societies					
16.1 Reduce all forms of violence	3	1	**2**	4	Self-driving autonomous robots can constantly patrol areas to ensure the safety of people and assets.[124]
16.2 End abuse, exploitation, trafficking and all forms of violence against and torture of children	**2**	1	3		Data analytics and image recognition software are used to collect timely / better information to make arrests and stop perpetrators of all forms of violence against children online.[125]
16.4 Reduce illicit financial and arms flows and combat all forms of organised crime	2	1	**3**		Mobile authentication enables consumers to verify the provenance of a product.[126]
2. Just Societies					
16.3 Promote the rule of law and ensure equal access to justice	**1**	2			Microsoft, Legal Services Corporation and Pro Bono Net established an online portal to direct low-income households to legal advice and service providers.[127]
16.5 Reduce corruption and bribery in all their forms	1	2	**3**		In Brazil, suspicious patterns of interactions between public service providers and users were uncovered by using data analytics.[128]
16.9 Provide legal identity to all, including birth registration	**1**	2	3		The Pakistani government uses a mobile app to extend the reach of birth registration services to remote communities and areas where registration is typically low.[129]
3. Inclusive Societies					
16.6 Develop effective, accountable and transparent institutions	**1**	2			Constitute is a database established by Google and researchers from multiple universities that offers online access to the world's constitutions.[130]
16.7 Ensure responsive, inclusive, participatory and representative decision making		1	**2**		Voatz is a mobile platform that allows citizens to participate in elections via their mobile phone. The system is secured by blockchain technology.[131]
16.10 Ensure public access to information and protect fundamental freedoms	1	**2**			An online database in Armenia allows citizens to access all government court cases and spending in an easily downloadable, open data format, with a smart search capability.[132]

1	2	**3**	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate

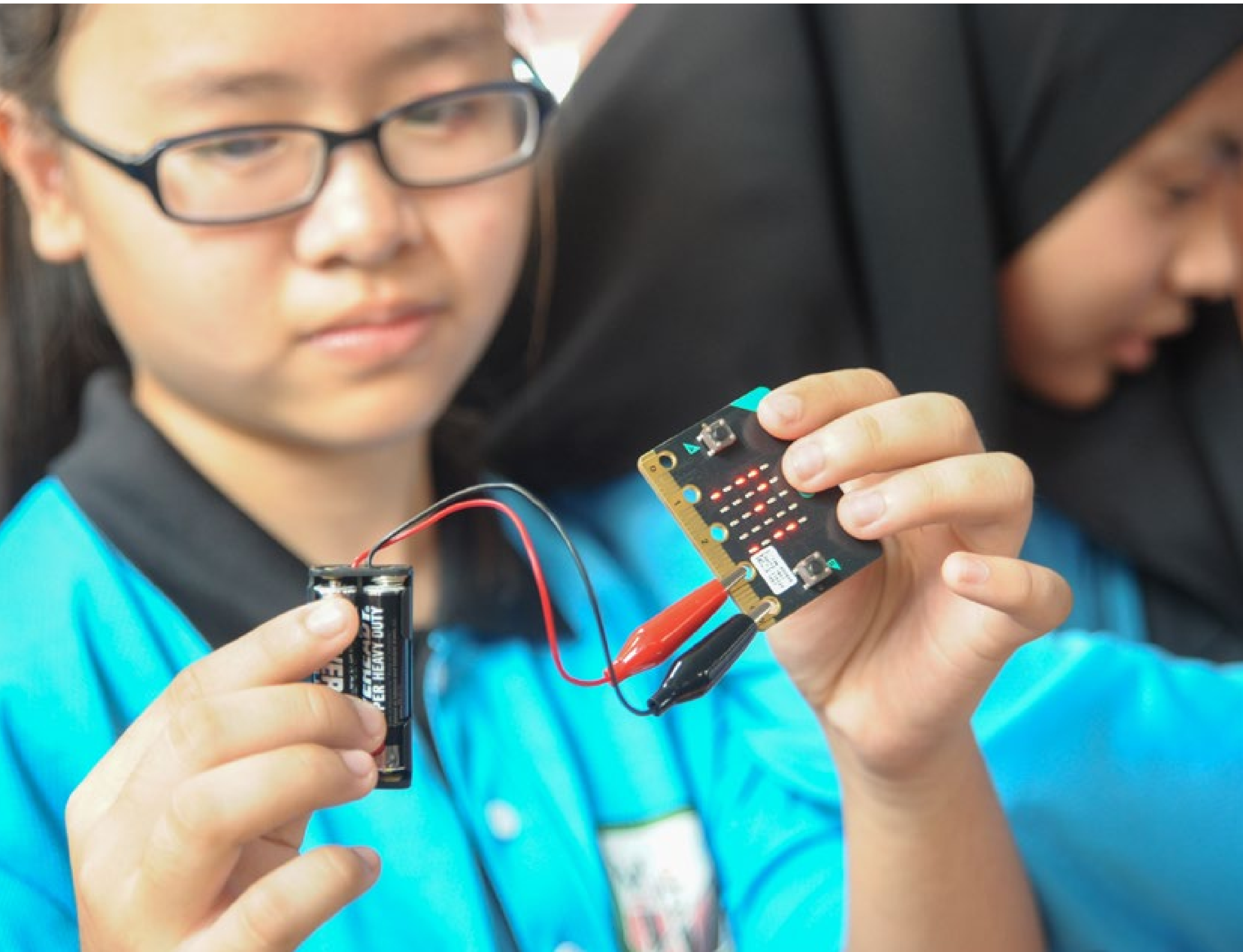
System Interactions

A peaceful, inclusive and sustainable society is at the heart of sustainable development. It promotes collective responsibility to ensure that everyone has access to the resources they need to fulfil their potential and role in society as well as promoting actions to protect the biosphere and pave the way for inclusive growth.

A lack of global engagement and commitment has meant that the most vulnerable people and countries are still largely excluded from societal progress, whilst issues such as gender equality and global hunger still need to be urgently addressed. However, it is clear that advancements are beginning to take shape with the number of people living in extreme poverty having declined from 36% in 1990 to 8.6% in 2018 as well as widespread immunisation, reduced child mortality rates, and increased access to electricity.[133]

Achieving the targets laid forth by the societal SDGs will involve trade-offs with the biosphere and economy that will have to be managed effectively in order to produce the overall best outcome for sustainable development.

For instance, ensuring an equitable society could present limitations for economic progress as being more socially inclusive may not always result in an optimal economic outcome. With increased focus on addressing gender equality and improving access to essential services, there is a chance that economic objectives may be deprioritised in order to promote equal opportunities and shared access. Furthermore, prioritising people and fulfilling their basic needs will increase pressure on the environment and the world's natural resources. For example, building sustainable communities, ensuring equal access to electricity and water, and tackling poverty will require building new urban infrastructure and utilising more resources which will strain an already-limited natural resource pool and damage the natural biosphere.



Negative externalities: impact of digital technologies

Whilst the increasing use of digital technologies will make an important contribution to the achievement of the society SDGs it may also lead to the emergence of various systemic risks which pose a threat to society. For instance as more and more aspects of day-to-day life become digitised, certain groups could be left behind due to a lack of digital literacy or digital access. This could enhance gender inequality, the SDG that the world is currently furthest behind on.[134] Lack of equal access could also prevent digital technologies from delivering the health, agricultural and education improvements to groups that need them the most. A digital world, unless carefully managed, could also see society become increasingly exposed to espionage and terrorism through cyber attacks, jeopardising citizen safety and creating conflict in society. The use of mobile phones and social media in particular also increases misinformation and "fake news" which can manipulate behaviour and threaten health, equality, peace and justice. Increased uptake of mobile phones also has well-documented cases of phone "addictions" and negative effects on mental and physical health.[135] New forms of governance must be enacted to manage these large risks.

As digital technologies become more integral to society and how it operates, societies will develop a dependency on such technologies which in turn will expose society to greater risks of deliberate attacks, accidents or natural threats, e.g. power outages. For instance, with the emergence of digitally-enabled smart cities, there is a significant risk that control systems could be hacked and citizen safety compromised. For example, terrorists could hack autonomous traffic control systems to cause road accidents. The risk of cyber hacks is of a similar magnitude within healthcare as systems and operations become digitalised; meaning human life is at stake. With a growing amount of data stored digitally and various key societal systems being connected to the internet, there is a general loss of privacy as almost all aspects of our lives are captured in digital data; "every two days, the world creates more data than in the entire human history up to the year 2003."[136] The use of connected devices to monitor health and poverty and track location and activity in smart cities could lead to unauthorised access to personal data which could be used inappropriately or with malicious intentions, threatening peace in society and degrading civil liberties.

The wider deployment of digital technologies in society could produce negative impacts on the economy in terms of economic opportunities and efficiency. For instance, the increase in eLearning through new teaching platforms and online interactive tools will create a digital divide as certain groups in society will still be limited in their ability to access this digital environment. This will translate to a lack of necessary skills needed to successfully participate in the future-oriented digital economy. As a result, individuals will face limited economic opportunities which could exacerbate disparities in income, both across and within countries. Potential hacking could also jeopardise the economy as well as society; the development of the smart grid means that the energy supply becomes a key target for hackers as they would be able to disrupt an integral part of the functioning economy.

The increasing use of digital technologies to benefit society will likely result in increased emissions and energy consumption, unless most of society becomes powered on renewable energy in the near future. The widespread deployment of sensors throughout society in order to manage healthcare, farming, and smart cities will produce huge amounts of e-waste through their use of batteries. Research suggest that over one trillion sensors could be deployed by 2020, and, unless a circular economy is adopted, this will result in massive amounts of e-waste.[137] Furthermore, the direct use of digital technologies in society, for example to build smart cities or automate agricultural practices, will result in increased energy usage and emissions, damaging the biosphere. However, digital technologies also have the ability to mitigate energy usage by implementing large-scale emission efficiencies in cities, and to reduce the overall environmental impact of cities by reducing air pollution caused by congestion and optimising waste collection. They also enable optimised processes throughout society which help to reduce energy consumption.

Whilst implementing the society SDGs may pose some challenges, their achievement is critical to sustainable development by creating the building blocks for a prosperous economy and conserved biosphere. Effective partnerships amongst all agents in society, based on strong political willpower and international cooperation and capitalising on the capacities of digital technologies, will help to fulfil the potential of society without compromising on economic progress or protection of the biosphere.

2.3
SDG impact

Economy

Only by achieving all 17 SDGs can shared and sustainable prosperity be fully realised.

The economy can be defined as the system by which we gather, produce and distribute resources.[1] The 2030 Agenda aims to ensure this system promotes prosperity for all, with sustainable consumption and production patterns that do not deplete natural resources for future generations.[2]

Only by achieving all 17 SDGs can shared and sustainable prosperity be fully realised. A healthy and thriving biosphere is needed to ensure the quality and quantity of raw materials and environmental conditions for effective economic development. A strong, safe and inclusive society is needed, so that all people can participate and positively contribute. Deep, multi-faceted and empowered partnerships are needed to steer the interventions required.

Four SDGs directly address the ‘shared prosperity’ challenge, falling into two thematic groups targeting inclusive growth and sustainable industry.

Inclusive growth: SDGs 8 and 10

Decent work and economic growth (SDG 8) articulates the challenge of increasing employment and opportunity through sustained economic growth. Whilst there has been exponential growth since the Industrial Revolution, the 2008 financial crisis has led to a global slowdown. Through increased productivity, resource efficiency, decent employment and financial inclusion, SDG 8 represents a set of targets for collective and individual growth.

Reducing Inequalities (SDG 10) calls for the improved redistribution of resources, both within and between countries. Despite gains in reducing poverty, disparities persist in access to basic services. Extreme inequalities can be found around the globe, particularly within cities.[3] SDG 10 seeks to address these imbalances by targeting social, economic and political inclusion, including by facilitating safe and responsible migration.

The global economy is increasingly reliant on digital technology as a platform and engine for growth. Digital technologies open up access to new markets, enable efficiencies, improve productivity and are a new means of collaboration and connection.

Where countries, regions, companies and individuals have the opportunity to deploy technology to their benefit, it can help to deliver the shared prosperity envisaged by the 2030 Agenda. However, those who cannot access or utilise digital technologies may face a more challenging future. It is incumbent upon technology providers, industry partners, policymakers and consumers to direct the tremendous potential of digital technology to the benefit of all.

Sustainable industry: SDGs 9 and 12

Industry, innovation and infrastructure (SDG 9) supports the drive for inclusive growth through sustainable industrialisation and the building of sustainable and resilient infrastructure. Whilst the growth and sustainability of industrial practice is improving overall, progress is unevenly distributed: developing countries face both weaker economic value add and increasing CO2e emissions per unit of productivity.[4]

Responsible Consumption and Production (SDG 12) targets the responsible treatment of resources and reductions in global waste. If, as predicted, the global population reaches 9.7 billion by 2050,[5] the equivalent of almost three planets could be required to provide the natural resources needed to sustain current lifestyles.[6]

In this context, there is an ever-increasing challenge to meet a central objective of the 2030 Agenda: to decouple economic growth from environmental degradation.

Without a shift to a more sustainable approach to both production and consumption, continued population and economic growth will further increase planetary pressures and exacerbate social exclusion and inequality.

Looking forward

Digital technologies have a critical role to play to help address the challenges of an inclusive, growing and sustainable economy. Through ‘Industry 4.0’ and the transition to low latency mobile networks, Operational and Information Technologies converge to enable more effective, efficient, connected and sustainable manufacturing and industrial practice. Newly connected supply chains are more transparent, providing the platform for effective interventions that enable greater efficiency, improve reuse and recycling, and reduce waste. Perhaps more fundamentally, there is an opportunity for the increased transparency enabled by digital technologies to drive a fundamental shift in behaviour by drawing a clear link between impact and sustainability and economic growth and commercial success.

Of course, digital technologies need to be carefully managed in pursuit of inclusive growth and sustainable industry. Growth must be managed in such a way that it does not lead to increased degradation of the biosphere in terms of carbon emissions, e-waste and resource extraction. For example, linear production of electronic devices places strain on the planet’s natural resources, requiring unsustainable mineral extraction.[7] Technologies must be deployed so that they do not exacerbate social inequalities and exclude the unconnected. Attaining accelerated economic growth alone will not achieve the SDGs by 2030.[8]

Furthermore, while digital technologies will play an important role in enabling an inclusive economy and sustainable industry, cross-sector partnerships are needed to realise the required transformation. Ensuring the availability of basic infrastructure, effective networks, functioning markets and positive consumer behaviours require stakeholders at all levels to act.

This chapter will set out the comprehensive set of capabilities that digital technologies offer, which can enable the world to set itself on a more sustainable journey to shared prosperity for all.

SDG progress overview

Significant progress has been made against some economy SDG targets – in particular global employment levels and investment in infrastructure. However, a number of targets are trending in the wrong direction, particularly those related to inequality and natural resource consumption. This demonstrates that the world must change the way it measures and pursues growth.

Inclusive growth

8 DECENT WORK AND ECONOMIC GROWTH

- ✓ **Increased employment:** global unemployment has returned to pre-crisis levels of below 5%, having reached 5.6% in 2009.[9]
- ✗ **Decent work:** informal employment remains pervasive in many countries, with more than half of all persons employed in non-agriculture sectors being informally employed in countries for which data is available.[10]
- ✗ **Inclusive and sustainable economic growth:** growth of economic output in least-developed countries is below the 7% targeted by SDG 8; real GDP growth in these countries was 4.5% in 2017, although it is expected to increase to 5.7% in 2020.[11]

10 REDUCED INEQUALITIES

- ✓ **Economic, social, and political inequalities:** in more than half of the 92 countries with comparable data during the period 2011–2016, the incomes of the bottom 40% of the population grew faster than the overall national average.[12]
- ✗ **Economic, social, and political inequalities:** the share of wealth of the world's top 1% wealthiest people[13] grew from 28% to 33% between 1980 and 2016.[14]
- ✗ **Improved experience of migrants:** remittance flows for migrant families are essential.[15] However, the average remittance cost in 2017 was 7.2% of the amount remitted over twice as high as the 3% targeted by SDG 10.[16]

Sustainable industry

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

- ✓ **Foster innovation and enhance R&D:** the proportion of global GDP invested in research and development increased from 1.52% to 1.68% from 2000 to 2016.[17]
- ✓ **Develop sustainable and resilient infrastructure:** total official flows for economic infrastructure in developing countries reached $59 billion in 2017, an increase of 32.5% in real terms since 2010.[18]
- ✗ **Ensure sustainable industrialisation:** while the intensity of carbon emissions per unit of manufacturing value added is declining, the volume of production in many geographies has been increasing (increasing overall emissions).[19]

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

- ✓ **Commit to responsible practices:** 93% of the world's 250 largest companies by revenue, report on sustainability, as do three quarters of the top 100 companies in 49 countries.[20]
- ✗ **Reduce global waste:** global waste is expected to rise by 70% by 2050.[21]
- ✗ **Responsible treatment of resources:** worldwide material consumption has increased every year since 2000 – in 2017 it reached 92.1 billion tonnes, over five billion tonnes more than 2015.[22]

Impact of digital technologies

Digital technologies will be central to facilitating inclusive growth and sustainable industry. All four impact functions are able to deliver progress against the economy SDGs. However, there are two major opportunities: i) monitoring supply chains accurately to create transparency in production; and ii) optimising processes to increase productivity while reducing energy usage and emissions. The impact generated by specific sub-functions is explored later in this chapter.

Connect & Communicate

Digital technologies have revolutionised the way in which people can connect and transact. Digital platforms connect individuals to allow the sharing and selling of information, goods and experiences online. These have created new business models, e.g. subscription and advertising based, and modes of work for those unable to commit to full-time employment. E-finance can provide quicker and easier access to resources, supporting rapid entrepreneurship and innovation. Digital technologies have also enabled universal collaboration, allowing isolated groups to participate in society and economic activity and providing the means for populations to address irresponsible consumption in unison.

Monitor & Track

To enable *sustainable* economic growth, the knowledge gap between participants in economies must be reduced. The element that is primarily lacking is accurate and good quality data. Digital technologies are therefore instrumental for bridging the gap. The integration of digital labels, such as QR and RFID, as well as IoT and blockchain into supply chains, enables radical transparency, linking the consumer’s purchase choice to the measured impact of the production process instantaneously, if the information is stored on the cloud. This can also benefit investors by connecting financial flows to the underlying impact caused. For workers, digital technologies offer the ability to secure their rights and hold employers accountable for upholding contracts. In addition, digital technologies provide greater oversight of the systems that sustain the economy, helping stakeholders to react to issues in real time.

Analyse, Optimise & Predict

The use of advanced analytics can drive efficiency and productivity gains across the economy. For example, the integration of cloud and AI into business processes can lower costs and free up worker time. Digital technologies can reduce the negative impacts of production and logistics, lowering the emissions of supply chains and minimising resource wastage. Use of predictive maintenance and digital twins not only enables greater efficiency but also improves worker safety during production. Additionally, AI and digital reality has the potential to transform R&D, accelerating innovation and product development. Finally, digital technologies enable the aggregation and analysis of data to allow all organisations to understand their true impact on the environment.

Augment & Autonomate

Digital technologies can improve safety and productivity in the economy. Wearables and VR enable workers to be guided through hazardous procedures and training in a safe environment. These technologies can also provide a new connection for secluded parts of society, immersing them in experiences they had been unable to realise in the real world. Autonomous systems are replacing humans altogether and intelligent automation drives efficiency in mundane tasks, for example in recycling and production; enabling workers to focus on increasingly complex, creative and human-centric issues.

Impact projections to 2030

A selection of economy-related SDG targets have been identified for modelling, selected on the basis of data availability and empirical impact evidence. The numbers presented serve as an illustration of the potential impact that ICT could have on achieving the Goals, giving a comparison of the business-as-usual scenario against how the outcome could look if some of the ICT opportunities identified in this chapter were more widely adopted.

This does not, however, illustrate the full potential of digital technology. The estimated impacts are based on use cases which currently exist, and do not take account of potential gains from further R&D to develop new use cases. In addition, the numbers are based on expected adoption levels, and hence there is potential for much greater impact with an accelerated penetration of digital technology.

8 DECENT WORK AND ECONOMIC GROWTH

Target 8.10

Financial inclusion

Mobile money is already a significant driver of greater financial inclusion, and it is expected that it will continue to have an impact. Based on the historic increase in mobile money accounts that is associated with increasing mobile subscriptions per 100 people, and the projected adoption of mobile phones to 2030, an additional 118 million mobile money accounts could be opened by 2030. If accounts are unique to people, then this is equivalent to an additional 1.9% of the global population having access to financial services.[23]

By increasing financial inclusion, mobile money services can help people escape the poverty trap: a study showed that M-Pesa, a mobile money system in Kenya, lifted around 194,000 households out of poverty, equivalent to 2% of Kenyan households.

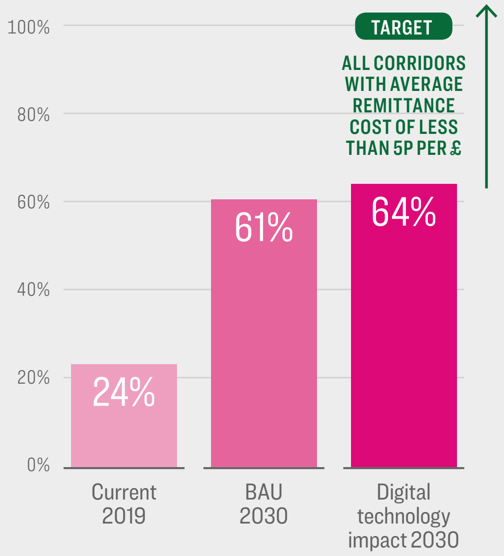
10 REDUCED INEQUALITIES

Target 10.C

Remittance costs

Analysis indicates that the increasing prevalence of mobile technology and mobile money services will support a reduction of remittance costs. The analysis of remittance service price data from the World Bank[24] indicates that remittance service providers (RSPs) offering services via mobile are 37% cheaper than traditional RSPs, which use agents or banks. Out of the remittance corridors tracked by the World Bank only 24% currently have an average remittance cost of less than 5p per £ as per Target 10.C. Although this is estimated to increase to 61% by 2030 based on current trends, wider adoption of remittance services using mobile could make this 64%.[25] Lower cost remittance services can substantially increase disposable income for remittance-receiving families, reducing inequality in migrants' home countries.[26] Based on the current volume of remittances greater adoption of mobile remittance services would represent an annual saving of $716 million in costs.

Corridors with an average remittance cost of less than 5p per £ (%)



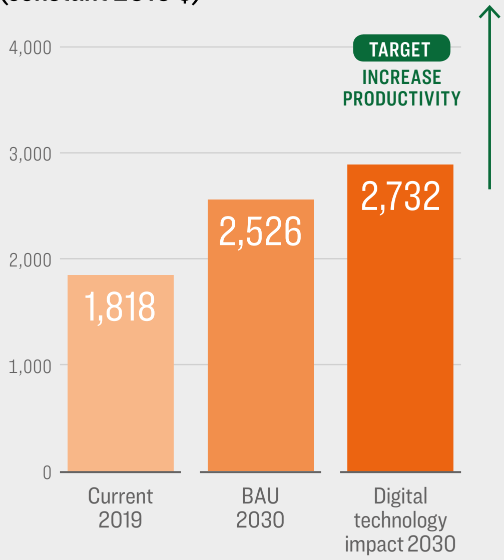
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Target 9.2

Manufacturing value add

It is estimated based on existing trends that the current value of manufacturing activities per person across all countries analysed is expected to rise from around $1,800 to around $2,500 by 2030 (values represent manufacturing GVA per capita in 2010 prices). However, the digital transformation of manufacturing via the adoption of Industry 4.0 is expected to produce substantial productivity gains by 2030. Smart factories that enable automated workflows, predictive maintenance, real-time monitoring of raw materials and work in progress could increase the value of manufacturing activities across countries to over $2,700 per capita, an increase of 8% attributable to Industry 4.0 relative to the business-as-usual scenario.[27] Furthermore, smart factories could lead to an emissions abatement of 0.33 Gt per year in 2030 against the business-as-usual scenario.

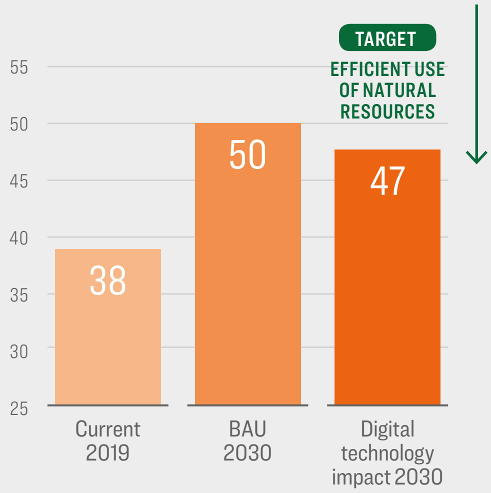
Manufacturing Value Add per capita (constant 2010 $)



Domestic material consumption

It is also estimated that use of Industry 4.0 will reduce manufacturing domestic material consumption through greater resource efficiency and productivity in production processes, which is relevant to SDG 8, SDG 9 and SDG 12. It is estimated that in 2019 manufacturing domestic material consumption was 38 billion tonnes of raw material, which, based on historic trends, is expected to rise to 50 billion tonnes of material by 2030. Factoring in adoption of Industry 4.0 and the impact this may have on domestic material consumption of the manufacturing sector at the country level the rise may be reduced to 47 billion tonnes, a 5% reduction compared to the business-as-usual case.[28]

Domestic material consumption in manufacturing (tonnes, billions)



12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Target 12.3

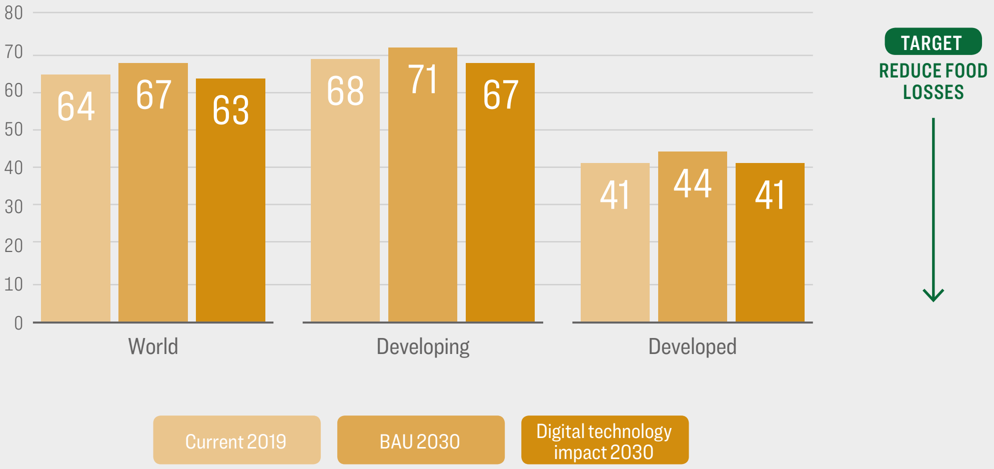
Food loss in the supply chain

Globally, it is estimated that a third of all food produced goes to waste, despite being safe for human consumption.[29] Food loss in the supply chain, defined as food lost post-harvest, in storage, during processing or in distribution, currently stands at around 62 kilograms per person annually. Based on the expected growth trends in food production and population, this figure could increase to 65 kilograms per person annually by 2030.

The adoption of digital technologies such as smart logistic solutions to reduce spoilage and AI to identify and target supply chain food loss more accurately can help reduce this loss. At the expected rates of digital technology adoption, food loss could be reduced to 63 kilograms of food loss per person globally per year (i.e. an estimated 0.9% lower than the current figure).[30]

The impact would be more significant in regions with high food loss in the supply chain, which consist mostly of developing countries (e.g. Latin America). Supply chain food loss in these regions is generally high post-harvest due to hot humid climates, difficult transportation and inadequate storage facilities, while food loss at the point of consumption is typically higher for developed countries.[31] Targeted implementation of relevant digital technology in food supply chains of developing countries will have a greater impact than in developed countries: under the expected rate of technology adoption food losses in developing countries are estimated to fall 1.7% between now and 2030. This compares with an estimated increase of 1.1% across developed countries between now and 2030 under the digital technology scenario if supply chain food loss continues to evolve at the historic rate.

Food loss in the supply chain (kg per person per year)



Globally, it is estimated that a third of all food produced goes to waste, despite being safe for human consumption. Food loss in the supply chain is currently around 64 kg per person, and expected to grow to 67 kg per person by 2030.

Connect & Communicate

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030…
Public awareness messages Digital technologies allow public sharing of information to guide decision making for both consumers and organisations towards sustainable development. Social media promotes transparency in corporate behaviour and platforms to encourage sustainable consumption.[32] Online petitions raise awareness and bring the public together to compel responsible economic activity. For organisations, the open sharing of big datasets online can influence sustainability strategies and goal setting.[33]	**Online petitions** Change.org is an open platform that hosts campaigns and allows people to sign up in support of these campaigns. One petition launched on the platform to 'End the sales of eggs from caged hens' by Tesco (a UK retailer) received c. 280,000 signatures. This pressure led to the company committing to end this practice by 2025.[34]	**Organisations and individuals will have access to the information they need to help influence economic activity toward sustainable development**
Targeted content Mobile platforms allow information and training to be shared with specific groups to promote inclusion in the economy. Some apps have been designed to improve the digital literacy of women,[35] while others target migrants, providing essential information for entering new countries.[36] Mobile platforms can also equip the population to participate in sustainable development, sharing information on the impact of consumption[37] and crowdsourcing information about the quality of local infrastructure.[38]	**Translation technology for inclusion** Sho is a real-time translation service in Sweden aimed at fostering inclusion where people that speak different languages can come together to connect. After signing up, users who speak different languages speak to each other using the service, which translates conversations in real time. It can enable immigrant populations to participate in society and the economy immediately. The service is being developed by Nokia and Tele2 based on Microsoft Translator technology.[39]	**Vulnerable groups across society will have access to specific information they need to help improve their resilience, quality of life and participation in the workforce**
Digital marketplaces and business models The proliferation of cloud technology and increasing data capacity of mobile networks allows consumers and organisations to connect, interact, and trade online – supplanting physical interaction. Mobile access and cloud technology connects people to the internet, fostering innovation[40], collaboration with investors and partners,[41] and rapid scalability of new businesses.[42] Digital platforms have created new peer-to-peer business models, which improve the utilisation of surplus materials[43] and food.[44] Platforms also provide flexible working opportunities for those unable to commit to full-time careers. In addition, digital access can help unconnected groups engage with the wider economy, for example through job matching platforms[45] and flexible working opportunities.[46]	**Innovative business platforms** Beat is an app, established in Athens but now also operating across cities in South America, which matches private drivers to individuals looking for one-off rides. The platform connects the driver with riders and handles the payment online.[47] Unlike competitors, its Beat Lite service aims to recruit drivers from lower-income demographics, driving older vehicles. This provides one-off, flexible working opportunities for those without the capital to invest in a new car.[48]	**A significant proportion of economic activity will be conducted online and be more scalable, inclusive and transparent than the equivalent 'analogue' businesses**
Digital payments and finance Digital access means that consumers and organisations can access finance more easily. Mobile money has made progress in connecting the unbanked to basic financial services[49] and SMEs to funds more quickly than traditional routes.[50] It also reduces remittance costs for migrant workers sending essential funds back to their families. Digital technologies offer new opportunities for financing business, too, for example through initial coin offerings[51] and crowdfunding.[52]	**Mobile money** Huawei offers a mobile money platform used by operators and banks internationally. Together, the services offered over the platform serve over 152 million users accounting for 22% of globally registered mobile money accounts and 50% of all transactions.[53]	**All people everywhere can access basic financial services to ensure their personal resilience and independence**

Monitor & Track

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030...
The environment IoT sensors enable accurate and real-time monitoring of the built and natural environment. Smart devices equipped to infrastructure (e.g. bridges) detect structural issues and alert the relevant authorities to improve the maintenance cycle.[54] Connected devices integrated in the waste management system expedite collection time by providing automatic updates to a central system.[55]	**Smart bins** Fujitsu has developed a Smart Bin solution to tackle e-waste recycling. When the Smart Bin detects it is full, it books its own collection slot with a courier to empty the bin. This makes e-waste recycling easy for companies, encouraging greater usage. On average, each bin diverts a tonne of e-waste from landfill annually.[56]	**Organisations can precisely measure their impact on the natural environment and intervene as appropriate**
Populations, people, and activities Digital technologies provide oversight of the activities and treatment of people, highlighting when systems are being exploited and impeding sustainable and inclusive growth. Blockchain technology has the potential to monitor the treatment of workers, through storing contracts and reports of working conditions.[57]	**Aggregated job ratings** Digital platforms collect feedback from employees on their workplace to build a picture about working conditions. Glassdoor, for example, hosts a database of workplace reviews and aggregates current and ex-employee opinions to rate employers.[58] This enables a 'race to the top' for employee engagement – improving working standards for all.	**Relationships between employers and employed are transparent, better, and based on robust and accurate data**
Organisations and supply chains Digital technologies provide greater transparency over supply chains, permitting traceability of products and reducing inefficiencies or downtime of machines. Digital technologies and cloud can be used to trace and verify the origin of products, as well as lowering the cost of logistics with precise supply chain mapping.[59] Likewise, smart logistics solutions, e.g. connected containers, allow individual batches to be monitored, reducing the risk of product or food wastage.[60] At an organisational level, digital technologies integrated into reporting processes allow accurate sustainability data collection.[61] Coupling blockchain with AI can also prevent fraudulent business activity, for example, tax evasion.[62]	**Monitor functionality of machines** AT&T has worked with Emerson to integrate IoT technology into its Grind2Energy solution. The solution converts food waste from grocery stores and restaurants into electricity or heat and fertiliser. AT&T connectivity helps to optimise the performance of the food grinders, reduce the downtime of the machines and improve the waste collection process. This solution is addressed in more detail within the AT&T case study. See AT&T case study for more (pg 196).	**Supply chains and industrial processes are transparent, allowing traceability and precise, robust performance and impact measurement**
Individual assets and rights Blockchain presents numerous opportunities to reinforce rights over identity and assets, enabling individuals to participate in a fair economy. Blockchain ledgers can store personal and biometric data to promote financial inclusion[63] and provide digital identities.[64] It can also be used to track the rights and transactions of digital creative work, ensuring the right person is credited when IP is distributed.[65]	**Secured digital identity** uPort is an identity and data platform built on Ethereum blockchain technology. It allows users to register a globally unique identifier and gives them control over their identity, private keys, user accounts and private data.[66] This technology secures the user's identity, providing immutable records with which to access finance.	**Individuals and organisations use digital identities and ledgers to enable transparency of ownership of all forms of property and secure finance**

Analyse, Optimise & Predict

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030...
Process Optimisation A combination of digital technologies can improve the efficiency of existing operations, driving cost reductions and better utilisation of resources. The integration of cloud and AI into business processes saves costs and time.[67] IoT sensors and AI modelling can optimise supply chain logistics, enabling reductions in emissions.[68] AI analysis of real-time data can lower food wastage amongst retailers.[69] For infrastructure planning, digitally-enabled building info modelling ('BIM') allows for sustainable and optimised designs.[70] Finally, AI algorithms integrated into reporting processes provide insight on the most critical ESG issues for organisations.[71]	**Dynamic pricing for waste reduction** Wasteless uses machine learning to track supermarket store inventories and update pricing according to sell-by date. Employees upload inventory data by using a smartphone app to scan deliveries of inventory and their respective expiration dates. This information is then collected and analysed in real time to adjust the shelf price automatically. Applying this technology reduced food waste generation by 33% in a recent case study.[72]	**Supply chains, industrial processes, utilities and amenities providers deploy AI and machine learning to ensure optimal efficiency**
Socio-ecological analysis and targeting AI algorithms can be employed to both track working conditions and better connect business operations to their socio-ecological impact. Advanced image recognition can detect exploitative treatment of workers through analysing satellite imagery (e.g. identifying areas of modern slavery).[73] In addition, cognitive technologies can scan satellite data to monitor and plan infrastructure and construction work.	**Detecting worker exploitation** Researchers at St Mary's University in London have demonstrated the importance of analysing satellite imagery to spotting areas of modern slavery.[74] This can be augmented by AI, such that areas can be detected automatically and more accurately.[75] Employment practices that can be detected in this way include human trafficking, child labour and forced labour.	**Policymakers, corporates and individuals use advanced imaging and analytics to analyse all forms of economic business activity in real time**
Rapid data analysis for innovation Machine learning and AI can optimise and enhance R&D processes. For example, deep learning has the potential to transform product R&D, accelerating innovation cycles.[76] It could soon be possible to enter a detailed innovation brief as an input into an AI algorithm, which then explores every possible configuration and hones in on a set of suggested solutions. The proposed solutions can then be tested using machine learning, offering additional insight as to which designs work best, are most sustainable and most climate friendly. These processes also often eliminate the need for physical prototyping, saving on raw materials.[77]	**Deep learning accelerating innovation** Google Brain is Google's deep learning research team, who are conducting research into deep learning and its potential application to product design and human life, with the aim of accelerating innovation and improving people's lives.[78] The team developed a real-time suggestions system, currently integrated in Gmail, that assists users to construct emails based on advanced machine learning and language recognition.[79]	**Organisations of all types have rapid innovation processes, creating new sources of value across the economy**
Future state prediction AI-enabled predictive models use historical data and physical asset data to predict events that could hinder productivity or affect worker safety. For example, smart management systems, using data from sensors installed in equipment, accurately predict the remaining useful life of machines.[80] Similar technology can also anticipate faults in equipment before they happen, improving workplace safety.[81]	**Predictive maintenance of oil wells** Santos, a leading oil and gas producer, developed predictive models that ingest data from connected assets and other sources, and give early warning of potential failures. By alerting engineers, the solution helps cut travel time and boost production output – potentially saving AUD 10 million a year.[82]	**Employers and regulators predict and prevent hazardous events occurring across the economy**

Augment & Autonomate

IMPACT FUNCTIONS	USE CASE EXAMPLE	BY 2030...
Augmented humans Digital technologies allow humans to navigate the real world with enhanced clarity, safety and efficiency. Wearables and mobile apps can support isolated groups in society, for example mobile accessibility apps that assist the blind.[83] In workplaces, AR wearables boost productivity by placing a virtual layer over real-world tasks[84] and improve the ability to repair machines to increase safety.[85]	**Wearables for the visually impaired** AT&T and Aira have worked together to deliver wearable technology, enabled by artificial intelligence, which can aid the blind and those with low vision. Using AI and with the help of a remote professional agent, the wearer can be provided with a real-time description of what is around them. They can also be used to access public transportation, navigate busy streets, shop in stores or recognise people, without needing another person to physically accompany them.[86]	**All people, no matter where they are or their accessibility needs, can participate in the economy**
Immersive experiences to aid human development and decision making VR technology can simulate entire environments, allowing humans to experience realities that were previously inaccessible or intangible. Virtual trips provide a gateway to secluded members of society, for example the elderly[87] or vulnerable children[88], to new places and experiences. Workers can use VR for training, for example practising potentially hazardous procedures to reduce injury risk. VR also speeds up production cycles through virtual prototyping, saving costs and excessive material usage.[89]	**VR-designed infrastructure** Arup total design VR solutions can accelerate infrastructure programmes and provide far richer data sets, by creating 3D mesh models, complete with topographical and infrastructure features, which can help assist with concept designs, construction reviews and ongoing asset management. This allows infrastructure projects to be faster, cheaper, and more accurate than before. It also improves the sustainability of such projects, saving on emissions and raw materials through virtualising once physical prototype cycles. [90]	**All physical products and structures are first built virtually, allowing designers, employees and the wider public to trial their efficacy while minimising resource usage**
Autonomous processes and machines Through real-time data processing and machine learning, autonomous machines assimilate data from their environment (be it physical or digital) and carry out processes with minimal human intervention. This greatly improves productivity and allows people to focus on tasks that require more creativity or human-centric approaches. Organisations use intelligent automation systems to automate IT processes[91], improve the efficacy, quality and rate of recycling[92], and to operate manufacturing lines.[93] In particular, robotics are now used across a number of sectors to increase productivity and improve customer experience.[94] Autonomous systems also encourage the fluid movement of finance[95] and people,[96] which can in turn expand sustainable and global economic growth.	**Autonomous manufacturing** By the end of 2018, there were more than 1.3 million industrial robots at work in factories all over the world, driving increased productivity, uptime, and quality, as well as reduced costs and waste.[97] A leading electronics company used a fully automated production system, complete with integrated machine control. The benefits of this automation included lower lead times for customers and lower overall costs, along with production capacity improvement of 25% and 50 % fewer defective products.[98] The continuing adoption of this and other industry 4.0 technologies in factories will increase the value of manufacturing activities.	**All mundane and back-end tasks are performed by machines, while humans are employed to perform the most stimulating and creative work**

8 DECENT WORK AND ECONOMIC GROWTH

SDG 8

Decent Work and Economic Growth

The SDG 8 targets can be split into three main sub-groupings. Inclusive and sustainable economic growth (target cluster 1: 8.1, 8.2, 8.4 and 8.A) aims to secure sustained per capita economic growth across all countries; in particular, it targets 7% growth in output for least-developed countries. This is directly supported by increased productivity, resource efficiency and Aid for Trade. Increased employment (target cluster 2: 8.5, 8.6, 8.9 and 8.B) targets full and productive employment for all, with specific reference to youth employment and training. Decent work (target cluster 3: 8.3, 8.7 and 8.8) targets working conditions and issues such as modern slavery, child and forced labour. Inclusive and sustainable economic growth is also supported by financial inclusion (target cluster 4: 8.10).

Despite low international unemployment and rising labour productivity, growth across developed and developing countries remains low relative to the period pre-financial crisis. Youth unemployment and informal employment persist as concerns and many workers, particularly in developing countries, experience poor and unsafe working conditions. The world must act to ensure that these concerns are addressed as part of a wider effort to promote sustainable growth and decent work available to all to 2030.

Digital technologies have become embedded in economies and are key to driving growth through market access, innovation and greater productivity; principally through connectivity and augmentation. They also drive improved allocation and use of people's time and labour through flexible working and 'gig economy' platforms. Making workplaces safe and monitoring practices such as modern slavery are also enhanced by digital technologies. In addition, mobile money has fundamentally transformed access to financial services for many, and become a key driver of greater financial inclusion.

In the future, it is expected that augmentation and autonomation will drive increasing productivity and growth. Connectivity-based solutions such as apps and platforms will continue to support employment and advances in monitoring and tracking digital technologies such as blockchain will be of most use to ensuring decent work and ending poor labour practices. Digital technologies' role in driving financial inclusion has principally been driven by increased connectivity; however in the future this may shift towards augmented and autonomated processes and transactions.

Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Inclusive and sustainable economic growth					
8.1 Sustain per capita economic growth	🟥 1	2			UN Global Compact has established a global opportunity explorer that helps business leaders, entrepreneurs and investors connect with new partners, projects, markets and talents.[99]
8.2 Achieve higher levels of economic productivity	3		2	🟥 1	GE is applying augmented reality across its businesses to deliver information to workers, enabling them to engage with processes in smarter and more innovative ways.[100]
8.4 Improve global resource efficiency in consumption and production[101]	3		2	🟥 1	Analysis by Deloitte indicates that 93% of public cloud users experience operational efficiencies, driven predominantly by timesavings enabled by cloud.[102]
2. Increased employment					
8.5 Full and productive employment and decent work for all	🟥 1		2		Bilforon is a food delivery platform in Jordan which enables people, including female refugees, to sell home-cooked food in order to generate an income.[103]
8.6 Reduce youth NEET	🟥 1		2		Applied is a UK jobs platform which uses behavioural and data science to remove bias from hiring decisions and make recruitment fairer and more diverse.[104]
3. Decent work					
8.7 End forced labour, modern slavery, human trafficking and the worst forms of child labour		🟥 1	2		The US State Department and Coca Cola are working on a project to create a secure registry for workers' contracts using blockchain technology.[105]
8.8 Protect labour rights and promote safe and secure working environments		🟥 2	1		Industrial use of augmented reality smart glasses provides machine operators, maintenance and repair service workers with key information that can improve repair of machines and ultimately worker safety.[106]
4. Financial Inclusion					
8.10 Encourage and expand access to banking, insurance and financial services for all	1	3		🟥 2	Amdocs provides a mobile financial services platform which enables banks, operators and service providers to provide mobile financial services to customers. The solution covers digital payments, digital banking and connected money.[107]

1	2	🟥 3	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C Connect & Communicate
M&T Monitor & Track
AOP Analyse, Optimise & Predict
A&A Augment & Autonomate

10 REDUCED INEQUALITIES

SDG 10

Reduced Inequalities

The main focus of SDG 10 is the overall reduction in economic, social and political inequalities (target cluster 1: 10.1 and 10.2). The remaining targets support this through a focus on components that are key to reducing inequality. The experience of migrants (target cluster 2: 10.7 and 10.C) is important in enabling the inclusion of all. In addition, providing sufficient support and inclusion of developing countries (target cluster 3: 10.A, 10.B and 10.6) will help these countries tackle inequality both within and between countries. Furthermore, the policy and legal environment (target cluster 4: 10.3, 10.4 and 10.5) must itself be non-discriminatory and provide adequate support for the most vulnerable.

Inequality is generally on the rise, despite gains in reducing poverty, with a lower share of incomes going to the poor even as their absolute incomes rise. The UN finds wide disparities between and within countries in access to basic services e.g. health and education. At a local level, extreme inequality can be found in cities around the world.[108]

Digital technologies have a key role to play in addressing inequality. Mobile money is increasing financial inclusion, which leads to greater levels of incomes, savings and access to finance. In addition, it is driving down remittance costs. Connectivity and communication promote inclusion and economic, political and social participation. Digital technologies also help in combatting inequalities affecting the disabled and elderly. Furthermore, digital technology has become an essential part of safe and well-managed migration, in which its role is expected to increase.

In the future, it is expected that connectivity will continue to drive relative income growth of the poor and drive down remittance costs. However, digital technologies for augmentation will play an increasing role in fostering inclusion. As they become further developed, monitoring and tracking technologies will be increasingly important for managing migration well and safely.

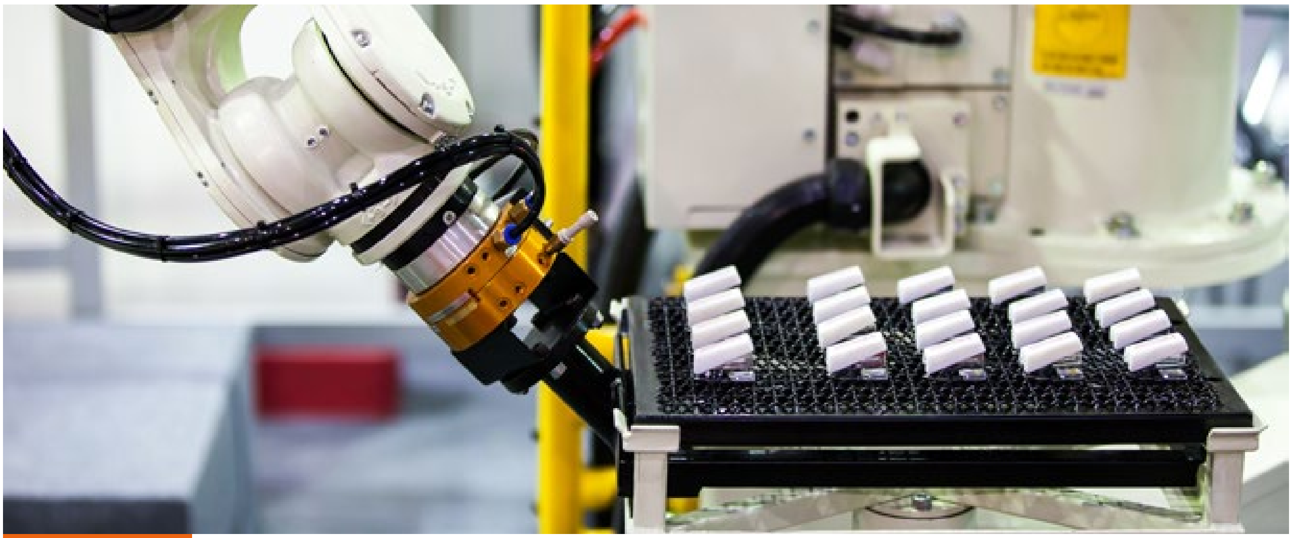
Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
Economic, social and political inequalities					
10.1 Achieve income growth of bottom 40% at a higher rate than national average	1				Huawei offers a mobile money platform used by operators and banks internationally. Together, the services offered over the platform serve over 152 million users, accounting for 22% of globally registered mobile money accounts and 50% of all transactions.[109]
10.2 Promote inclusion of all	1			2	Sho is a real-time translation service in Sweden aimed at fostering inclusion where people from different backgrounds that speak different languages can come together to connect and make friends.[110]
Improved experience of migrants					
10.7 Facilitate orderly, safe, regular and responsible migration of people	1	3		2	MigApp is a service developed by the UN's International Organisation for Migration that provides information, notifications and access to services to migrants via smartphones.[111]
10.C Reduce the transaction cost of migrant remittances to less than 3%	1			2	SimbaPay uses an AI-powered chatbot service that allows users to order remittances by SMS. Users provide the recipient's phone number and then the AI obtains bank details and processes the transaction.[112]

1	2	3	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

SDG 9

Industry, Innovation and Infrastructure

SDG 9 addresses three important aspects of sustainable development: firstly, to ensure sustainable industrialisation through boosting industrial productivity whilst reducing CO2 emissions per unit of productivity (target cluster 1: 9.2 and 9.4), assisted by fostering innovation and enhancing R&D (target cluster 2: 9.5 and 9.B) and the development of sustainable and resilient infrastructure (target cluster 3: 9.1 and 9A). The two remaining targets, access to finance for SME and small-scale industries (9.3) and access to ICT (9.C), in particular the internet, are critical enablers of all three clusters, as well as of economic growth and sustainable development more broadly.

In the face of a rapidly changing global economic landscape and widening inequalities, sustained economic growth must include industrialisation that is inclusive, sustainable and productive.[113] However, benefits are currently unevenly distributed. Industry's economic value add per capita in Europe and North America is $4,500, but only $100 in least-developed countries (LDCs), and R&D expenditure follows a similar pattern.[114] Poor access to basic infrastructure remains a major barrier to industrialisation and diversification in developing countries.[115] Progress against SDG 9 must be accelerated, as it will facilitate the fulfilment of many other SDG themes including job creation, technology and skills development, food security, resilient cities, green technologies, and climate change mitigation.[116]

Digital technologies are already commonplace in industry and manufacturing, and in the construction of infrastructure. A combination of IoT sensors and algorithms are most common, allowing for various improvements in production lines and supply chains, including monitoring of product faults and quality, optimisation of productivity and delivery routes, and prediction of machine failure. Digital access, VR/AR and cloud are all facilitating rapid innovation cycles and business scalability. In addition, mobile money, crowdfunding and Bitcoin all represent digitally-enabled methods for SMEs to secure credit to enable continued growth.

Autonomation and augmentation of industry is expected to be the largest focus of activity going forward, with 3D printing, robotics and AR/VR driving increasing productivity and growth. However, as this occurs, reshoring of industry from developing countries back to developed countries could take place and stagnate industrialisation in developing countries; this must be carefully managed. Digitally-enabled monitoring of existing infrastructure and optimised design of new infrastructure is expected to accelerate, improving quality and access to infrastructure. Finally, digital technologies will continue to connect the unconnected to the internet and to financing.

Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Ensure sustainable industrialisation					
9.2 Promote inclusive industrialisation and raise industry's share of GDP		3	1	2	Microsoft's AR HoloLens has been used to improve productivity in spacecraft manufacturing, helping workers mark fastener locations and reducing a two-day task down to two and a half hours.[117]
9.4 Upgrade industries to increase sustainability and resource efficiency		3	1	2	Bell worked with other technology innovators such as BeWhere and Trak-iT on the first fleet management and asset tracking solution delivered exclusively over Bell's LTE-M network.[118]
2. Foster innovation and enhance R&D					
9.5 Enhance R&D, tech capabilities and innovation of industrial sectors	1	4	3	2	Climate-KIC's Climathon is a year-round innovation and hackathon platform, translating climate action solutions into tangible projects and addressing policy changes.[119]
3. Develop sustainable and resilient infrastructure					
9.1 Develop quality, reliable, sustainable and resilience infrastructure	3	4	1	2	A bridge in Amsterdam is equipped with IoT sensors that monitor the structural integrity of the bridge, streaming data and maintenance alerts to the cloud to pre-empt failures.[120]
4. Enabling targets					
9.3 Increase access of small-scale industrial enterprises to financial services	1				Bitbond is the first global lending platform for small business loans. They use blockchain to connect creditworthy borrowers with investors, delivering instant, secure funding.[121]
9.C Increase access to ICT and the internet, in developing countries especially	1				Huawei has worked in more than 50 countries to deploy their RuralStar solution, designed specifically to bring affordable mobile network connections to remote areas. By the end of 2018, RuralStar had covered 40 million rural residents that previously had no access to internet.[122]

1	2	3	4
MOST			**LEAST**

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate

SDG 12

Responsible consumption and production

Responsible treatment of resources (target cluster 1: 12.2) is the central aim of SDG 12, which aims to decouple material usage from economic growth. Reducing global waste (target cluster 2: 12.3, 12.4 and 12.5) is closely linked to this, for example, improved recycling rates will tend to lead to more sustainable use of natural resources. Commitment to responsible practices (target cluster 3: 12.1, 12.6 and 12.A) will drive progress against these aims, promoting better resource management in the private and public sector. Additionally, public sustainability initiatives (target cluster 4: 12.7, 12.8, 12.B and 12.C) can encourage and enforce responsible treatment of resources.

Economic growth is still matched by rising material use. As the world continues to advance, it seems likely that irreversible environmental damage will be caused unless this can be corrected. To address this, economies must move away from traditional linear models of production to circular models, and develop effective methods for measuring the impact of economic growth. Achieving SDG 12 will be of great benefit for both current and future generations (if not imperative) and ensure that economic growth can be maintained sustainably.

Digital technologies make supply chains transparent and verifiable. This provides a tangible link between consumption choices at the point of sale and the impact made by the rest of the supply chain, influencing more sustainable consumption and production choices, and realising the development of circular business models. Additionally, digital technologies create platforms and communities that allow the sharing and recycling of surplus goods, providing an outlet for what would have previously been landfill waste.

In the future, it is expected that digital technologies will be used across supply chains to give verifiable oversight of a product's origin and condition. Additionally, AI-driven data analytics may be fully incorporated into supply chains and sustainability reporting, promoting transparency and the ability to accurately measure the impact of human consumption. Digital marketplaces and mobile apps will continue to allow people to connect to exchange knowledge and products, promoting improved resource utilisation.

Target level impact function mapping

TARGET	C&C	M&T	AOP	A&A	EXAMPLE
1. Responsible treatment of resources					
12.2 Sustainable use of resources	1	2		3	US car sharing firm Getaround is a peer-to-peer car rental service. It offers an easy way for sharing goods, reducing demand for further resource extraction for car production.[123]
2. Reduce global waste					
12.3 Halve global food waste	3	1	2		Wasteless is a company using machine-learning to track store inventories and update pricing according to sell-by date, thereby reducing food waste generated by retailers.[124]
12.5 Reduce waste generation	1	2	4	3	Fujitsu has developed a Smart Bin solution to tackle e-waste recycling. When the Smart Bin detects it is full, it books its own collection slot with a courier to empty the bin.[125]
3. Commit to responsible practices					
12.6 Companies adopt sustainable practices	2	1	3		The Open SDG Data Hub collects all authoritative SDG data sources in one place, allowing businesses to easily view progress against the SDGs and their targets.[126]

1	2	3	4
MOST			LEAST

Numbers indicate relative weight of use cases identified.
Grey shading indicates no use cases identified.
Coloured shading indicates expected focus of activity going forward.

C&C	Connect & Communicate
M&T	Monitor & Track
AOP	Analyse, Optimise & Predict
A&A	Augment & Autonomate

System interactions

An inclusive and sustainable economy characterised by shared prosperity is a key driver of sustainable development. It enables resources to be mobilised towards strengthening the biosphere and supports building a more inclusive society.

However, achieving some economy goals may involve trade-offs with the biosphere and society, particularly if economic development is pursued without considering the environmental or social cost. For instance, greater industrialisation, while good for economic growth, will need radical transformation to prevent greater amounts of GHG emissions being released and more ecosystems being damaged as industrial and natural resource collecting activity expands. In addition, without addressing inequalities and shared access to essential services, higher economic growth will exacerbate divides, increasing relative poverty. This could lead to a breakdown in social fabric around the world.

Negative externalities: impact of digital technologies

While greater adoption of digital technologies will be important for achieving economic development, this could also put some of the economy targets at risk. In particular, wider, but uneven, digital adoption could lead to even greater inequality, both between and within countries. This could arise if the 'digital divides' that exist today are not addressed, i.e. if people do not have the resources and skills required to use and fully benefit from digital technologies, and developing countries do not have the underlying infrastructure, research base and human capital that adopting digital technologies at a large-scale demands. Accounting for the digital divide may require a 'delocalisation' of the benefit of digital technologies, where the direct beneficiaries from use of digital technologies share these benefits with non-users. For example, researchers can share the insight and analytical capabilities of AI models with decision makers in developing countries, where the skills and infrastructure to build and use these models may be lacking.

The uptake of digital technologies can also lead to an increase in consumption and consumerism, through both established digital marketing channels and new approaches such as selling holidays using digital reality systems. However, the extent to which advertising actually increases overall levels of consumption, as opposed to just prompting a switch in brand choice, is unclear.[127] The ICT industry itself might also promote increased consumption of digital technologies, by reducing the life cycles of digital technologies through more frequent replacements and upgrades, prompting consumers to buy new devices more often. There is evidence that the life cycle of digital technologies is falling over time.[128] Increased consumerism and consumption, unless circular business models are adopted, increases raw material usage, e-waste generation and emissions.

There are also concerns that wider adoption of digital technologies, particularly those related to automation, will lead to job displacement and polarisation of the workforce, leading to reduced employment and higher inequality. Jobs carried out by the young and women have been identified as particularly at risk.[129] Another aspect to this is the reshoring of certain activity (e.g. manufacturing) in developed countries, which could increase unemployment in developing countries and hold back economic progress, ultimately leading to greater international inequality. This may occur if automation begins to replace labour-intensive work, thus eroding the cost advantage of locating jobs in developing countries.[130]

Other concerns directly affecting the economy goals include hidden bias within AI and the spread of misinformation. Digital technologies should not impinge on the rights of workers nor create division amongst populations, yet there is a risk that these issues could hinder progress towards equitable economies.

A further risk presented by increased reliance on digital technologies is threat of cyber attacks. Cyber attacks not only cause short-term damage (e.g. reduced productivity or loss of data), but can create significant long-term issues, such as reduced trust in organisations and misuse of personal data.[131] The impact on the economy is massive; a report by ForgeRock found that cyber attacks cost US businesses $654 billion in 2018.[132] Furthermore, as organisations become more dependent on digital technologies, the potential risks will grow. It is estimated that some criminals can execute cyber attacks for $34 a month (with the potential gains exponentially higher).[133] Organisations must invest in appropriate and substantial cyber security to minimise these risks.

As digital technologies become ever more deeply integrated into work, industry and the economy more widely, it will be important to decouple the economic growth they generate from the environmental degradation with which growth has traditionally been associated, in particular through the implementation of a circular economy, and circular business models. For instance, without this decoupling, increasing use of digital technologies for industrialisation may increase emissions both directly, with energy required to run these technologies, and indirectly, through accelerating overall productivity and therefore energy use. In addition, shortening lifespans of digital devices will, without radical intervention, increase the volume of e-waste and resource extraction to potentially unsustainable levels.

It will continue to be difficult to boost economic growth and industrialisation, and reduce inequality while combatting climate change and environmental degradation. However, increasing transparency across economic activities, led by digital technologies, is moving the world closer to equitable markets, where the true impacts on society and the biosphere are accounted for. Additionally, open information exchange will allow individuals, industry, and government to harness the benefits of innovation to augment sustainable growth. Government policy and organisational strategy must recognise, prioritise and endorse cross-sector collaboration to achieve the economy SDGs. Furthermore, those who benefit from digital transformation have a responsibility to help those who suffer to ensure no one is left behind. With the right tools and intent, the world can achieve fair and sustainable growth.

03

Sectors

Introduction

For digital technologies to be developed and deployed for the achievement of the SDGs, the ICT sector must collaborate with partner sectors across the economy. This chapter explores the opportunities for delivering impact within eight partner sectors, drawing from sector-specific use cases and activities identified in the 17 SDG deep dives, which can be explored in more detail at the end of this report.

Partner Sectors[1]

Government and public sector – includes health and social care, defence, security and justice, regional and civil government.

Financial services – includes banking, insurance, investment and real estate management, development and equity investments trusts.

Agriculture and fisheries – includes agriculture, plantations, fisheries and aquaculture.

Life science and health care – includes health care providers, medical suppliers, pharmaceuticals and biotechnology.

Consumer products and industrials – includes automotive, consumer products, retail, wholesale, hospitality and services, industrial products and construction.

Transport and logistics – includes road, train and maritime-based distribution, as well as public and private transport.

Energy, extractives and utilities – includes oil & gas producers, equipment, and services distribution as well as alternative energy, fuels and renewables.

Travel and Tourism – includes hotels, catering and tourism services, as well as recreational aviation.

The eight sectors have been selected and categorised, in part, to reflect the emphasis of the SDGs. Indeed, some SDG targets explicitly refer to individual sectors in the economy. Whilst other targets do not call out specific sector involvement, they often include an implicit indication that the responsibility and opportunity for realising the target rests with a particular sector.

This chapter lays out a set of priority SDG targets and key actions for each sector to consider, reflecting the intersection of their core business activity and the potential deployment of digital technologies for impact.

Government and public sector is the first critical partner sector, with links across the 2030 Agenda and responsibility for policy making on SDG delivery and country-level SDG impact reporting. Each further sector is then explored in alphabetical order. The opportunities and responsibilities of the Technology Media and Telecoms (TMT) sector are covered throughout the rest of this report.

Government and public sector

The public sector has a specific remit associated with a proportion of the SDG targets, and is a key enabler for other sectors to achieve the 2030 Agenda through the provision of investment, policy and legislation. Country borders have only ever gone so far in defining societal issues faced by government, but as the world becomes increasingly interconnected, disruptive actors, both positive and negative, have made tackling these issues even more challenging. Climate change, poverty, migration, and pollution are multi-jurisdictional, inter-related and complex to solve. No single government is capable of solving such issues, so increasingly greater levels of international cooperation is required to build towards solutions.

The shape, size and scope of the public sector differs by country, but certain functions are common, for example, basic government services such as providing identities, providing benefits to citizens, granting and upholding land rights, managing borders, basic education and public health messaging. Digital technologies, particularly when paired with effective policy and financing, provide critical support to governments as they work towards delivering impact in these areas.

There are three key areas in which the sector can develop and deploy digital technology for the achievement of the SDGs: basic government services, sustainable urban development and managing the natural environment.

Basic government services require digital access to modernise service provision, improve security, and to improve the functioning of the organisations that deliver services. Sustainable urban development requires technologies to monitor and track pollution and waste, and provide solutions for improving urban planning. Digital technologies can also be used to plan, track and manage climate change and natural disasters.

The public sector offers support to a number of other sectors where it is not the primary stakeholder. As such, the public sector will be referenced throughout this chapter as a key supporting actor to the other seven partner sectors.

Basic government services

A well-functioning government forms the fundamental basis for an inclusive, peaceful, and just society. It provides basic services to meet human rights, facilitates more advanced development initiatives, and enables private sector investment. Basic services include verification of personal identity, provision of land rights, effective institutions, basic education, public health and a binding rule of law. Whilst utilities, including energy and water, are frequently state provisioned, these are covered within the discussion on the energy, extractives and utilities sector.

OPPORTUNITIES TO CONTRIBUTE

Provision of unique identity

Having a unique identity is a fundamental human right.[2] This assertion of existence affords an individual the ability to exercise their right to access government services. Currently, one billion people do not have official proof of identity.[3]

The need for legal identity underpins a number of SDGs, but is most directly linked to:

Target 16.9: Provide legal identity for all, including birth registration

Target 1.3: Ensure equal rights to economic / tech resources and basic services

ROLE OF DIGITAL TECHNOLOGIES

Digital identities are more verifiable, and potentially more secure than paper-based records. The complexity of solutions varies, from simple digital database records to blockchain / AI-based offerings:

- Digital technologies are a key solution for registering births. Optimising the process of birth registration can reduce cost and time commitments.
- Digital identification systems for refugees who have been stripped of all identity documents are increasingly implemented by multi-national organisations. This helps avoid corruption and increases efficiency in processing, but requires high levels of security.

Provision of cash benefits

Providing cash transfers is the simplest means for a government to distribute monetary benefits to its citizens. Only 45% of the global population are effectively covered by at least one social protection benefit, while 55% are unprotected.[4]

Cash transfers are a key way to reduce poverty, impacting targets in SDG 1:

Target 1.1: Eradicate extreme poverty (those living on under $1.90 a day)

Target 1.2: Reduce by at least half the number of those living in poverty

ROLE OF DIGITAL TECHNOLOGIES

Digital technologies can fundamentally alter the means and therefore speed by which those living in poverty receive cash transfers:

- Governments are able to use digital access to directly transfer social security payments and benefits to the poorest in society using mobile transfers. Digitalising this process results in quick transfers, and a lower risk of payments not reaching the intended recipient. In particular, if paired with a digital identity, there are clear audit trails.

Securing of land rights

Land rights are critical for promoting the self-reliance of people in developing countries, increasing the potential for food security and poverty alleviation.[5] Nearly 70% of the global population does not have access to land registration systems,[6] preventing them from using secured property to take out loans, start businesses and grow crops for self-subsistence.[7]

SDGs related to this opportunity call for:

Target 1.4: Ensure equal rights to economic / tech resources and basic services

Target 2.3: Double productivity and increase incomes of small-scale food producers

ROLE OF DIGITAL TECHNOLOGIES

Land rights are complex and influenced by national and state law, customs, traditions and history.[8] Developing digital land registries provides the means to establish, track and transfer land rights:

- Digitising land records rapidly increases the speed at which information can be accessed, and reduces disputes. Increased speed of access also enables individuals to benefit from land ownership sooner.
- Blockchain can store immutable and permanent records for land ownership and property exchanges. This is particularly significant in areas where land grabbing is common, and public records are easily lost or subject to alteration.

Provision of public health services

Provision of public health services allows governments to lessen their nation's disease burden. Both communicable and non-communicable diseases are costly, deadly, and to an extent preventable. Deaths from lack of high-quality medical care cost the world over $6 trillion in 2015 alone.[9]

SDGs targeting this are:

Target 3.1: Reduce maternal mortality

Target 3.2: Reduce neonatal and under-5 mortality

Target 3.3: End epidemics of communicable diseases

Target 3.4: Reduce non-communicable disease mortality and promote mental health and well-being

ROLE OF DIGITAL TECHNOLOGIES

Governments and their associated regulatory bodies can utilise digital technologies to spread awareness, as well as prevent, predict and control the spread of diseases. Key activities for this include:

- Using connected devices to monitor national and global health risks.
- Providing information and reports on epidemics through digital access.
- Analysing data to map the spread of disease so that regions or populations at risk can be identified.

Also see the section on life sciences and health care.

Facilitate the safe, consenting and managed movement of people

It is estimated there are around 258 million international migrants,[10] as well as 26 million refugees globally.[11] Managing and tracking this flow of people, whilst acting to reduce exploitation and trafficking is a challenging and critical role for governments.

SDGs in this area call for:

Target 10.7: Facilitate orderly, safe, regular and responsible migration of people

Target 5.2: Eliminate violence against women i.e. trafficking and sexual exploitation

Target 16.2: End abuse, exploitation, trafficking and all forms of violence against and torture of children

ROLE OF DIGITAL TECHNOLOGIES

The digital provision of a verifiable identity is key to managing the legal movement of people. However, technology can go further towards monitoring movement at borders, improving the migration experience, and working to reduce trafficking:

- Digital identity, based on digital access or blockchain technology can be used to give migrants and refugees digital identification to facilitate border crossings and improve administrative processes.
- Aggregation of digital footprints can identify risk to individuals and potential perpetrators.
- Digital technologies such as AI and blockchain are being used to assist with the enhanced efficacy and efficiency of the administration and processes that facilitate orderly migration.

Improve literacy through universal access to education

Universal access to education remains a challenge. Over 250 million children and youths are currently out of school, including 64 million of primary school age.[12]

The SDGs call for achieving universal access and improving literacy:

Target 4.1: Increase access to primary and secondary education

Target 4.6: Achieve universal literacy and numeracy

ROLE OF DIGITAL TECHNOLOGIES

Governments can have a positive impact in the provision of basic education by deploying digital technologies to reach those unable to access quality, in-classroom learning. Key activities include:

- Provision of online educational content for direct pupil learning, particularly for those far from in-classroom learning.
- Provision of online educational resources to support teachers and other community figures.

Promote just and inclusive societies

Ensuring the enforcement of justice, and effective, transparent institutions is critical to guarantee a fair government. Globally, 5 billion people have unmet justice needs.[13]

A number of SDG targets address this theme:

Target 16.3: Promote the rule of law and ensure equal access to justice for all

Target 16.6: Develop effective, accountable and transparent institutions at all levels

Target 16.5: Substantially reduce corruption and bribery in all of their forms.

ROLE OF DIGITAL TECHNOLOGIES

When used appropriately, digital access and digital technologies may be a means to fight against corruption and improve law enforcement. They can increase both access to information and broader transparency. For example:

- Digital access provides greater access to legal information, expertise and representation.
- AI can be used to analyse unstructured data to identify patterns and anomalies, flagging risks of bribery and corruption.
- Digital technologies can be deployed to increase the transparency and traceability of law enforcement activity and improve the ability of the public to report risk and crime.

Sustainable urban development

A hallmark of economic development is the rising proportion of populations concentrated in cities. This rapid urbanisation creates multiple challenges for governments, from providing adequate housing and managing waste and pollution levels, to ensuring inclusive, sustainable urbanisation and planning capacity. Realising these short and medium term social needs of citizens must be balanced with a sustainable path for development.

OPPORTUNITIES TO CONTRIBUTE

Ensure access to adequate, safe and affordable housing

Housing is a global challenge; the number of people living in slums has increased to 882 million,[14] and in developed countries house prices have risen at three times the price of other basic services.[15]

SDGs targeting this are focused in 1 and 11:

Target 11.1: Ensure access to adequate, safe and affordable housing and upgrade slums

Target 1.4: Ensure equal rights to economic / tech resources and basic services

ROLE OF DIGITAL TECHNOLOGIES

Establishing the principle of land rights is the first step toward securing appropriate housing. However, digital technologies can enable governments to go further:

- AI applied to drone or satellite images can help identify insecure housing conditions. This can lead to targeted interventions for individuals in need of housing.
- AI can model efficient housing design options, leading to faster planning, reduced building fees and less use of materials.
- IoT can be deployed through 'smart home' technology to monitor and track conditions.

Ensure inclusive and sustainable urbanisation and planning capacity

Inclusive urban planning is vital for sustainable urban development. However, just 48% of cities currently engage civil society prior to building urban developments.[16]

SDG targets focus on the role of government to incorporate citizens into planning:

Target 11.1: Ensure inclusive and sustainable urbanisation and planning capacity

ROLE OF DIGITAL TECHNOLOGIES

Digital technologies facilitate participatory and inclusive urban planning to allow citizens to communicate preferences and to register concerns:

- Digital access can help make cities more inclusive for those with disabilities, or other diverse minority needs, through transforming how they receive information.
- Digital access connects citizens to the urban planning processes, through apps and phone / internet based engagement and consultations.
- AR / VR headsets improve urban design, making the design process more interactive.

Managing waste and pollution

Governments have a particular responsibility to manage, track, monitor and legislate against air pollution and improper dumping of waste. The scale of the problem is vast. In 2016, 91% of the urban population worldwide were breathing air that did not meet the WHO air quality guidelines for particulate matter also known as PM2.5, resulting in an estimated 4.2 million premature deaths that year.[17] Food waste is covered in the section on Agriculture.

Management of waste and pollution impacts on SDGs in 11 and 13:

Target 11.6: Reduce the adverse per capita impact of cities (inc. air quality and waste management)

Target 13.2: Integrate climate change measures into national policy

ROLE OF DIGITAL TECHNOLOGIES

Governments need to directly monitor and track air quality, and from this can produce policies or issue executive directives to reduce pollution. The public sector is also typically in charge of waste management. Digital technologies can particularly support in monitoring and tracking waste and pollution, for example:

- Sensors installed around cities can monitor and map air pollution levels in real time, providing accurate feedback.
- Sensors can also monitor waste levels, and enable optimised waste collection routing. Sensors on waste bins combined with AI-enabled dynamic routing of waste collection routes improves management and reduces environmental impact.

Managing the natural environment

Without adequately dealing with the causes of climate change and its costly and deadly impacts, attempts by the public sector to improve the quality of life of citizens will be stymied. Governments must be accountable for their own emissions and support international climate agreements. There is also a responsibility to support other sectors and in particular hold them to account for taking action to reduce CO2 emissions. A key example is investment in renewable energy and implementation of the smart grid – as discussed in the section on the Energy, Extractives and Utilities sector. Disaster management is a separate, but related, discipline where digital technologies will be critical for success and where the public sector typically plays a more direct role.

OPPORTUNITIES TO CONTRIBUTE

Preparing populations for disasters

Disasters are increasing and becoming more costly. For example, 2017 natural disasters including hurricanes, earthquakes, and wildfires cost $306 billion worldwide, nearly double 2016's cost of $188 billion.[18] From 2007-2017 the average year has seen 354 disasters, 68,000 deaths and 210 million people affected.[19]

SDGs dealing with this target are spread across 11, 13 and 1:

Target 1.5: Build resilience and reduce the poor's vulnerability to climatic events

Target 11.5: Reduce the number of deaths and loss to GDP caused by disaster

Target 13.1: Strengthen resilience to natural hazards

ROLE OF DIGITAL TECHNOLOGIES

Digital technologies have a powerful impact on governments' ability to plan, track and respond to disasters:

- Mobile devices raise citizens' disaster awareness, promoting a culture of disaster prevention and responsible citizenship. Mobile devices also enable governments to send out targeted early warning systems.
- Sensors are able to monitor hazards, and can be combined with AI and analytics to predict occurrence, and to model potential impacts.
- IoT-enabled smart drains monitor and react to water conditions, leading to a reduced risk of flooding.
- Real-time analytics inform disaster response through victim locating, and AI classification of social media messages and images.

Improve education, awareness and capacity to act

Developing countries in particular still lack the necessary financial and technical resources to undertake action on climate change. Capturing the extent of the issue is challenging as there is no globally-agreed methodology to track capacity building.

Supported by policy targets, one target aims to rectify this:

Target 13.3: Improve human / institutional capacity to mitigate and adapt

ROLE OF DIGITAL TECHNOLOGIES

Implementing digital technologies will go some way towards improving the capacity of countries to deal with climate change, as the public sector can:

- Use digital access to increase public understanding of the magnitude and effect of climate change.
- Deploy AI to improve long-term climate model projections.
- eLearning to raise awareness of which behaviours can reduce footprints

The public sector must use a range of digital technologies in order to successfully manage the challenges of a modern government. However, by definition of its remit, the public sector can go deeper and further than any other sector due to its legislative power, as well as the international funding and cooperation to support the 2030 Agenda. The government has a responsibility to work in partnership with the private sector to achieve these aims and deliver better, digitally-enabled public services.

At the international level, collaboration and funding towards a shared agenda must drive global change, ensuring no nation is left behind in the pursuit of the SDGs. The transfer of technology and expertise from more developed countries into developing ones is also critical to improve the capacity of all nations to deal with climate change and development challenges. Each nation must pursue sustainable, inclusive development through budget allocation and legislation. This requires political tenacity and commitment to ensure each country tracks an appropriate path.

A combination of digital technologies and a pivot towards the large-scale system transformation required from governments will be imperative to ensure the funding, policy and technological capability is present for the 2030 Agenda to be achieved.

Keep reading: see deep dives on SDGs 1, 3, 4, 5, 10, 11, 13 and 16

Agriculture and fisheries

The influence of the agriculture and fisheries sector extends across the SDG Agenda, but has specific relevance to SDGs 2 and 14 which include targets relating to sustainable and productive farms and fisheries and increasing the incomes and market access of small-hold farmers and fishers. The sector is a key enabler of a number of other development outcomes, in particular job creation and poverty reduction.[20]

The introduction of high yield varieties, chemical fertilisers and basic mechanisation have all boosted agricultural and fishery productivity over the past few decades. However, increases in productivity have come with large environmental costs, including freshwater withdrawals, marine pollution, soil degradation, biodiversity loss, decreasing fish stocks and high levels of greenhouse gas emissions.[21] Many farmers and fishers still lack access to markets, credit and knowledge, operate unsustainably and are increasingly vulnerable to climate change. Growing populations are putting increasing pressure on food production systems, with food output required to increase by 70% in order to ensure the population in 2050 does not go hungry.[22]

The world's food production systems are now reaching a tipping point. In order to ensure sufficient food is available whilst the integrity of the biosphere is protected, the Agriculture and Fisheries sector must take action, fast. The sector can deploy digital technologies to ensure resilience and productivity of these systems in three main ways: (i) ensuring farmers and fishers have the knowledge, capacity and finances available to thrive, (ii) improving the monitoring and forecasting of harmful fishing activities, weather events and food yield, and (iii) increasing productivity whilst reducing use of resources.

OPPORTUNITIES TO CONTRIBUTE

Access to markets, finances and information

Access to markets, finances and pricing information is crucial for sustainable development, as 40% of the global population depend on agriculture for their livelihoods,[23] and 10-12% depend on fisheries and aquaculture. [24] Additionally, lack of information has led to poor fishing and agricultural practices have pushed the boundaries of sustainability.

The SDGs call for increasing incomes of small-scale farmers and fishers, through market and info access:

Target 1.4: Ensure equal rights to economic / tech resources and basic services

Target 2.3: Double productivity and increase incomes of small-scale food producers

Target 8.2: Achieve higher levels of economic productivity (and other 8 targets) & 8.10 encourage and expand access to banking, insurance and financial services to all

Target 14.B: Provide access for small-scale fishers to marine resource and markets

Target 17.11: Significantly increase the exports of developing countries, especially LDCs

ROLE OF DIGITAL TECHNOLOGIES

The Agriculture and Fisheries sector could facilitate digital access, primarily through mobile phones, to all previously unconnected farmers and fishers. This will enable remote, small-hold farmers and fishers to be instantaneously connected to digital marketplaces and up-to-date information, increasing incomes and improving practices. High priority use cases include:

- Mobile platforms to connect farmers/ fishers to free advice on sustainable practices, as well as up-to-date pricing and weather information.
- Mobile platforms to provide access to digital marketplaces, to buy and sell goods or purchase cheap farm / fishery inputs.
- Mobile platforms to provide cheap forms of credit, loans and insurance to farmers.
- Creation of digitally accessible networks to aggregate goods and reduce "food miles".
- Traceability and transparency for consumers about provenance and ingredients of the food they eat.

Improved monitoring of farm and fishing activities

Over-fishing, illegal and unregulated fishing, and bad fishing practices have caused deteriorating fish stocks and ocean health, with the proportion of marine fish stocks within biologically sustainable levels declining from 90% in 1974 to 70% in 2015.[25] At the same time, farm areas are becoming increasingly vulnerable to climate shocks and yield loss, threatening both food security and the livelihoods of millions.

The SDGs call for ending destructive fishing and farming practices, and improving climate change resilience:

Target 1.5: Build resilience and reduce the poor's vulnerability to climatic events

Target 2.4: Ensure sustainable and resilient food production systems

Target 13.1: Strengthen resilience to natural hazards

Target 14.4: End overfishing, illegal and unreported fishing, bad fishing practices and restore fish stocks

ROLE OF DIGITAL TECHNOLOGIES

The Agriculture and Fisheries sector has an opportunity to make use of emerging digital technologies and global big data sets and satellite imagery to continuously monitor and predict destructive practices, weather and yield trends – and democratise such data. This improves the sustainability and resilience of the sector, with the following high-impact solutions:

- Radar systems and satellite data analysis to observe fishing vessels and activity and detect illegal activity. AI-enabled prediction can also pre-empt locations.
- Blockchain technology and / or the above data to monitor fish origin and assure sustainability.
- Predictive models to analyse historic and current weather and yield data, in order to predict trends and offer forward-looking advice for risk mitigation, planting seasons etc.
- Analysis of the above satellite data to instantly verify yield loss, enabling faster insurance payouts and improved farm resilience.

Optimising yield and resource-use efficiency

Agricultural yield must increase to feed the world's growing population, but in a resource-efficient way. Agriculture currently accounts for 70% of all freshwater withdrawals[26] and around 20-30% of global carbon emissions.[27] Global nitrogen fertiliser usage has increased by 800% over the past few decades, and large amounts now move into aquatic ecosystems, damaging marine life and fish stocks.[28]

The SDGs call for increasing yield, whilst at the same time reducing use of resources:

Target 2.3: Double productivity and increase incomes of small-scale food producers & 2.4 Ensure sustainable and resilient food production systems

Target 6.4: Increase water-use efficiency across sectors and address water scarcity

Target 8.4: Improve global resource efficiency in consumption and production

Target 12.2: Sustainable use of resource

Target 13.2: Integrate climate change measures into national policy

ROLE OF DIGITAL TECHNOLOGIES

The sector has an opportunity to ensure low-cost precision farming technologies, those that monitor and / or autonomously react to farm conditions, are deployed to small-scale farmers. They also should consider new and lower-impact farming configurations. The following high-impact solutions enable yield and resource-use optimisation:

- IoT sensors or cameras monitor farm data and crop health in real time, enabling precision farming activities that minimise water, fertiliser and other resource use.
- Digital platforms can collate the above farm sensor data with other data sets, e.g. weather, to enable even more targeted advice.
- Indoor and vertical farming options should also be explored, as they optimise space and resource utilisation, can be situated closer to cities and are less vulnerable to climate change.

In addition to facilitating the uptake and dissemination of digital technologies, the agriculture and fisheries sector can improve productivity of small-scale food producers by lobbying for coastal and land tenure rights and investing extensively in basic rural infrastructure, such as electricity, all weather roads and internet. [29] The sector can also improve the resilience and productivity of food production systems by implementing various land management techniques, such as crop rotation, to reduce degradation and conserve biodiversity. [30] The sector can further partner with governments and other sectors to implement effective cross-sector water management policies, and agro-ecology policies. There should be a focus on approaches that integrate crops, trees, livestock and fishery management to enhance biological synergies and resource-use efficiency, improving climate change resilience. [31] Finally, food innovation, such as weather resilient crops and meat grown in labs, can and should be led in partnership with bio-tech and engineering firms.

Keep reading: see deep dives on SDGs 2 and 14

Consumer products and industrials

The consumer products and industrials sector ('CPI') encompasses much of the goods production supply chain. The sector contributes greatly to economic growth with nearly 23% of the global employment population employed in the industry in 2018.[32]

Driving down the cost of both food and key consumables, e.g. sanitary products, has been a key feature of the sector, leading to widespread increases in quality of life.[33] However, this has come at a cost, particularly for the biosphere, hindering the progress of the 2030 Agenda. The traditional, linear business models that compete on low-cost consumerism have led to unmanageable amounts of waste, particularly in developing countries that have taken on waste from the developed world.[34] Business models focused on producing vast quantities of new products to fulfil and fuel customer demand has led to the distribution of disposable goods, often not designed to be reused or recycled.[35]

Consumers, policymakers and other stakeholders increasingly expect that companies in the sector will mitigate their impact on the environment,[36] and the sector is responding: transforming its operations to ensure sustainability and to prevent further damage to the biosphere and contributing more broadly to Agenda 2030. Still, this response is not progressing quickly enough. Few companies are truly transforming their core business models in order to transition to more responsible economic models. The deployment of digital technologies can assist in this transition, particularly in three areas: i) enabling a circular economy, ii) reducing food waste, and iii) promoting transparency.

OPPORTUNITIES TO CONTRIBUTE

Circular economy

The world is on an unsustainable consumption trend; the equivalent of almost three planets' worth of natural resources could be required to maintain current lifestyles in 2050.[37] Global waste is expected to rise by 70% by 2050[38].

The SDGs call for achieving a circular economy:

Target 8.4: Improve global resource efficiency in consumption and production

Target 9.4: Upgrade industries to increase sustainability and resource efficiency

Target 12.2: Sustainable use of resources

Target 12.5: Reduce waste generation

Target 13.2: Integrate climate change measures into national policies, strategies and planning

ROLE OF DIGITAL TECHNOLOGIES

Deployment of digital technologies allows the CPI sector to move towards a more sustainable and resilient economic model, reducing the strain on diminishing natural resources. Example ways digital technologies are being deployed include:

- Creating and using digital marketplaces to encourage the sharing, repurposing and reuse of goods.
- Innovative design methods that reduce the need for prototyping and minimise the risk of faulty products.
- Smart recycling systems to improve recycling efficacy.
- Trace hazardous substances.
- Predictive maintenance to reduce waste, improve durability of products and enable manufacturing.

Food waste

One third of all food produced globally is wasted each year. If food waste were its own country, it would be the third largest emitter of greenhouse gases in the world.[39] Reducing food waste would not only aid those struggling with food scarcity, but also minimise unnecessary land use and reduce carbon emissions by the industry.

The SDGs call for reducing food waste:

Target 2.1: End hunger and ensure access to sufficient food all year round

Target 12.3: Halve global food waste

Target 13.2: Integrate climate change measures into national policies, strategies and planning

ROLE OF DIGITAL TECHNOLOGIES

Digital technologies allow food producers and retailers to reduce food waste in a systematic manner. Reducing the amount of food waste in supply chains will lower demand for food down the chain, preventing excess food, and as a result emissions, from being produced.[40] Increased adoption of the deployment of digital technologies can help manage food loss and waste:

- Using digital platforms to connect surplus food to those facing food scarcity.
- Smart food monitoring to ensure produce is assigned an accurate use-by date and does not go bad in transit.
- Implementing dynamic pricing mechanisms to encourage purchases of food going out of date.
- Real-time analysis of food waste generated by restaurants to adjust inventory orders and portion size.

Transparency

Organisations and consumers lack access to reliable information on the impact of their consumption. 88% of consumers would like their brands to help them be more ethical and environmentally friendly.[41] True transparency will facilitate responsible consumption.

The SDGs call for achieving transparency in production:

Target 8.7: End forced labour, modern slavery, human trafficking and the worst forms of child labour

Target 12.2: Sustainable use of resources

Target 12.6: Companies adopt sustainable practices

Target 13.2: Integrate climate change measures into national policies, strategies and planning

ROLE OF DIGITAL TECHNOLOGIES

The CPI sector can integrate digital technologies within their supply chains and reporting processes to provide transparency on the impact of the business.

Key activities that should be undertaken include:

- Using digital technologies to monitor and verify the sustainability of supply chains, enabling traceability and transparency for consumers.
- Integrating analytical solutions into impact tracking and reporting.
- Make sustainability information publically available and share data with other organisations to allow collaboration.

Alongside the deployment of digital technologies, the CPI sector should seek to collaborate with government, civil society and other stakeholders in order to maximise their impact. Through partnerships, the sector should seek to establish consistency in responsible production habits across cross-border value chains and to educate citizens on how to consume responsibly. Such education might go some way in addressing the throwaway mentality of consumers which has had such a devastating impact on the environment. The sector must also take increased responsibility for products after purchase, through driving forward circular business models, designing products to be reused, upgraded or recycled, and establishing buy-back schemes to collect and repurpose old goods.

Keep reading: see deep dives on SDGs 9, 8 and 12

Energy, extractives and utilities

The energy, extractives and utilities sector (EEU) fulfils basic human needs through the provision of energy, water and sanitation, and as the provider of power and resources for all human activities. Through this provision however, the sector is also the source of a significant proportion of CO2 emissions and acts as a significant contributor to other forms of environmental degradation. The 2030 Agenda calls on the sector to act in three key areas to accelerate positive impacts and mitigate negatives: (i) improve access, (ii) improve resilience, and (iii) enable a transition to a net zero-carbon future.

The spread of affordable access to utilities drives social development and reduces poverty.[42] However, universal access to utilities is still lacking, particularly amongst poorer demographics.[43] Ensuring that access spreads sustainably will be critical for ensuring the long-term resilience of the system. Without a transition to a climate-neutral and renewable future there will always be an inherent tension between supporting economic growth and worsening the effects of climate change, which often fall upon the poorest in society who are least equipped to deal with them. Fossil fuels currently contribute to 82.5% of all final energy consumption,[44] and the utilities sector must radically transform and commit to the deployment of renewable energy at scale if the world is to avert a global climate crisis and fulfil the 2030 Agenda.

OPPORTUNITIES TO CONTRIBUTE

Improve access

There are still 840 million people living without access to electricity,[45] and 785 million people that lack access to clean local drinking water.[46] Ensuring universal access to these services is both a basic human right and also necessary to eradicate poverty.[47]

The SDGs call for achieving universal access:

Target 1.4: Ensure equal rights to economic / tech resources and basic services

Target 6.1: Achieve universal access to safe and affordable drinking water

Target 6.2: Achieve access to adequate sanitation for all, especially women and girls

Target 7.1: Universal access to affordable, reliable and modern energy

ROLE OF DIGITAL TECHNOLOGIES

The EEU sector can scale its use of digital technologies to continue to connect the unconnected to essential utilities. The following key solutions can be implemented to drive progress in this area:

- Innovative financing schemes to connect and maintain access for remote communities to utilities, e.g. water and solar energy.
- Predictive maintenance via connected sensors to reduce downtime, reduce leakage, and enhance efficiency.
- Track coverage of utility services across a population using cloud platforms, in order to identify and target populations without coverage or access.
- Monitor the quality of freshwater bodies in real time to detect and respond to pollution.

Long-term resilience

Between 2005 and 2030, global energy consumption is expected to increase by 50 per cent.[48] It is also estimated that half the global population will live in water-stressed areas by 2025.[49] As the threat of environmental disturbances due to the climate crisis becomes more relevant, and a rising demand for utilities strains networks, there is an urgent need for more resilient EEU infrastructure, and sustainable methods of extraction and distribution of energy. By better absorbing stresses and disturbances, resilience enables consistent provisioning for communities.

The SDGs call for increasing long-term resilience:

6 CLEAN WATER AND SANITATION

Target 6.4: Increase water-use efficiency across all sectors and address water scarcity

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Target 9.1: Develop sustainable, resilient and inclusive infrastructures

Target 9.4: Upgrade all industries and infrastructures for sustainability

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Target 12.2: Sustainable use of resources

13 CLIMATE ACTION

Target 13.2: Integrate climate change measures into national policies, strategies and planning

ROLE OF DIGITAL TECHNOLOGIES

Digital technologies will be a key enabler of long-term resilience, which will allow the EEU sector to monitor and detect disturbances, and deploy safe and sustainable methods of energy generation and distribution. The following activities are examples of key solutions that lead to increased resilience of EEU systems:

- Smart meters allow suppliers and consumers to monitor energy and water use. Smart meters allow quick detection of leakages and pipe faults, preventing excessive loss, and encourage consumers to use utilities efficiently (as they provide a clear link between consumption and cost).
- Smart grids enable automatic outage detection and enable the quick restoration of service, while collecting data to predict and reduce further disruptions.
- Micro grid solutions decentralise energy distribution, limiting the risk of outages.
- Using predictive analytics and autonomous robots to detect and prevent wasteful oil spills, breakdowns, and dangerous methane leaks.

Zero-carbon future

While slow progress is being made to increase the share of renewables in energy production, renewables only comprise 17.5% of global consumption.[50] The world is thus not on track to reach zero-carbon energy by 2050.[51] Further, though the carbon intensity of the global economy has fallen over 10% since 2000, overall carbon emissions hit a record high in 2018.[52] A zero-carbon future is a necessity, not an aspiration, if we are to avoid the worst effects of climate change. This must be done both by increasing energy efficiency, and transitioning to renewable energies.

The SDGs call for a zero-carbon future:

Target 7.2: Increase share of renewable energy in global energy mix

Target 7.3: Double the improvement in energy efficiency

Target 12.2: Sustainable use of resources

Target 13.2: Integrate climate change measures into national policies, strategies and planning

ROLE OF DIGITAL TECHNOLOGIES

Digital technologies can and do further aid efforts to move to a zero-carbon economy. While increasing investment in renewable energy production is clearly an essential component to this opportunity, the following use cases can also effect change in this area through improving energy efficiency and integration of renewables into the grid:

- Smart contracts allow decentralised grids of renewable prosumers to trade excess energy amongst themselves.
- The smart grid increasingly allows the integration of renewable energy into the national supply. Increasing amounts of data mean improved understanding and prediction of renewable supply and end-user demand. In turn this can lead to demand-side management strategies to encourage consumers to shift demand to off-peak periods, reducing the need to ramp up energy production at carbon-intensive plants.
- AI and IoT can be used to improve the efficiency of power plants to create a greater yield of energy from the same amount of materials and thereby reduce the amount of fossil fuels required to meet energy demand.

Digital technologies can assist in each of the three target areas of access, resilience and reduced emissions, but transformation of the sector and the impact it has on the SDGs is heavily dependent on multiple other factors including physical infrastructure, financing and public policy. Creating effective, impact-based stakeholder partnerships, particularly with public organisations tasked with delivering utilities, will be critical. Digital technologies can support this collaboration by linking activities to impact, supporting coordination and catalysing specific interventions.

Keep reading: see deep dives on SDGs 6, 7, 11 and 13

Financial services

The financial services sector is specifically called out in 15 targets across 9 SDGs, and will play a key role across the 2030 Agenda, either through ensuring greater financial inclusion or as a provider of capital.

Financial inclusion can be understood as the degree of access to safe, appropriate and affordable financial services. This contributes to economic and financial development while at the same time fostering more inclusive growth and greater income equality. Barriers to financial inclusion that the use of digital technologies can positively impact on include:

- high costs associated with providing low-value financial services and products;
- difficulty of delivering products and services in remote areas;
- lack of financial information available on potential new customers;
- widespread lack of financial literacy.

Digital technologies enable innovative delivery of products and services, e.g. mobile banking, internet; removal of bias in financial access decisions, e.g. robotic process automation and AI; and the creation of customised products fit for the remaining unbanked households and SMEs, e.g. e-money and digital payment.

Greater financial inclusion is linked to greater financial literacy,[53] or the ability to understand financial concepts to make informed decisions about saving, investing and borrowing.[54] It is estimated that around 3.5 billion adults globally lack an understanding of basic financial concepts.[55] There is an opportunity for the financial sector to deploy digital technologies to address this issue through online and mobile learning modules and the use of chat bots for simple financial questions.

The estimated annual investment required to finance the SDGs is between $5 and 7 trillion. The financial services sector has a central role to play in providing capital for the Goals by harnessing investment for sustainable development and developing financial instruments to engage investors, e.g. bonds and crisis financing.

OPPORTUNITIES TO CONTRIBUTE

Financial Inclusion

A key indicator of individuals' financial inclusion is whether they have an individual or joint account at a formal financial institutions. Globally, there are approximately 2 billion people without accounts.[56]

Similarly, SMEs' financial inclusion is impeded by their lack of access to credit, with about 70 percent of all Micro, Small and Medium-sized Enterprises (MSMEs) in emerging markets lacking access to credit.[57]

Key targets are spread across SDG 1, 5, 8 and 9:

Target 1.4 : Ensure equal rights to economic / tech resources and basic services

Target 5.6: Enhance use of enabling technology to empower women

Target 8.10: Encourage and expand access to banking, insurance and financial services for all

Target 9.3: Increase access of small-scale industrial enterprises to financial services

ROLE OF DIGITAL TECHNOLOGIES

Digital technologies enable products to be customised for new potential customers, fight bias in access to financial services, deliver financial services and products in remote areas and increase financial literacy.

The following activities are examples of key solutions using digital technologies:

- Remove bias to enable customers usually discriminated against to access financial products by making the application process online-based; automate decision to grant loan or credit (internet, online/mobile platform, RPA and AI).
- Increase reach by delivering products and services through mobile banking, digital payments and e-money.
- Increase Financial Literacy by using chat bot for simple queries, online or mobile learning modules, and simple mobile apps to share info and knowledge on financial products. There is an opportunity for the financial services sector to partner with education institutions, NGOs and government to increase reach of digital solutions.

Provision of capital

The Financial Services sector is harnessing technology to redefine and accelerate financing of sustainable development, through increasing data quality for better assessment of investment risks, particularly ESG risks.

Key targets are spread across SDG 7, 9, 11, 13 and 15:

Target 7.A: Promote access and investment for clean energy research, infrastructure and tech.

Target 9.A: Support infrastructure development in developing countries

Target 11.C: Support LDCs financially to construct & resilient sustainable buildings

Target 13.A: Implement commitment to mobilise $100 billion annually for climate change by 2020

Target 15.A: Mobilise financial resources to conserve biodiversity and ecosystems

Target 15.B: Mobilise resources to finance sustainable forest management

ROLE OF DIGITAL TECHNOLOGIES

Digital technologies can be deployed to mobilise finance and increase its impact on achieving the SDGs. The following activities are examples of key solutions using digital technologies:

- ESG Screening, enabled by open source data collection, big data analytics and AI, helps organisations invest in, finance, and insure sustainable projects.
- Improving investment data quality through the use of technology enables better modelling and management of risks and the design of innovative pricing models (particularly regarding climate risks in the insurance and re-insurance space).
- The sharing of data helps collaboration with public sector to aid in disaster and climate change resilience.

SDG Target 10.5 aims to improve the ‘regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations’. There is an opportunity for the financial services sector to engage on creation and implementation of these regulations.

The increased transparency enabled by digital technology will also enable the sector to collect financial data and translate this into risks, such that the sector can better address environmental and social externalities in their evaluations of an investment. Transparency will also give consumers greater choice of their own investments. This is further tied into reporting. As companies multiply efforts to achieve the SDGs, reporting on these is important to accelerate culture shifts for a more sustainable economy, and to educate and raise awareness of shareholders and consumers on sustainable investment and financial products and services.

Keep reading: see deep dives on SDGs 8 and 10

Life science and health care

The global health care sector plays a hugely significant role, both in the sustainable development agenda and the wider economy, with expenditures projected to increase 5.4% annually from 2017 to $10 trillion in 2022.[58]

The health care sector consists of medical insurance companies, private and public health care service providers, pharmaceutical companies, researchers and government regulatory bodies. These stakeholders combine to treat patients with curative, preventive, rehabilitative and palliative care.

The sector faces the challenge and opportunity to deliver inclusive, affordable and quality health care. As well as directly contributing to the targets under SDG 3, improved health outcomes have a profound effect on other sustainable development issues, enabling children to receive and complete an education, adults to be more productive in the workforce, and disadvantaged communities to gain access to the labour market, culminating in the reduction of inequalities.

OPPORTUNITIES TO CONTRIBUTE

Inclusive health care

Half the world lacks access to essential health services[59], including an estimated 56% of rural communities. Access to sexual health care is also lacking. Young women and children face a heightened vulnerability to HIV infection: 7,000 young women acquire the virus weekly.[60] A greater uptake of medical insurance in disadvantaged communities is needed to increase their access to health care.[61] Despite global economic growth, the global underinsurance gap is $162 billion.[62] The world is counting on the health care sector to improve the quality of life for vulnerable groups.

These SDGs call for achieving inclusive health care:

Target 1.4: Ensure equal rights to economic/tech resources and basic services

Target 3.7: Ensure universal access to sexual and reproductive healthcare services

Target 5.6: Ensure universal access to sexual and reproductive health

ROLE OF DIGITAL TECHNOLOGIES

Digital technologies can be deployed to expand health care reach in rural communities, track inventories and expand insurance provision. The key activities the health care and life science sectors can undertake include:

- Better patient-doctor connectivity through mobile apps.
- Use mobile devices as diagnostic tools.[63]
- Use real-time data to track drug, vaccine and sexual health item inventories to improve delivery.
- Implementing decentralised ledger technology to enable more flexible and innovative provision of health insurance.
- Investing in remote surgery technologies increases access for patients in rural communities.

Affordable health care

Rising health care cost expenses have pushed 100 million globally into extreme poverty[64]. Waste in the sector can be reduced: $750 billion is spent on unnecessary services, administrative costs and missed prevention opportunities, amongst other sources.[65] There is thus an urgent need to lower the cost of health care, especially for prescription drugs and medical services.

These SDGs call for achieving affordable health care:

Target 1.4: Ensure equal rights to economic/tech resources and basic services

Target 3.8: Achieve universal healthcare coverage

ROLE OF DIGITAL TECHNOLOGIES

The health care sector can deploy digital technologies to automate administrative tasks and increase the mobile monitoring of patients, thereby reducing costs. The key activities the sector can undertake include:

- Self-monitoring apps and connected devices providing patients with access to their own health information reduces unnecessary hospital visits.
- Cloud-based medical record systems reduces administrative costs.
- Digitising insurance claims processing and collections saves time and reduces administrative costs.
- Implementing technologies to track the supply chain reduces waste and increases clinician's productivity.

Quality health care

Poor quality health services are holding back progress on health outcomes in all countries. 7-10% of hospitalised patients acquire infections during their stay.[66] Health care workers, especially in developing countries, suffer from a lack of training, leading to inappropriate, unnecessary or unsafe treatments. Clinical guidelines for common conditions were followed less than 45% of the time in 7 low and middle income African countries.[67] The sector should thus consider investing in solutions to improve the quality of the services they deliver.

This SDG target calls for achieving quality health care

Target 3.C: Increase health financing, training and recruitment of health workforce

ROLE OF DIGITAL TECHNOLOGIES

The health care sector can deploy digital technologies to train the health workforce, predict health outcomes, and personalise and improve the quality of treatments. These key activities include:

- Increase access to health care worker training programs online, especially in rural areas.
- Analysis of patient data can be used to build models to predict individual patient's diagnosis, and devise appropriate treatment and optimise care pathways.
- Enable development of new and more effective drugs and vaccines through analysis of genetic, bio-chemical, and disease and patient data.
- Cognitive artificial health workers used to triage patients deliver personalised medicine, increasing treatment effectiveness.
- Digitalise medical records to document care, arrange follow-ups, detect complications and identify areas for improvement.

Regulatory bodies play a significant role both in the overall achievement of SDG 3 and specifically in determining the uptake of digital technologies across the sector. A first critical step is to catalyse the digitisation of medical records and the responsible use of medical data to improve health care outcomes.

Keep reading: see deep dives on SDGs 3 and 5

Transport and logistics

The transport and logistics sector has an important role to play in fulfilling the 2030 Agenda. The sector is directly referenced in SDG target 11.2 and directly and indirectly contributes to many other targets. The sector itself drives economic growth, directly employing millions and contributing to significant proportions of GDP in parts of the world.[68] The efficient and effective flow of goods and people is a critical enabler of development outcomes, including food security, access to health and education, poverty reduction and labour mobility, e.g. the ability to work in new jobs and markets.[69]

However, the sector is currently associated with a range of negative social and environmental impacts. For example, transport systems are a large end user of energy, contributing to a high proportion of global greenhouse gas emissions and fossil fuel demand. The impact is highest for forms of road transport, which account for 70% of all transport-related greenhouse gas emissions.[70] Traffic congestion leads to high concentrations of air pollution as well as road accidents with significant impacts on human health and livelihood. Effective transport solutions are also not accessible or affordable to everyone, particularly those with disabilities, the poor, and those in remote areas.[71]

The transports and logistics sector has an opportunity to further deploy and scale digital technologies to develop sustainable transport and logistics systems that minimise the negative and maximise the positive impacts of the sector. Effective sustainable transport should have four attributes: i) efficiency ii) climate resilience, iii) safety and iv) universal accessibility.[72] Digital technologies play a leading role in enabling each one of these attributes, in particular through enabling connected, intelligent transport and logistics systems, mobility and journey services accelerating the uptake of autonomous and / or electric vehicles.

OPPORTUNITIES TO CONTRIBUTE

Efficient and sustainable transport

The transport sector is currently responsible for around 15% of global greenhouse gas emissions[73] and 62% of all oil used each year.[74] Increasing numbers of vehicles on the roads leads to more congestion and traffic, further increasing emissions and air pollution. The sector is estimated to be responsible for over 30% of urban air pollution and 3.5 million premature deaths annually.[75]

The SDGs call efficient and sustainable transport systems:

Target 3.9: Reduce deaths and illnesses from pollution

Target 7.3: Double the rate of improvement of energy efficiency

Target 8.4: Improve global resource efficiency in consumption and production

Target 9.4: Upgrade industries to increase sustainability and resource efficiency

Target 11.2: Provide access to safe, accessible and sustainable transport & 11.6: reduce environmental impact of cities

Target 13.1: Integrate climate change measures into national policy and planning

ROLE OF DIGITAL TECHNOLOGIES

Accelerating deployment of digital technologies will allow the sector to optimise traffic and logistics routing and increase the efficiency of journeys, and overall improving the efficiency and sustainability of the sector:

- The most promising solution for sustainable transport is adoption of cleaner fuels and electric vehicles. Digital technologies can accelerate uptake, through digital twin simulations of the needed infrastructure, predictive grid management to manage charging demand, and applications to locate charging facilities or locate shareable options, such as e-bikes.[76]
- IoT sensors, big data analysis and mobile access enable connected and intelligent traffic management and parking space routing.
- Mobile platforms enable carpooling, optimised public transport information routing, and encourage inter-modality.
- Fleet telematics and the cloud enable smart fleet management, and optimised delivery routing.
- Digital technologies such as drone delivery, video conferencing, and VR simulations eliminate the need for transport altogether.

Safe transport

Road transport accounts for 97% of transport-related fatalities worldwide, with 1.35 million people dying each year as a result of road traffic crashes. Road traffic crashes cost most countries 3% of their GDP.[77] Transport systems, if increasingly connected and digitally-enabled, are also more vulnerable to cyber attacks, which could have serious implications on citizen safety.[78]

The SDGs call for safe transport systems:

3 GOOD HEALTH AND WELL-BEING **Target 3.6:** Halve deaths and injuries from road traffic accidents

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE **Target 9.1:** Develop quality, reliable, sustainable and resilient infrastructure

11 SUSTAINABLE CITIES AND COMMUNITIES **Target 11.2:** Provide access to safe, accessible and sustainable transport and improve road safety

ROLE OF DIGITAL TECHNOLOGIES

The deployment of digital technologies is improving the safety of the sector, through reducing transport-related accidents, and monitoring the cyber security of smart transport systems. The following solutions will improve the safety of the sector, and should be scaled:

- Autonomous vehicles and traffic controls remove room for human error whilst driving, improving safety. However, time frames for introduction are unclear.
- IoT wearables, car safety systems and road sensors monitor driver drowsiness and road conditions, alerting to any conditions that would compromise safety.
- Monitoring technologies will mitigate the vulnerability of transport systems to cyber attacks, as well as transport infrastructure integrity.

The transport and logistics sector has an opportunity to increase development and scale digital technologies that improve the accessibility of transport for those with disabilities.

Accessible transport

In urban areas, demand for accessible public transport has increased by almost 20% between 2001 and 2004.[79] Additionally, transport is inaccessible for many people with disabilities, a UK report shows a fifth of the 11.6 million people living with disabilities in the UK have difficulty accessing transport.[80] In rural areas, people often struggle to pay for transport. For example, farmers struggle to pay to transport their goods to market.

The SDGs call for accessible transport and logistics:

1 NO POVERTY · 2 ZERO HUNGER · 3 GOOD HEALTH AND WELL-BEING · 4 QUALITY EDUCATION

Access to basic services, food & food markets, healthcare and education

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE **Target 9.1:** Develop quality, reliable, sustainable and resilient infrastructure

10 REDUCED INEQUALITIES **Target 10.2:** Promote the social, economic and political inclusion of all

11 SUSTAINABLE CITIES AND COMMUNITIES **Target 11.2:** Provide access to safe, accessible and sustainable transport

ROLE OF DIGITAL TECHNOLOGIES

The sector has an opportunity to increase development and scale digital technologies that improve the accessibility of transport for those with disabilities. They can also improve accessibility to those living in remote areas, through increasing the efficiency of logistical chains and availability of affordable transport options. The following digital technologies will improve accessibility of the sector:

- Mobile platforms enable innovative logistics solutions, such as pooled first mile food deliveries, improving the inclusivity of often expensive logistics solutions.
- Augmented apps and autonomous vehicles help those with accessibility challenges access transport options. However, time frames for introduction are unclear.
- "Mobility on demand apps", such as ride sharing or membership rental, improve the affordability and accessibility of transport.

In addition to the deployment of digital technologies, the transport and logistics sector can collaborate with governments, in particular with city authorities and other stakeholders to increase the sustainability of underlying transport infrastructure, improve urban, peri-urban and rural linkages, and promote road safety and efficient driving training. They can also support the removal of fossil fuel subsidies, lower taxes for electric vehicles and accelerate vehicle emissions standards – and assist with re-skilling and up-skilling workers in the automotive supply chain to implement such standards. Finally, they should lead the way by adopting cleaner fuels and transitioning to electric or hydrogen cars, buses and trucks. Adoption of electric vehicles has the potential to reduce emissions by at least 50%, if the energy mix is not carbon intensive.[81]

Keep reading: see deep dives on SDGs 11, 9, 13 and 2

Tourism and travel

The $8.8 trillion tourism industry generates 10.4% of all global economic activity.[82] Tourism and travel accounts for 20% of all new jobs created worldwide and is projected to contribute 100 million new jobs globally over the next 10 years, accounting for 421 million jobs by 2029.[83] However, the increasing carbon emissions from travel, overcapacity in tourist destinations, exploitative labour practices and large quantities of waste generated from the industry are all unsustainable.[84] The industry needs to find solutions to these issues if it is to rise to the 2030 Agenda.

The SDGs explicitly call for sustainable tourism that creates jobs and protects cultural and natural heritages. Creating a more sustainable industry will have knock-on effects on the availability of decent work and reducing carbon emissions. Digital technologies can enable the tourism industry to reach these targets in three broad ways: by creating accountable and inclusive employment opportunities, protecting tourist destinations, and further developing their sustainability and safety practices.

OPPORTUNITIES TO CONTRIBUTE

Accountable and inclusive employment

The 114% increase in tourists in the last 30 years[85] is leading to an increase in exploitative labour practices and alienated local residents in many countries[86]. It does not have to be this way: tourism is an activity that generates new opportunities, and can therefore offer a way out for disadvantaged groups. Tourism employment helps reduce poverty and economic and social exclusion and may offer alternatives to migration to cities.[87]

The SDGs call for achieving sustainable accountable, equitable and inclusive employment:

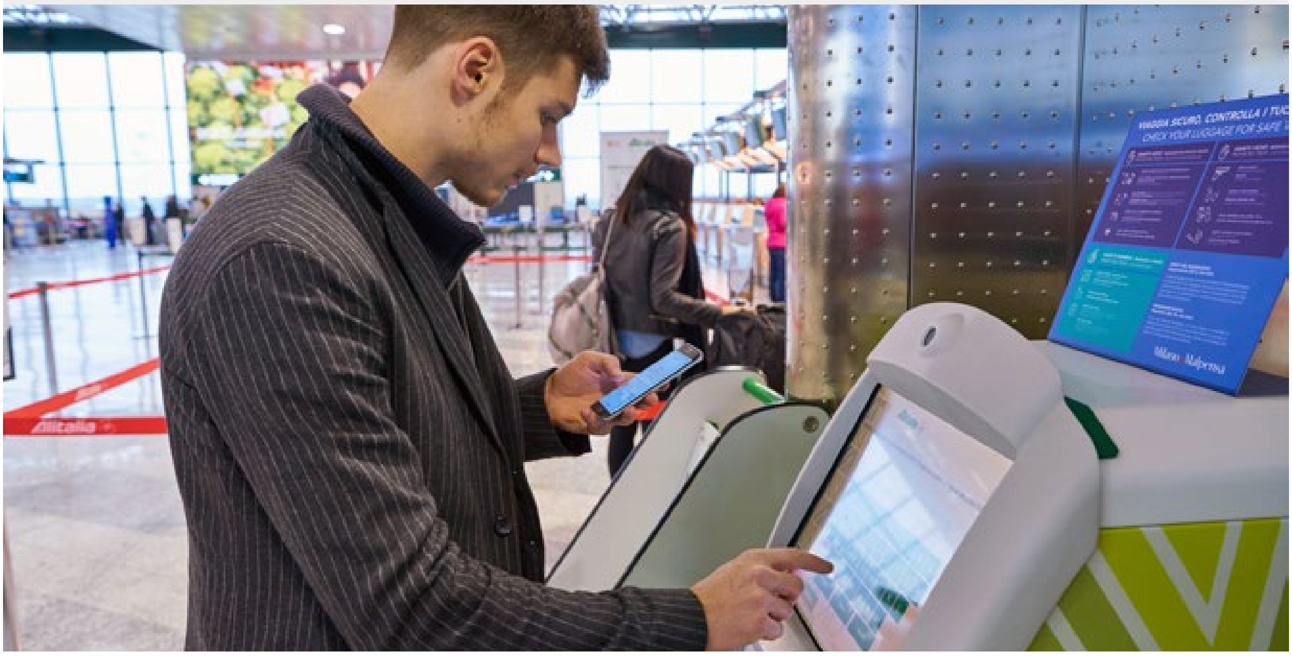
Target 8.8: Protect labour rights and promote safe and secure working environments

Target 12.6: Companies adopt sustainable practices

HIGH-IMPACT SECTOR ACTIVITIES AND DIGITAL TECHNOLOGIES

Digital technologies effectively track and control human flows, increase accountability and improve training for local residents. The key activities the sector can undertake include:

- Monitoring supply chain activity to detect exploitative employment practices.
- Using blockchain technology to securely transfer money to employees.
- Increasing transparency by publishing internal business practices online.
- Increasing tourist awareness of the effects of overtourism through online platforms.
- Increasing technical training for SME entrepreneurs and the seasonally employed.



Sustainable physical and natural environment in tourist destinations

Overtourism has led to overloaded infrastructure and degraded natural environments in many tourist destinations. For example, nearly 80% of the coral reefs in the Koh Khai islands in Thailand have been damaged by humans[88]. Since much of the infrastructure used by tourists is shared with residents, visitors pose challenges in terms of cost of living, energy usage and waste management[89]. And as communities experience higher tourist numbers, erosion and deforestation occur from tourist infrastructure development. There has been a rapid degradation of marine ecosystems due to tourist marine activity.[90] The sector should seek solutions to mitigate the environmental consequences of its activity.

Target 11.1: Ensure access to adequate, safe and affordable housing and upgrade slums

Target 14.2: Sustainably manage and protect marine and coastal ecosystems

Target 15.3: Combat desertification, and restore degraded land and soil

HIGH-IMPACT SECTOR ACTIVITIES AND DIGITAL TECHNOLOGIES

Here, the tourism sectors, especially tourism regulatory bodies, can use digital technologies to effectively track environmental indicators, optimise housing allocation and preserve cultural sites. The key activities the sector can undertake include:

- Monitor and map terrain to enable construction in safe and sustainable land plots.
- Digitally map natural resources, monitor marine ecosystem health and limit tourist visits.
- Implementing digital waste reduction tools in hotels for lighting, heating, laundry and consumables.
- Enable online accommodation platforms that increase housing efficiency.
- Using data to encourage the geographic spread of tourists across crowded cities, by nudging visitors in real time and through dynamic pricing strategies.

Sustainable, safe passenger travel

A significant contributor to the rise in travel sector carbon emissions is from international aviation, which is projected to be 70% higher in 2020 than in 2005,[91] accounting for 2% of carbon emissions worldwide[92]. There are also direct human consequences of flying: 10,000 people die annually from plane pollutants[93]. Further, traffic accidents are the leading cause of tourist fatalities in every region.[94] The world's aviation sector needs to reconsider its role in a cleaner environment.

The SDGs call for achieving sustainable transportation:

Target 3.9: Reduce deaths and illnesses from hazardous chemicals and pollution

Target 11.2: Provide access to safe, accessible and sustainable transport and improve road safety

HIGH-IMPACT SECTOR ACTIVITIES AND DIGITAL TECHNOLOGIES

The transport sector can deploy digital technologies to monitor and reduce pollutants and to increase transport safety and efficiency. These key activities include:

- Optimising transportation routes to shorten travel distances and prevent engine idling, and increase passenger load factor to maximise fuel efficiency.
- Investment in autonomous vehicular technology and IoT transport.
- Investment in renewable technologies for air and land transport.
- Encourage tourists' uptake of public transport using mobile apps.
- Increase the use of teleconferencing for business conferences and events.

Government policy plays a significant role in ensuring the sustainability of the tourism industry. For example, it is the role of government boards to implement relevant tourist taxes, fund the maintenance of natural and cultural heritage sites, and legislate fair labour standards and promote upskilling. Greater cooperation is required by tourism boards and private companies to increase accountability and transparency of labour and environmental practices.

The first and most effective step companies can take is to increase transparency and accountability, for example by publishing their own labour practices. More stringent tracking of financial flows is needed to ensure revenue from tourism is going to local communities. Open accountability should be seen as a significant asset as tourists increasingly seek to patronise ethical and sustainable firms.

Keep reading: see deep dives on SDG 8

Call to action

The above sectors must work in close partnership with the ICT sector, supporting and challenging each other to deploy the digital technologies critical to delivering impact against the SDG Agenda.

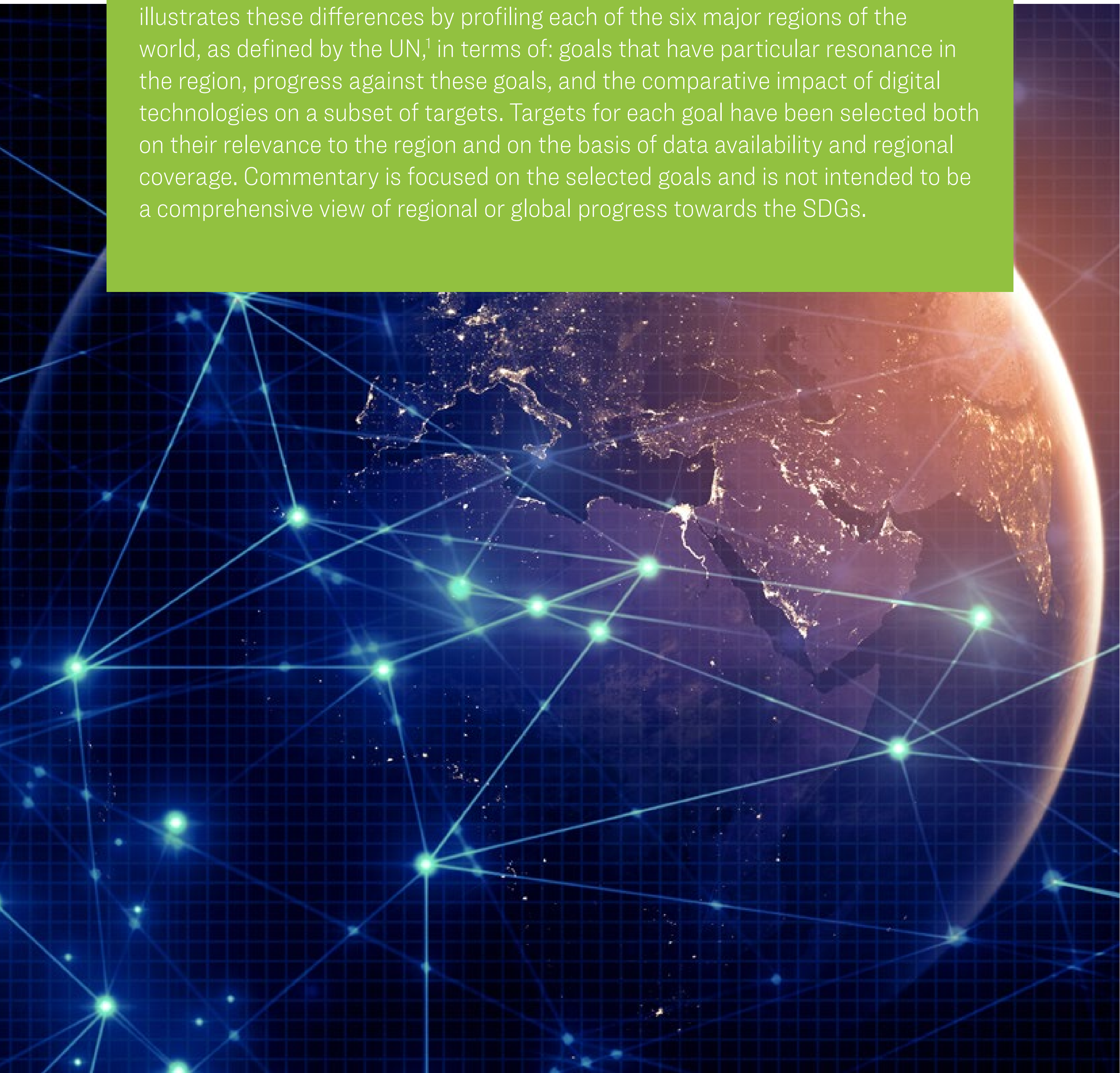
Partnerships will be particularly important to ensure “no one is left behind”, which will require intra-sector collaboration, together with governments and others to provide the needed digital access.

The “Actions to deliver a SMARTer2030” section of this report outlies the universal commitments and suggested activities that each partner can undertake, in order to maximise their deployment of digital technology for positive impact and accelerate achievement towards the SDGs.

04

Geographies

Implications for the deployment of digital technology to realise the 2030 Agenda differ significantly by geographic region and level of development. This section illustrates these differences by profiling each of the six major regions of the world, as defined by the UN,[1] in terms of: goals that have particular resonance in the region, progress against these goals, and the comparative impact of digital technologies on a subset of targets. Targets for each goal have been selected both on their relevance to the region and on the basis of data availability and regional coverage. Commentary is focused on the selected goals and is not intended to be a comprehensive view of regional or global progress towards the SDGs.



The SDGs and targets considered at the regional levels are:

AFRICA
SDG 2 (2.3 Agricultural productivity)
SDG 3 (3.1 Births attended by skilled health professional)
SDG 6 (6.1 Access to clean drinking water)

OCEANIA
SDG 5 (5.6 Access to family planning)
SDG 4 (4.6 Youth literacy)

NORTH AMERICA
SDG 6 (6.4 Efficient use of water resources)
SDG 7 (7.3 Energy efficiency)

ASIA
SDG 2 (2.4 Sustainable farming – fertiliser)
SDG 11 (11.6 Air pollution)

LATIN AMERICA AND THE CARIBBEAN
SDG 12 (12.3 Food loss)
SDG 15 (15.2 Sustainable management of forests)

EUROPE
SDG 2 (2.4 Sustainable farming – emissions)
SDG 9 (9.4 Resource efficiency in industry)

It is further recognised that Climate Action, SDG 13, is a global challenge. Climate change is observed to have extensive impacts globally by damaging the biosphere that humankind lives in, with human activity having already caused approximately 1.0°C of global warming on average. However, regionally the impacts are disproportionate.[2] For instance, warming in the Arctic is approximately three times higher than average, and temperature extremes on land also accelerate in mid-latitudes.[3] Sea level rise could also have disastrous and uneven impacts, particularly on small island states,[4] but even large cities could be deeply affected. Warming of 3°C would fundamentally re-draw the world map, drowning large parts of coastal cities including Shanghai, Hong Kong, Osaka, Alexandria, Miami and Rio de Janeiro, with 275 million people worldwide living in areas that will be flooded.[5]

These issues are a global problem and have the potential to further detriment the achievement of other SDGs. Climate change can limit the ability of countries to manage water supply and demand (SDG 6), efficiently produce food (SDG 2), or provide stable homes and jobs for their populations to allow them to escape the poverty trap (SDG 1).

The opportunity to mitigate further climate change by limiting emissions also varies by region. Analysis of IEA data shows that emissions per person are highest in Asia (including China, largely attributable to its large export market),[6] and whilst emissions intensity has been improving globally, increasing populations and economic output are both risk factors in terms of reducing total emissions. In the face of this risk, digital technology offers opportunities. As discussed in this chapter and for respective SDGs in the appendix, there is emissions abatement opportunity in Industry 4.0 (SDG 9, discussed in the Europe section to this chapter); smart electricity grids and renewable energy (SDG 7, discussed in the North America section); and smart transport systems (SDG 11, discussed in the Asia section).

The remainder of this chapter steps through the six major regions of the world.

Africa

The sustainable development challenges facing Africa are substantial. Africa contains 33 of the 47 Least-Developed Countries worldwide[7] and by 2030, 87% of extreme poverty is estimated to be concentrated in this one continent.[8] Access to primary and secondary education is low, with the primary net enrolment rate at 79%[9] compared with a global average of 89%[10] and the use of dirty fuels for cooking and heating homes is widespread with poor health and environmental implications. There is comparatively limited access to infrastructure, with infrastructure constraints estimated to be holding back African firms' productivity by 40%[11], and 3G mobile networks cover only 60% of the population in sub-Saharan Africa compared with 88% globally.[12]

The primary challenge facing Africa is enabling access to basic services. Digital technologies provide a means of leapfrogging standard development pathways to achieve this. Digital access is being deployed to improve health outcomes, farm productivity and access to clean water. Mobile money services have become a foundation of improvements in economic participation, and provision of better quality education in the region is increasingly reliant on digital access.

Yet the need remains great. Africa needs better access to best practice technology deployed in other areas of the globe. For instance, IoT technology for precision farming can enable better agriculture; and blockchain-based applications can enable more secure peer-to-peer lending in the region, accelerating financial inclusion.[13] However, these solutions need to be made accessible in ways that accommodate the relative lack of infrastructure and digital capabilities in the region.

The SDGs in focus, SDGs 2, 3 and 6, are a selection of immediately relevant goals to Africa and represent areas in which digital technologies can be deployed to support progress against a subset of targets.

SDG in focus – SDG 2

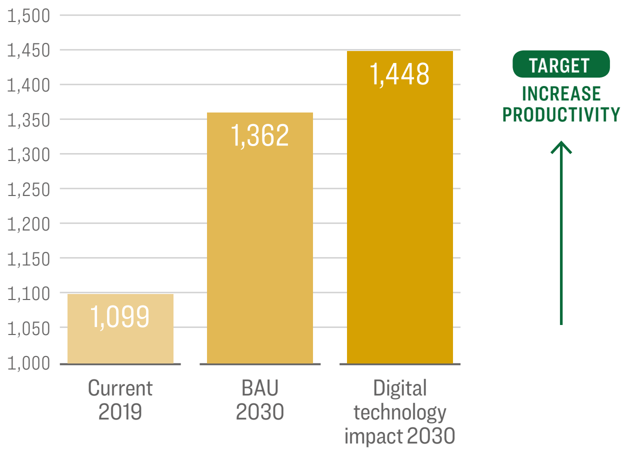
Zero Hunger

In Africa, 27% of people are affected by severe food insecurity; three times higher than the global average of 9%.[14] This problem is expected to persist over the coming decades.[15] In terms of food production, there are around 33 million smallholder farms in the region, which make up 80% of farms and 90% of food production.[16] Therefore, improving agricultural productivity of smallholder farms (Target 2.3) in Africa is a high priority, not only to boost incomes for smallholder farmers but also to ensure there is enough food.

Digital technologies, such as digital access providing connectivity to services, information and real-time tailored advice, as well as IoT sensors and satellite imagery for monitoring and tracking farm data, can be expected to substantially increase productivity of smallholder farmers across the continent. African agricultural productivity in 2019 for smallholder farms, measured by cereal yield per hectare (kg/ha), is estimated to be 1,099 kg/ha, lower than any other region globally except for Oceania. With no increase in adoption of digital technologies cereal yield is estimated to rise 24% by 2030; however with expected increased adoption the rise could be 32% by 2030 – an increase in productivity of 86 kg/ha relative to the business-as-usual scenario, based on currently observed and expected benefits.

Whilst this would be progress, it is still a fraction of the doubling of productivity called upon by Target 2.3. More fundamental change will need a mix of better education and access to resources, including a significant uplift in overall connectivity and adoption beyond what is expected to be achieved.

Cereal yield (kilograms per hectare)



SDG in focus – SDG 3

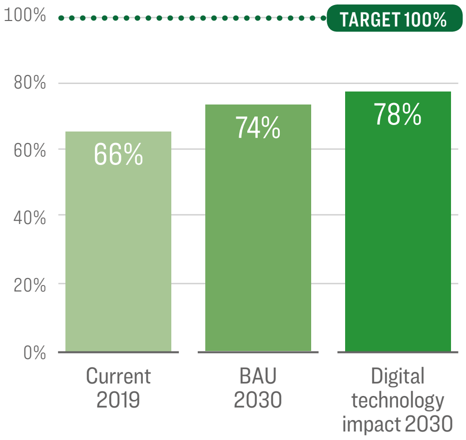
Good Health and Well-being

Africa accounted for over two thirds of global maternal deaths in 2015[17] and in sub-Saharan Africa maternal mortality was the highest globally at 546 deaths per 100,000 live births.[18] A key component to reducing these figures (Target 3.1) is ensuring births are attended by skilled healthcare professionals.[19] In 2019, 66% of births in Africa will have been attended according to estimates, compared with 84% globally and 81% in Oceania, the next worst performing region.

Communication and other health-related services provided through digital access technologies, characterised as mHealth, have been shown to increase attendance at births by strengthening communication between pregnant women and antenatal care providers.[20] With no increase in adoption of mHealth, the proportion of births attended by a skilled healthcare professional is estimated to grow by 2030 to 74% of births. However, with greater adoption, the proportion is estimated to increase to 78% of births. This translates to approximately an extra 2.1 million African births in 2030 attended by skilled health professionals.[21]

This increase relative to the business-as-usual scenario of 4.4%, is higher than for any other region and compares to a global average increase of 2.5%. This is driven by an expected higher impact of mHealth in low-income countries and also the fact that most other regions have close to 100% of births attended by skilled health professionals.

Proportion of births attended by skilled health professionals



SDG in focus – SDG 6

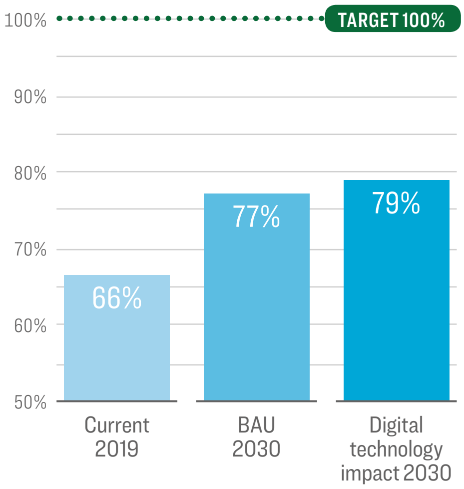
Clean Water and Sanitation

For a large majority in Africa, access to drinking water is a challenge (Target 6.1). In 2019, just 66% of the African population is estimated to have access to clean drinking water, compared to 91% globally. At the country level, in only 12 out of 54 African countries no more than 80% of the population have access to clean drinking water, and in 10 countries this was less than 50%.[22]

Digital technologies are expected to help improve this, with smart water infrastructure supporting demand management through analysis and optimisation; monitoring, including leak control and detection; and better water quality. Without this technology, access to clean drinking water is estimated to rise to 77% by 2030 based on historic trends and with existing adoption of digital technologies. However, with increased adoption of digital technologies, specifically smart water infrastructure, this could be boosted to 79%, which translates to an extra 32 million people with access to clean drinking water.

Despite this extra increase from smart water infrastructure, Africa will remain far behind the other regions and far below the target of 100% of people with access to clean drinking water. Further improvement in access will require investment in adequate infrastructure as well as restoration and protection of water-related ecosystems essential to mitigating water scarcity.[23]

Proportion of the population using at least basic drinking-water services



Asia

Asia is the world's most populous continent, home to over half the human population. The region has experienced significant development over recent decades, particularly in India and China, which have seen income per capita grow over five and ten times respectively, as well as decreases in the rate of poverty by 40% and 30% in the last 20 years.[24] In addition, in the period 1970-2015 life expectancy in Asia increased at a faster rate than any other region[25] and school enrolment has also increased.[26]

Despite this trajectory, Asia is not on track to achieve any of the 17 SDGs by 2030.[27] In 2017, 250 million Asians were living below the poverty line[28] and the region is experiencing health challenges related to both over- and under-consumption with high rates of both obesity and undernutrition.[29] In addition, maternal mortality in the region's developing countries is still double the SDG target. In terms of education, the region hosts half the world's out-of-school children and youth[30] and the quality of education varies widely: student basic numeracy is over 90% in Hong Kong, compared to under 40% in Indonesia.[31]

In the face of these challenges, digital technologies are having an impact in Asia to improve progress against the SDGs. In India, IoT is being used to monitor teacher absenteeism, which currently stands at 44% of teaching days and costs the economy $1.5 billion annually,[32] and to improve child achievement levels in literacy and numeracy.[33] In addition, in a region where half a billion people do not have enough food to eat, companies are applying digital technologies to smart, indoor greenhouse operations, which increases irrigation efficiency and improves overall farm efficiency.[34]

There are also opportunities for further impact. Precision farming will help improve the sustainability and efficiency of the region's vast agricultural sector. Deployment of digital technologies will support further progress in industrialisation and enable the decoupling of emissions from economic growth. Distance learning supported by digital technologies will enable education to reach those in rural and remote communities. However, successful development and deployment of digital technologies in this way will require investment as well as effective management driven by policymakers and businesses.

The SDGs in focus, SDGs 2 and 11, are a selection of immediately relevant goals to Asia and represent areas in which digital technologies can be deployed to support progress against a subset of targets.

2 ZERO HUNGER

SDG in focus – SDG 2

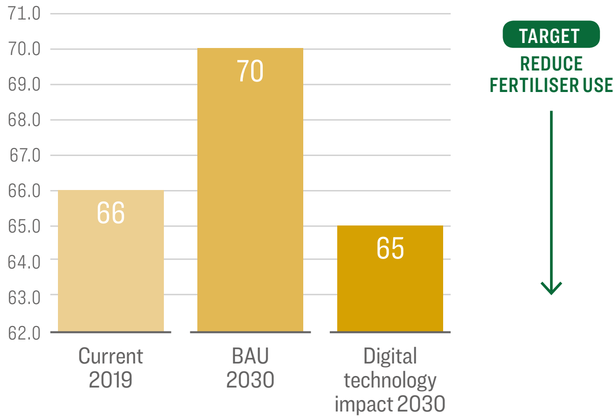
Zero Hunger

Use of nitrogen-based synthetic fertiliser in agriculture is important to boosting yields. However, excessive use can be a damaging pollutant to land and water ecosystems, and runs counter to sustainable farming practices (Target 2.4). In Asia, use of this fertiliser is higher in absolute terms than any other region at 66 million tonnes in 2019, although when accounting for area harvested, relative use is higher in North America, and in Latin America and the Caribbean.

Digital technologies are expected to drive increased productivity and efficiency in agriculture, limiting the need for synthetic fertiliser to increase production. This will include digital access connecting farmers to real-time information and advice, IoT to monitor and enable precision farming, as well as automated farms using IoT sensors and AI to monitor and automatically react to changes in crop health and optimise yields.

Without wider adoption of digital technologies, use of synthetic fertiliser is estimated to increase 7% in Asia by 2030 in order to support agricultural production. This absolute increase of 4.2 million tonnes is equivalent to the whole synthetic fertiliser use of Africa estimated for 2030. However, with digital technologies being widely adopted to increase efficiency and productivity, the amount of fertiliser used is estimated to be 7% (4.7 million tonnes) lower than in the business-as-usual scenario.

Synthetic fertiliser (nitrogen nutrient) use, million tonnes



Without wider adoption of digital technologies, use of synthetic fertiliser is estimated to increase 7% in Asia by 2030 in order to support agricultural production. This absolute increase of 4.2 million tonnes is equivalent to the whole synthetic fertiliser use of Africa estimated for 2030.

11 SUSTAINABLE CITIES AND COMMUNITIES

SDG in focus – SDG 11

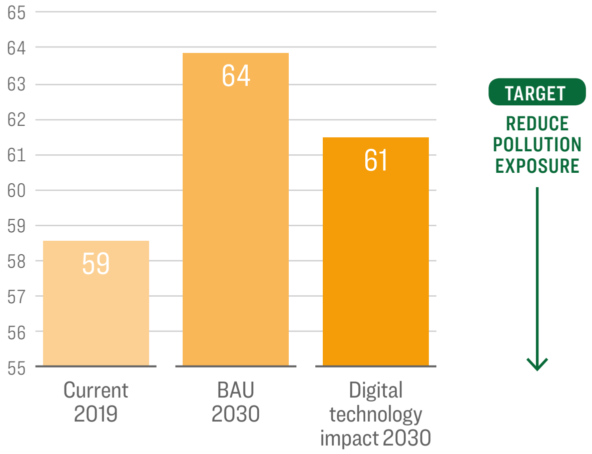
Sustainable Cities and Communities

Air pollution is higher in Asia than any other region, with PM2.5 in Asia estimated to be 59 micrograms in 2019, compared to the global average of 46 micrograms, and all of the top five polluted countries are located in the continent.[35] High exposure to particulate matter can place a burden on public health.[36] The WHO estimated that air pollution in both cities and rural areas caused 4.2 million premature deaths worldwide in 2016, with 91% of these deaths occurring in developing countries, particularly in South-East Asia and the Western Pacific regions.[37] Road transport is a large contributor to air pollution in cities, particularly in developing countries in Asia.[38] Reducing overall levels of air pollution (Target 11.6), in particular the pollution emanating from road transport, is therefore a key priority to achieving improvements in public health and broader sustainable development.[39]

Digital technologies can help to decrease the average PM2.5 concentration through intelligent traffic systems, driven by IoT and AI, that improve the efficiency of transport. Cities in China are already using cloud-based smart parking that incorporates IoT and digital access technologies to relieve congestion and mitigate air pollution.[40] In addition, AI-powered smart city technology being deployed in Vietnam's capital, Hanoi, will enable traffic management and pollution monitoring.[41]

Without greater adoption of digital technologies, PM2.5 in Asia is estimated to increase 9% by 2030 to 64 micrograms per cubic metre. This would be more than six times higher than the recommended PM2.5 concentration by the WHO.[42] However, with increased adoption of digital technologies, such as smart traffic management systems, the rise could be limited to 5%.

PM2.5 air pollution (micrograms per cubic meter)



Oceania

Oceania, which includes Australasia, Melanesia, Micronesia and Polynesia, is the smallest region by land size (8.5 million km^2)[43] and population (40 million people).[44] Development and demographics within the region are highly unequal: Australia and New Zealand make up nearly 75% of Oceania's population, and have an income per capita roughly 10 times higher than the rest of Oceania.[45]

The sustainable development challenges for developing countries within Oceania are considerable. In 2013, 41% of Micronesians lived below the national poverty line, and a quarter of the population did not have access to electricity.[46] In education, male literacy in the Solomon Islands is 14% higher than female literacy[47] and Vanuatu's secondary school enrolment rate is under 50%, compared to the global average of 76% and 93% in Australia.[48]

Despite this, digital technologies have already made considerable headway in Oceania for supporting progress towards the SDGs. For example, in developing countries in the region, digital access is playing a key role in providing access to quality education.[49]

Further adoption of solutions enabled by digital technologies will be important to achieving greater progress. In particular, more accessible distance learning will be crucial in lowering barriers to education, especially for women and indigenous populations.[50] However, one-third of Oceania's population do not currently have internet access[51] and mobile internet penetration is lower in the Pacific Islands than for any other region in the world, at 18%.[52] Deployment is held back by Oceania's unique geography, with more than 10,000 islands spread over an area the size of Africa.[53] For digital technologies to be adopted more widely in the region to progress sustainable development, efforts to connect the region must continue apace.[54]

The SDGs in focus, SDGs 5 and 4, are a selection of immediately relevant goals to Oceania and represent areas in which digital technologies can be deployed to support progress against a subset of targets.

SDG in focus – SDG 5

Gender Equality

Ensuring women's access to adequate family planning services (Target 5.6) is associated with important social, economic and health benefits.[55] However, the proportion of women who have their family planning needs satisfied in Oceania is estimated to be 51%, compared with 74% globally.

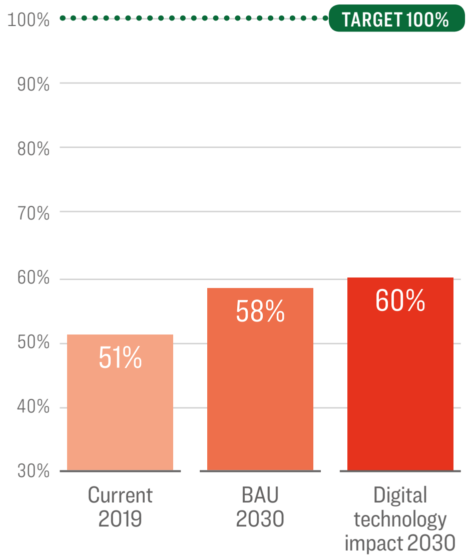
The challenge is greatest for developing countries within the region. Whereas Australia and New Zealand had a contraceptive prevalence rate of 67% and 70% respectively in 2017, smaller developing countries in Oceania had rates below 50%. In addition, for six countries in the region, more than 20% of women in a relationship had unmet family planning needs, with Samoa having the highest value globally at 43%.[56]

Digital technologies have a role to play in supporting access to relevant services through connectivity, by disseminating sexual information via digital access and mHealth services, and ensuring supply chains of contraceptives and other sexual health items are functioning correctly and efficiently with monitoring and analysis functions.[57] In addition, mHealth services support nurses and women to gain greater knowledge concerning aspects such as contraception use.

Without greater adoption of digital technologies, the proportion of women who have their family planning needs satisfied in Oceania is estimated to increase to 58% by 2030. With increased adoption of digital technologies, the proportion of women who have their family planning needs satisfied is estimated to reach 60%, equivalent to an extra 200,000 women relative to the base case.

However, even with the support of digital technologies, Oceania is expected to remain the poorest performing region globally in meeting family planning needs. Greater impact will require wider deployment of digital infrastructure to support connectivity. In addition, increasing access to family planning requires financial commitments, policy action and making services and sexual health products available, particularly to young people.[58]

Proportion of women of reproductive age (15-49 years) who have their need for family planning satisfied with modern methods



SDG in focus – SDG 4

Quality Education

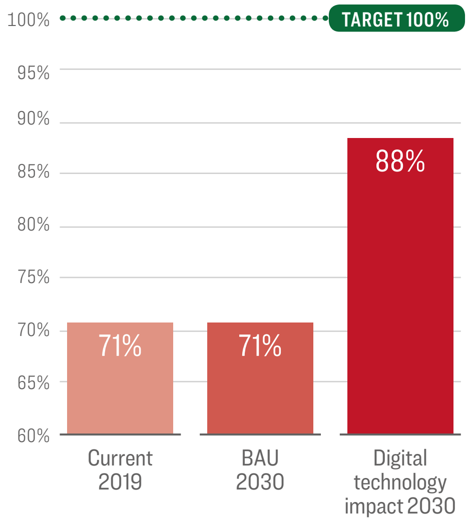
In Oceania, in the developing countries (i.e. not including developed countries Australia and New Zealand) for which data is available,[59] the youth literacy rate in 2019 is estimated to be 71%. This compares with 88% globally and is lower than any other region. Developing youth literacy (Target 4.6), as part of wider basic education, is important for achieving many of the other SDGs. For example, ensuring people have at least a basic education is important for enabling poverty reduction as well as for developing strong institutions and partnerships.[60]

Digital technologies, especially digital access, help with improving literacy rates by providing shared access to effective educational material and online courses, as well as to applications and services that help users improve their literacy. For example, in Papua New Guinea, the World Bank has used text message stories and lesson plans to improve child literacy rates with some success.[61] Furthermore, some providers of digital learning content are using AI to personalise and tailor the material provided to users.[62]

Without adoption of digital technologies, youth literacy is estimated to remain at 71% to 2030. However, with wider adoption it is estimated to increase to 88% by 2030, equivalent to an extra 400,000 literate young people. However, on this basis, Oceania will remain well below other regions, which will be closer to 100%, including Africa.

Provision of education, attendance by teachers, and provision of books in schools are all important factors to making wider gains in youth literacy in Oceania. In addition, deployment of at least basic digital access covering more of the population, which is lacking in some parts of Oceania particularly the Pacific Islands, will support this.

Youth literacy rate (%)



Without adoption of digital technologies, youth literacy is estimated to remain at 71% to 2030. However, with wider adoption it is estimated to increase to 88% by 2030, equivalent to an extra 400,000 literate young people.

Latin America & Caribbean

Since 2000, Latin America and the Caribbean ('LAC') has made strides in reducing poverty. However, in 2017 the proportion of people living in extreme poverty in the region (10.2%) was the highest since 2008, representing a significant step back from progress in prior years.[63] While there have been overall increases in income per capita,[64] the rate of reduction in income inequality has also slowed.[65]

In addition to inequality, LAC faces major challenges in ensuring sufficient healthcare for all. While wealthier nations, such as Brazil and Chile, have relatively well-developed health systems, a number of poorer countries, such as Guatemala and Bolivia, struggle to spread well-financed access to all citizens.[66] In 2014, Latin American countries only spent an average of 7.3% of GDP on health, compared to the OECD average of 12.3%.[67] The region also suffers from high rates of crime and violence, for example the number of homicides relative to the total population is higher than in any other region.[68]

An additional, and significant, challenge for LAC is preserving its local biosphere. The region hosts over 40% of the planet's biodiversity yet relies heavily on primary products and natural resources to sustain its economy.[69] If deforestation continues at the historical rate (2.2 million hectares annually between 2010 and 2015),[70] it will threaten the region's extensive ecosystems and contribute to accelerating climate volatility.[71]

Digital technologies are being used in LAC to address some of these challenges. For example, digital access and AI are deployed to provide personalised financial support to poor families, while IoT sensors are employed to detect risks of natural disasters and automatically inform local authorities. In addition, IoT and AI technologies are being used to detect illegal activities, such as logging, in rainforests, while accessible data stored in the cloud promotes cross-border collaboration and better understanding of regional biodiversity.[72]

There is broad scope to extend the use of digital technologies in LAC to promote sustainable development. The spread of digital access can drive inclusion, particularly for those in rural regions, provided that basic infrastructure is maintained to support this (e.g. electricity coverage) and that digital literacy is spread along with physical devices.[73] Cloud, AI and blockchain can also be deployed to improve healthcare services, for example AI can analyse patient data to expedite and optimise diagnosis.[74]

The SDGs in focus, SDGs 12 and 15, are a selection of immediately relevant goals to LAC and represent areas in which digital technologies can be deployed to support progress against a subset of targets.

SDG in focus – SDG 12

Responsible Consumption and Production

In LAC, food loss in the supply chain (Target 12.3) is higher per capita than any other region and is widely recognised as a problem.[75] In 2019, 158kg of food is expected to have been lost per person, compared to 64kg globally and 72kg in the next highest region, Africa. Food loss in the supply chain represents a waste of the scarce resources that are used in producing food, e.g. water, energy and land.[76] Minimising food loss supports efficient use of resources and reduces the burden placed on the environment and ecosystems from food production. The FAO estimates that global food waste would be enough to feed two billion people.

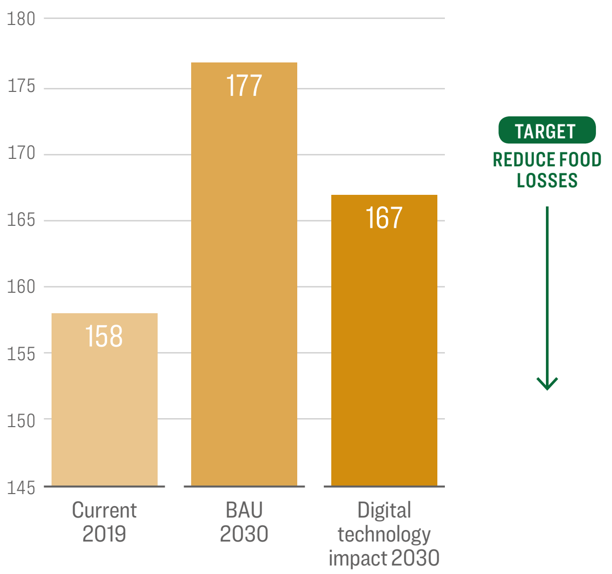
In Latin America 15% of food available is lost or wasted each year while 47 million people in the region still suffer from hunger.[77] Food loss in the region is driven by a lack of infrastructure, packaging, transportation and storage, as well as regulations relating to food standards.[78] Increasing investment in supply chain infrastructure and raising public awareness have been identified as key factors to enable reduced food loss. This will undoubtedly require appropriate policy and regulation, but in addition, digital technologies can play a role; in particular, the FAO has identified post-harvest and monitoring technology for use in LAC.[79] This includes smart monitoring using IoT sensors and connected devices, as well as cloud-based apps and digital platforms that connect organisations and individuals allowing them to share surplus food.[80]

Without wider adoption of digital technologies in relation to supply chain food loss, food loss per person in LAC is estimated to grow 13% by 2030, based on historic trends. However, with adoption of digital technologies, in particular logistics solutions to monitor produce as well as AI to identify points of food loss, estimates are that this rise will be limited to 6%, saving 10kg of food per person relative to the business-as-usual scenario.

It should be noted that supply chain food loss is typically higher in developing countries compared to developed countries due to hot humid climates and inadequate transportation and storage infrastructure. In developed countries food waste at the level of consumption, rather than in the supply chain, is higher than in developing countries.[81]

In order to reduce food loss in LAC, relative to the current rate, it will be important to apply new digital technologies, develop appropriate public policy, increase current knowledge and promote sustainable behaviour.[82]

Food loss in the supply chain (kg per person per year)



SDG in focus – SDG 15

Life on Land

Sustainable management of forests (Target 15.2) is a key target for LAC. The region's forests are important ecosystems and support the livelihoods of billions of people. The Amazon itself hosts 10-15% of the terrestrial species on Earth.[83] Forests are also critical for mitigating the impact of climate change and reducing atmospheric CO2.

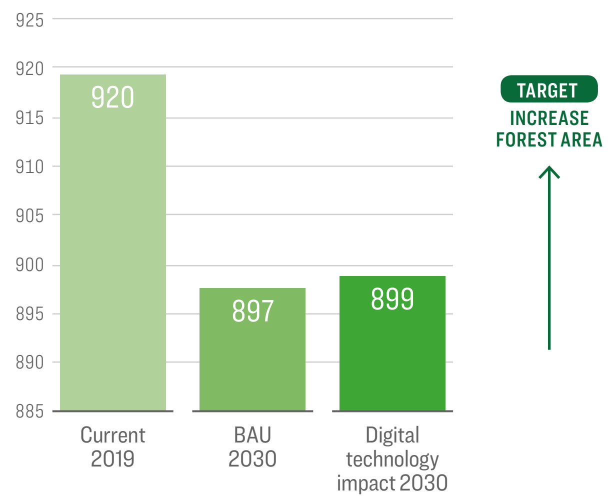
Forests in LAC make up nearly a quarter of the global total, with only Europe hosting more forest area. Total forest area in the region is estimated to be 920 million hectares in 2019. However, in the same year over two million hectares of forest area is expected to be lost. This is only slightly less than the loss in Africa and in all other regions there is estimated to be growth in forest area. This is driven by deforestation, both legal and illegal, as well as insufficient management of forest resources.[84]

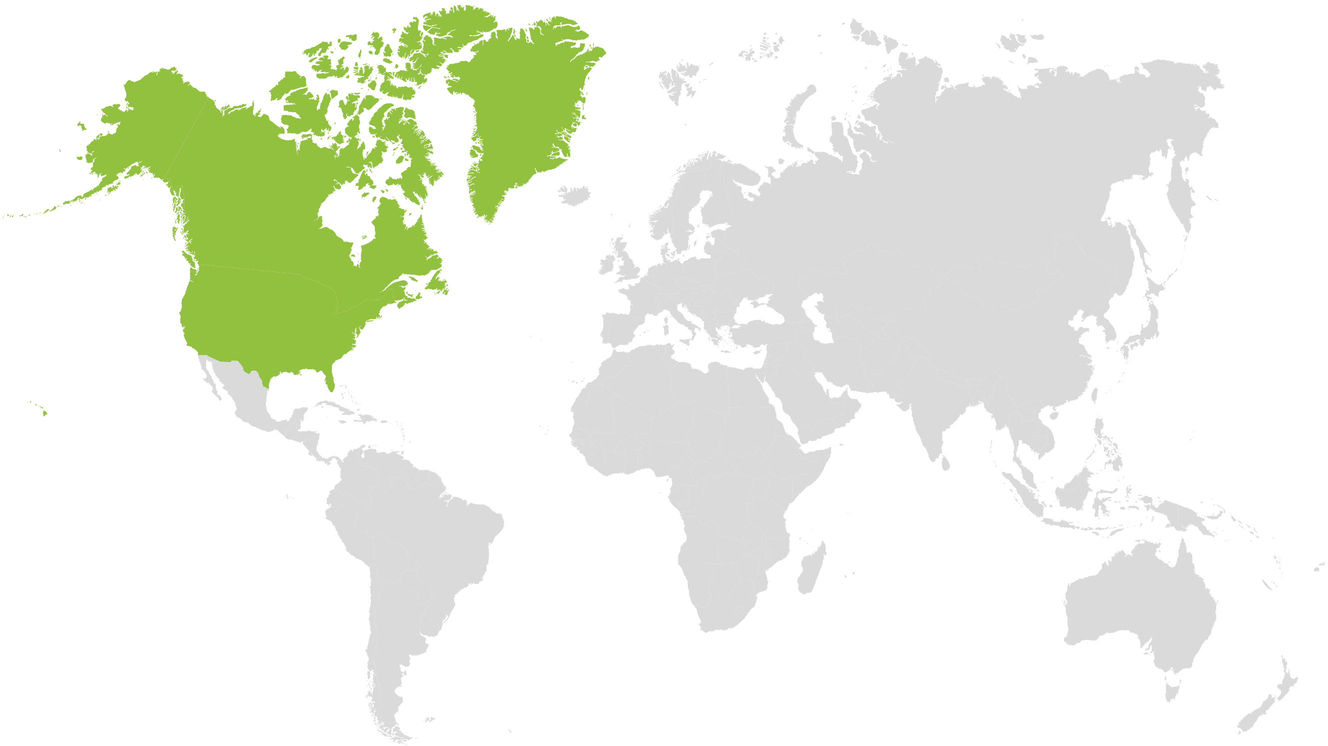
Digital technologies have an important role to play in the sustainable management of forests. For instance, collecting data enabled by digital access through satellite images and open source platforms, as well as analysis using cloud and AI can help monitor and track changes in canopy and inform conservation management. In addition, digital tools are being used in innovative ways globally, including in LAC, to detect illegal activities such as illegal logging.[85]

Without greater adoption and use of digital technologies in the sustainable management of forests, forest area in LAC is estimated to fall 2.4% by 2030. However, with wider adoption of digital technologies, such as connected forest monitoring systems and big data analysis of cloud-based environmental information, the fall in forest area will be limited to 2.3%, reducing the rate at which forest area is lost in the region by 6%. This impact equates to a reduction in net emissions of 392 kt in 2030.

Reducing the loss of forest area further in LAC requires policy changes from national governments, as well as greater enforcement against illegal activities linked with deforestation, and coordination and cooperation between countries. In particular, policymaking and action on forest, agriculture, food, land use, and rural and national development must be integrated and considered as one.[86] Further development of digital technologies and supporting future innovation will be important to achieving this; in particular, to improve access to markets and increase efficiency of agrochemicals and other inputs.[87]

Global forest area (million hectares)





North America

Whilst economic growth has allowed for progress across the SDGs, as well as increased investment in developing innovative technologies, such economic activity is often coupled with a negative impact on the environment. The need to negotiate this tension between protecting the biosphere and sustaining economic growth is particularly prevalent in North America. Annual CO2 emissions per capita from the US is among the highest in the world at 17 tonnes as of 2014 – over three times the global average of 5 tonnes,[88] and the domestic material consumption per capita in the region is nearly 20 tonnes – significantly above the global average.[89] Therefore, the need to decouple economic development with environmental degradation and move towards a circular economy is of high priority.

In addition, the prevalence of adult obesity, although in decline, remains high in both the US and Canada at 36% and 29% respectively in 2017.[90] Obesity is a major risk factor for non-communicable diseases such as cardiovascular diseases, diabetes and some cancers.[91] Further progress is also required to reduce inequalities, particularly in the US where significant racial disparities remain. For example, black women are 2.5 times more likely to die in pregnancy and childbirth than white women.[92] Inequality, as measured by the share of income earned by the top 1%, has increased in the US since 2000.[93]

North America is amongst the most developed regions in its application of digital technologies, driven by higher investment in R&D (the US accounts for 47% of global ICT R&D spend)[94] and a strong presence of ICT firms to develop solutions. However, whilst a large number of North American companies have declared a commitment to the SDGs, the US remains the only country to have neither submitted nor planned a Voluntary National Review (VNR). This provides some challenge to predicting their ability to achieve the Goals by 2030. This reduced engagement also increases the risk of negative externalities such as exacerbated inequalities or irresponsible consumption patterns. For example, e-waste remains particularly high, at an average of 20 kg per capita.[95]

The SDGs in focus, SDGs 6 and 7, are a selection of immediately relevant goals to North America and represent areas in which digital technologies can be deployed to support progress against a subset of targets.

SDG in focus – SDG 6

Clean Water and Sanitation

Sustainable and efficient use of water resources (Target 6.4) is important to guaranteeing the long-term supply of water and limiting those suffering from water scarcity. It also limits environmental degradation related to water withdrawal that comes from over-exploitation of resources.

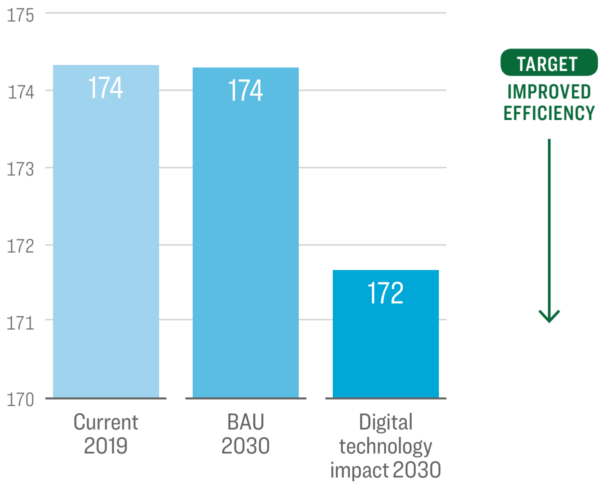
In North America, municipal water withdrawal (i.e. water used for use by the general population from natural water resources) is estimated to be 64 billion m3 in 2019, equivalent to 13% of the global total and 174,000 m3 per capita – the most of any region. In order to ensure efficient use of resources and progress towards sustainability it is important for national governments, utility companies and the public to address this high usage. For example, public bodies in California are working with other organisations and the public to save water in the face of severe drought in recent years.[96]

Digital technologies can support more sustainable water use. In particular, smart water infrastructure, enabled by digital access, incorporates IoT at both the consumption and distribution levels and is optimised by AI. Smart water infrastructure includes water demand management and identification of excessive consumption, leakage control and detection, improved billing accuracy and improved water quality through IoT monitoring. This technology can help monitor and improve efficiency of water use, and utilities in North America are already investing in the technology.[97]

Without wider use of digital technologies enabling smart water networks, municipal water withdrawals per person are estimated to remain at current levels to 2030. However, with wider adoption of digital technologies and smart water infrastructure, this is estimated to fall 1.5%, representing an annual water saving of one billion m3 in 2030.

Further progress in reducing water use requires greater infrastructure investment, change in behaviour, and a wider move towards a circular economy. This is supported by digital technologies driving efficiency and also monitoring and analysis in order to provide transparency and enable optimisation.

Municipal water withdrawals per person ('000s m3 per year)



7 AFFORDABLE AND CLEAN ENERGY

SDG in focus – SDG 7

Affordable and Clean Energy

Improving energy efficiency (Target 7.3) is important to improving overall resource efficiency and relieving stress on energy networks, as well as reducing emissions and decoupling economic growth from environmental degradation.[98]

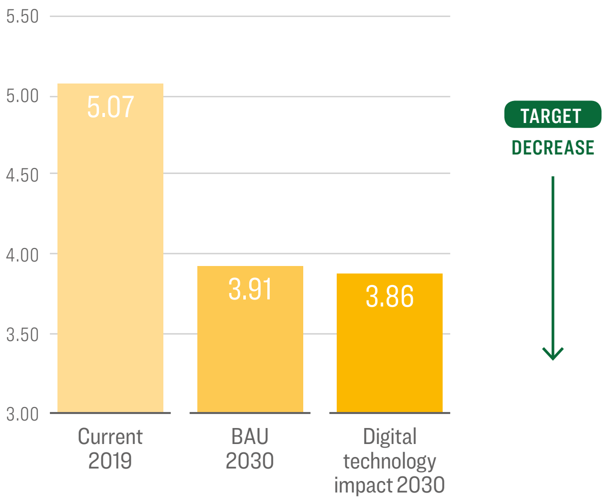
In North America, energy intensity (i.e. energy per unit of GDP) is 5.07 megajoules per 2011 international $, among the highest in the world, surpassed only by Asia. Lowering the energy intensity improves the sustainability and longevity of existing infrastructure and frees up resources for other purposes, supporting the reduction of emissions. The problem is already recognised in the region with local investment in energy efficiency set to rise in the coming decade.[99]

Adoption of digital technologies supports improving energy efficiency. For instance, connected grids and connected homes powered by IoT and AI can improve the efficiency and operation of networks and reduce home energy usage. Such technologies are seen as important components to modernising energy networks in the region.[100]

Without wider adoption of digital technologies, energy intensity in North America is estimated to fall 23% by 2030. However, with digital technologies, this reduction will be 24%. Although it appears only a marginal improvement, it represents an estimated drop in emissions of 66 Mt CO2 annually.

Further improvement in energy intensity requires raising awareness and promoting public behaviour change, as well as supporting wider market transformation and making investment and resources available to progress this.[101] As part of this transformation, digital technologies such as blockchain will be important to enabling new models such as microgrids.[102]

Energy intensity per unit of GDP (megajoules per 2011 international $)



Europe

Europe has made positive progress towards almost all SDG goals in the last five years.[103] Indeed, the top 10 countries in the 2019 Global SDG Index ranking are from Europe.[104] In general, progress is expected to continue as the EU remains publically committed to the 2030 Agenda, including commitments to become carbon neutral by 2050.[105]

However, there have been a number of areas identified where sufficient progress has not been made, such as reducing the number of people at risk of poverty or social exclusion.[106] Inequality is also a widespread issue with mixed progress. There are now more women in leadership positions and female participation in the labour force has increased; however, the share of women who are inactive due to care responsibilities has increased and economic inequality has been rising in general since the financial crisis.[107]

Biosphere trends are also concerning. There has been a steady increase in energy consumption since 2014 and, although the share of renewable energy throughout Europe has increased,[108] progress has slowed.[109] CO2 emissions per capita remain substantially above the global average, despite increasing commitments to climate finance.[110] Waste also remains too high to meet all aspects of the targets set out by the SDGs.[111] Biodiversity is declining in the EU, as human settlement continues to expand and climate change alters ecosystems. Decoupling emissions from economic activity and moving towards a circular economy will need to be a key focus for Europe moving forward in order to meet the 2030 Agenda.

The SDGs in focus, SDGs 2 and 9, are a selection of immediately relevant goals to Europe and represent areas in which digital technologies can be deployed to support progress against a subset of targets.

SDG in focus – SDG 2

Zero Hunger

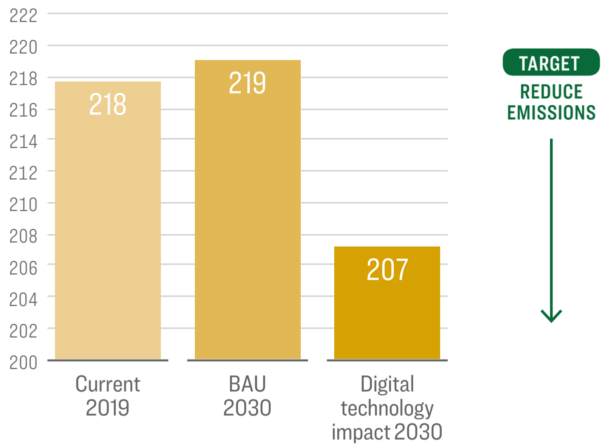
The agricultural sector is a key emitter of greenhouse gases and a proportion of these come directly from the digestive process of livestock, known as enteric fermentation. Addressing this is important in promoting sustainable agriculture (Target 2.4).

In Europe, annual enteric fermentation emissions are estimated to be 218 Mt CO2e in 2019. Although emissions were lower in North America, on a per capita basis Europe produces the lowest amount of emissions from this source. However, it is widely recognised that more needs to be done to address emissions from the agricultural sector, including enteric fermentation,[112] and the EU has identified enteric fermentation as a key area in which to reduce emissions.[113]

Digital technologies, in particular IoT, can be used to automate monitoring of livestock and alert farmers to changes. This can reduce the risk of disease and improve the efficiency with which meat is produced, ultimately reducing total emissions from enteric fermentation.

Without digital technologies, annual emissions in Europe are estimated to grow 1% by 2030. However, with greater use of digital technologies, emissions are instead estimated to fall 5%, reducing annual emissions by 12 Mt CO2e in 2030, relative to the business-as-usual scenario. Digital technologies and innovation in the agricultural sector could form part of wider strategy to reduce emissions, with other components being improved animal health and overall agricultural efficiency, adjusting animal diets and vaccinations and overall changes in dietary habits.[114]

MT CO2e from enteric fermentation



SDG in focus – SDG 9

Industry, Innovation and Infrastructure

The manufacturing sector is a key consumer of natural resource and reducing this is an important component of achieving greater sustainability and resource efficiency in industry (Target 9.4); is relevant to developing a circular economy (Target 12.2); and is essential for promoting sustainable economic growth (Target 8.4).

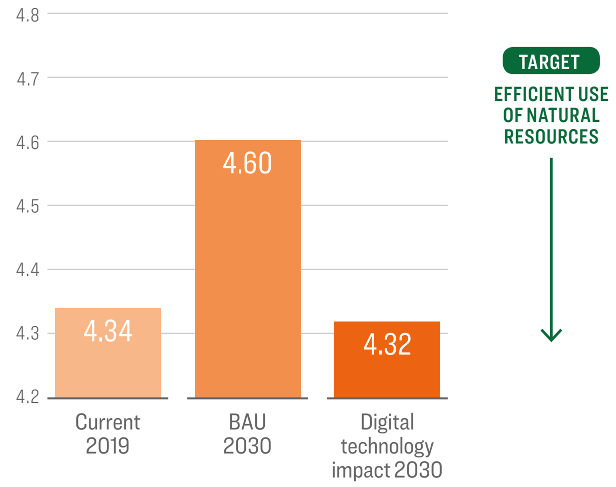
In Europe, manufacturing is expected to consume 4.3 billion tonnes of material in 2019; this is higher than any other region apart from Asia. However, per unit of manufacturing GVA, Europe is the smallest consumer of material for manufacturing purposes, reflecting relatively efficient industrial processes.

Nevertheless, further progress can yet be made. The EU has targeted reducing material consumption in its Industrial Modernisation Platform, with a key role identified for digital technologies and 'smart specialisation'.[115]

Digital technologies, in particular Industry 4.0 enabled by IoT and AI, are expected to enable substantial productivity gains in manufacturing, improve resource-use efficiency and ultimately support a reduction in domestic material consumption.[116]

Without Industry 4.0, domestic material consumption from manufacturing in Europe is estimated to rise 6.0%, counter to the SDG targets. However, with greater deployment of Industry 4.0, material consumption is estimated to instead fall marginally by 0.5%.

Manufacturing Domestic Material Consumption (tonnes, billions)



05

The ICT Sector: the Catalyst for Sustainable Development

1 Introduction

Prior chapters have focused on the enabling impact that digital technologies have on the SDGs, both positive and negative. This chapter turns to the direct impact that the ICT sector has, and describes this against the context of that enabling impact. The chapter comprises the following sections:

- **ICT sector definition:** an explanation of the way the ICT sector and its component parts is defined for the purpose of this report;
- **Direct impacts:** a quantitative assessment of the positive and negative direct impacts the sector has, in terms of baselines and projections to 2030;
- **Enabling impacts:** a summary of the impacts on SDGs reported in earlier chapters, providing context to the direct impacts of the ICT sector;
- **A comparison of direct to enabling impacts:** a comparison between the direct impacts and the enabling impacts together with reference to findings from previous SMARTer2030 reports; and
- **Conclusions:** a distillation of the implications and a segue into the actions laid out in the next chapter.

Unless an external reference is provided, the statistics and projections quoted in this section have been derived for this report from existing research and statistics, primary research with panels of sector experts, together with inputs and advice from GeSI members and the expert panel convened for this report.

Each projection is accompanied by a qualitative description of the upside and downside risks. This approach captures the unavoidable uncertainty surrounding outcomes in a fast-moving sector over more than a decade into the future, in a way that highlights the most important risks to mitigate and the most important opportunities to embrace.

There is more detail on all aspects of the approach and comparisons to the wider literature in the Methodology appendix.

2 ICT Sector definition

The ICT sector is broadly defined as equipment and services related to the electronic collection, transmission and analysis of data (reflected in broadcasting, computing and telecommunications). In terms of a practical classification that can be matched to economic data, this report draws on the framework used in the PREDICT project[1] commissioned by the European Commission as it provides a time series from 1995 to 2015 which in turn can underpin the projection to 2030. This classification of the ICT sector is split into two subsectors:

- Manufacturing, including: the manufacture of electronic components and boards; the manufacture of computers and peripheral equipment; the manufacture of communication equipment; the manufacture of consumer electronics; and the manufacture of magnetic and optical media, and
- Services, including: the wholesale of computers, computer peripheral equipment and software; the wholesale of electronic and telecommunications equipment and parts; telecommunications, including wire, wireless satellite and other telecommunications; software publishing (including computer games); computer programming, consultancy and related activities; data processing, hosting and related activities; web portals; and the repair of computers and communication equipment.

An important caveat to any measurement of the ICT sector is the lack of a hard line between 'digital' and 'non-digital'. National accounting statistics used to measure the size of economic sectors work on the basis of classifying companies based on their functions. In the case of software in particular, this is a challenge as "more and more major businesses and industries are being run on software and delivered as online services – from movies to agriculture to national defense."[2] This includes both digital native businesses, e.g. Netflix, delivering services digitally, but also established businesses, e.g. Disney, reorienting their business model towards digital distribution. This trend in the services sector is also affecting manufacturing through IoT and Industry 4.0.

These trends mean that attributing value and other impacts to the sector is highly dependent on the definition used of what is, and what is not, an ICT business. The assets of the sector are also becoming harder to measure with the growing importance of intangible assets, e.g. IP. More details on the classification are provided in the Methodology appendix.

Given the rapid digital transformation of other sectors, it is reasonable to expect that any measure of the size of the ICT sector will be conservative. This is particularly the case for this report and others which rely in part on historical definitions and data to formulate a high-level set of global estimates.

3 Direct impacts

Direct impact, i.e. the impact of the sector through its value chain and associated activities (as opposed to the impact enabled through the application of its products and services), comprises both positive and negative impacts:

- **Positive direct impacts** which include economic contribution, employment, and R&D. For each impact a baseline has been estimated and then a projection made to 2030; and
- **Negative direct impacts** which include emissions, and the use of natural resources. Commentary is provided for both a baseline and projections to 2030, with quantitative estimates included for emissions and e-Waste.

3.1 Positive direct impacts

This section first considers the current, or baseline direct impact of the ICT sector in terms of economic contribution (measured by its GVA contribution), employment, and spend on research and development. It then lays out projections for each of these impacts to 2030.

3.1.1 Current positive direct impacts

3.1.1.1 Current economic contribution

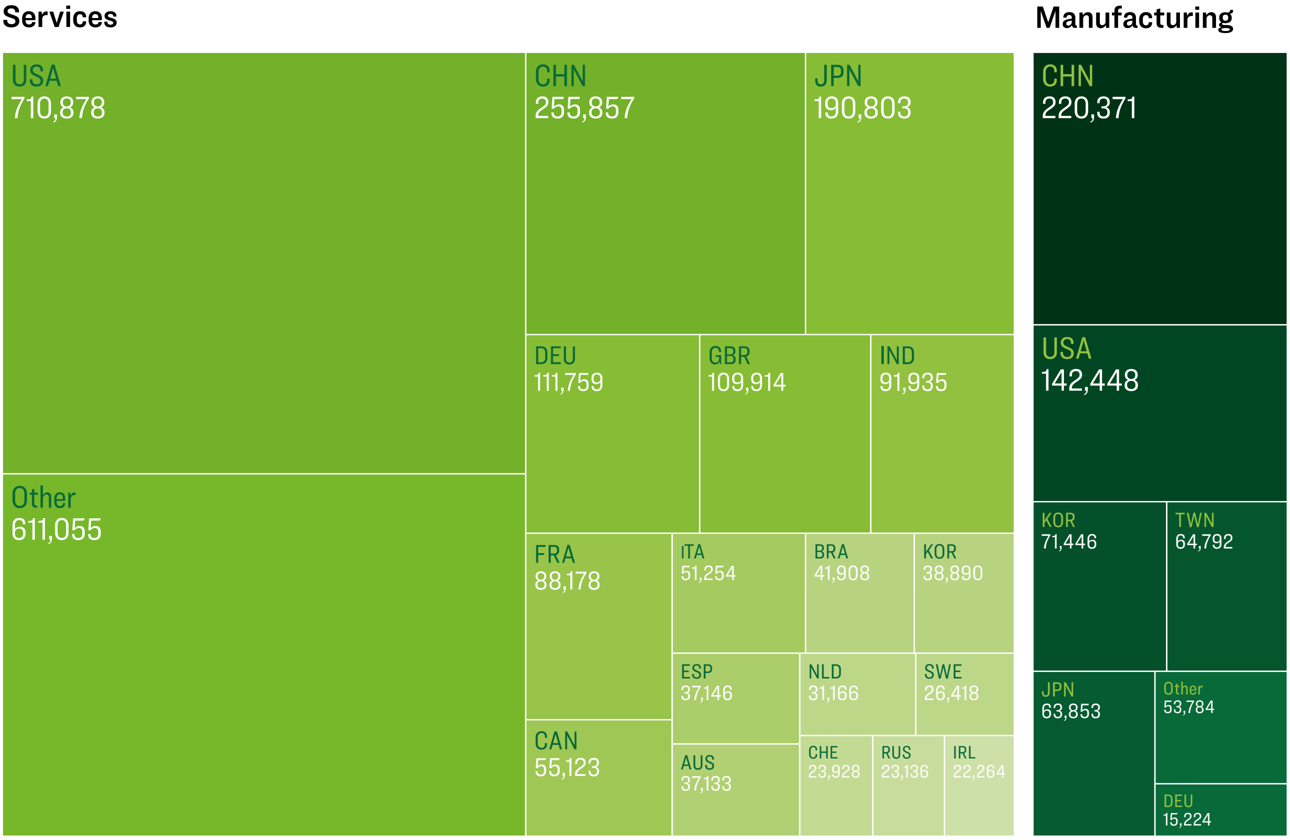
The global ICT sector as conventionally measured, based on companies in the ICT manufacturing[3] and services[4] sectors, amounted in 2015 to around €3.2 trillion in GVA terms (2015 prices, used throughout this chapter). Of this, around €2.6 trillion is accounted for by services and €630 billion by manufacturing.

The geographic distribution of this economic activity varies, with services broadly allocated in line with GDP and manufacturing more concentrated in the US and a group of East Asian economies. In China and the US, the ICT sector accounts for around 5% of total GDP.

Whilst GVA can be considered as an established way of determining economic contribution, it is likely to be an incomplete and understated measure of the value of ICT on the basis that:

- many services are offered free at the point of use, e.g. user generated content;
- value in terms of enhanced consumer welfare, or time employed in production may not be captured in gross value added; and
- statistical authorities struggle to value drastic increases in the quality of ICT goods and services, e.g. the range of capabilities of a smartphone.

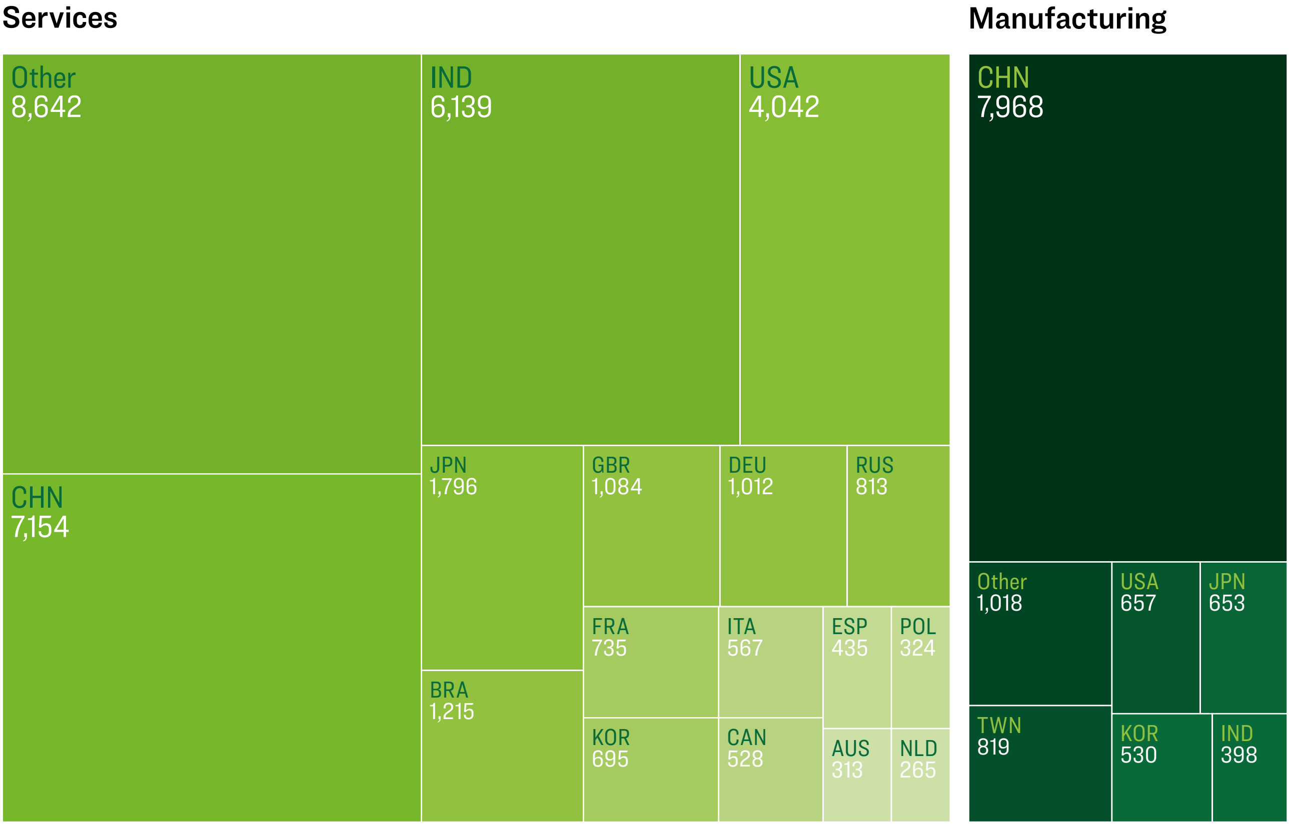
ICT Sector GVA, €m



3.1.1.2 Current contribution to employment

The ICT sector employed 48 million people in 2015 amounting to around 1.5% of global employment, with 12 million employed in manufacturing and 36 million in services.[5]

ICT Sector Employment, 000s



Over and above the volume of jobs created, the contribution and quality of these jobs is also significant, as hourly productivity in the sector is generally greater than in the wider business sector, for both manufacturing and services.

This higher productivity translates into higher pay, with a global survey by Global Knowledge finding typical entry level earnings of around $40,000 and executive earnings nearly $90,000.[6]

Table 1: Labour productivity, current euros per hour worked

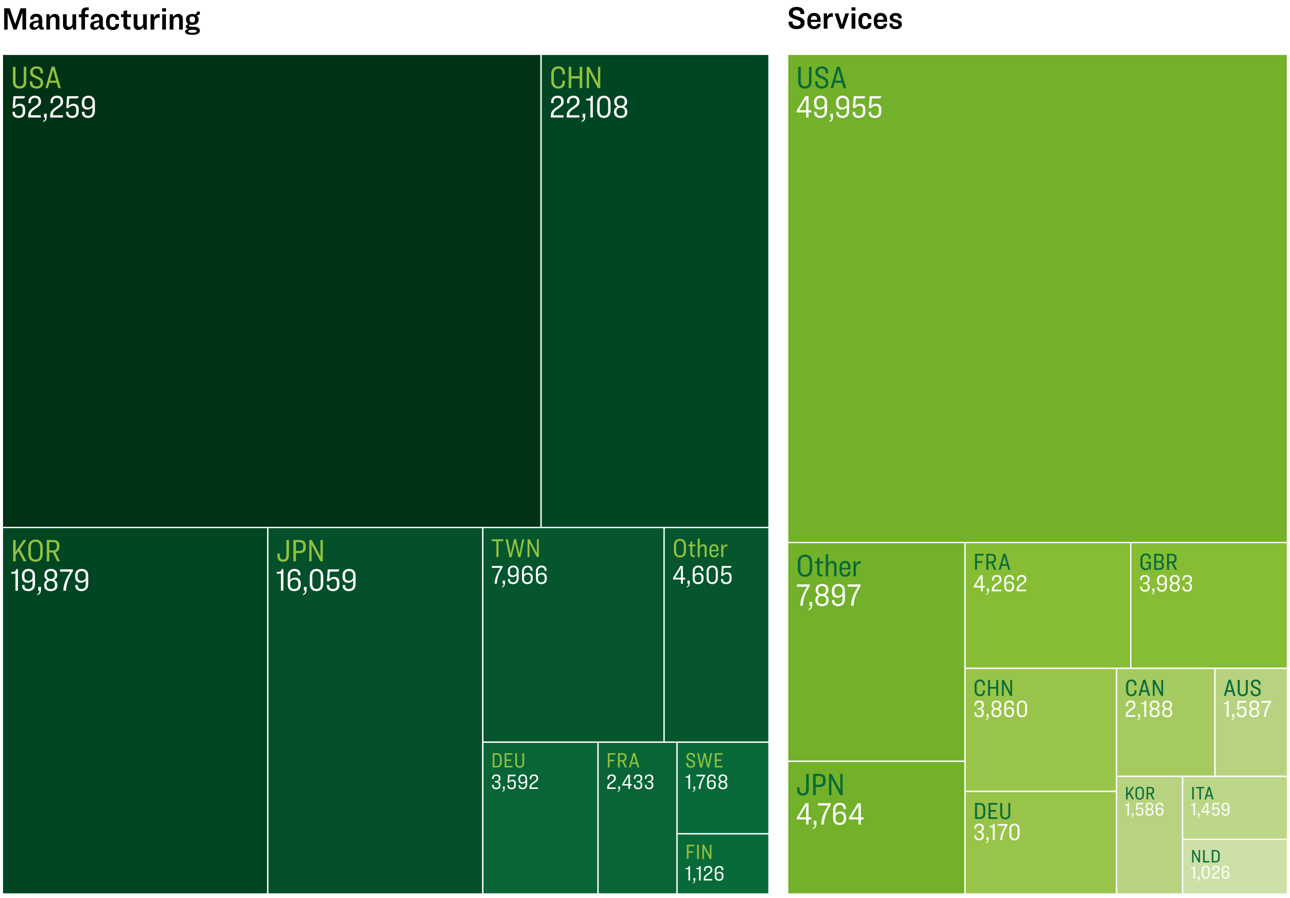
	ICT manufacturing	ICT services	Total economy
US	115	94	62
Japan	54	57	34
India	3	8	2
Germany	81	69	53

3.1.1.3 Current contribution in terms of R&D spend

R&D is generally acknowledged to have a range of positive spillovers, generating knowledge that can be deployed beyond the organisation and sector of origin.

The ICT sector spent €218 billion on research and development in 2015, of which €132 billion was accounted for by manufacturing and €86 billion by services. R&D spending in the ICT sector is particularly concentrated in the United States, where it accounts for 32% of business R&D spending. More generally, the ICT sector is a major contributor to R&D spending, accounting for 20% of business R&D spending in Japan, 17% in China, 15% in India and 11% in Germany. This is much greater than the equivalent shares of business value add or employment.

ICT Sector R&D, €m



3.1.2 Projected positive direct impact

3.1.2.1 Projected economic contribution

The industry has been growing steadily in the past two decades with ICT manufacturing growing by around 2% a year in real terms and ICT services by 5% in real terms. This compares with global GDP growth at around 3% in the same time frame. This trend provides a reasonable basis for a projection to 2030 given:

- There is no sign of a sustained deviation from the linear upwards trend, with earlier deviations, e.g. the dotcom boom, being subsequently corrected to trend;
- Metrics for investment in the future of digital technology remain positive, supporting continued growth, for example:
    - Global venture capital investment is strong, with estimates that over $90 billion was invested in Q4 2018, completing a "record year for the market."[7]
    - R&D spending in the ICT manufacturing and services sectors also appears to be rising over time. This is covered in more detail below.

As described throughout this report, the growth of the ICT sector will enable progress against the SDGs in a variety of directions. The importance of the SDGs and the enabling role that digital technologies play in contributing to sustainable development is an important reason to expect that the sector will continue to grow.

If the ICT sector continues to grow at the same trend rate, the ICT sector GVA will be €3.8 trillion in 2019 and will grow by €2.3 trillion (61% growth or 4.4% CAGR) to €6.1 trillion between 2019 and 2030, of which €0.9 trillion would be accounted for by manufacturing and around €5.2 trillion would be accounted for by services.

However, this growth is not without challenges. Just like other industries, the ICT sector faces a challenge to decouple its growth from environmental degradation and the exacerbation of societal issues to avoid constraining regulation, policy and other stakeholder behaviours. The key risks to this projection are considered in Table 2, together with upsides that could drive higher growth or offset these risks if they come to be.

ICT GVA Contribution Projection

€m, 2015 prices

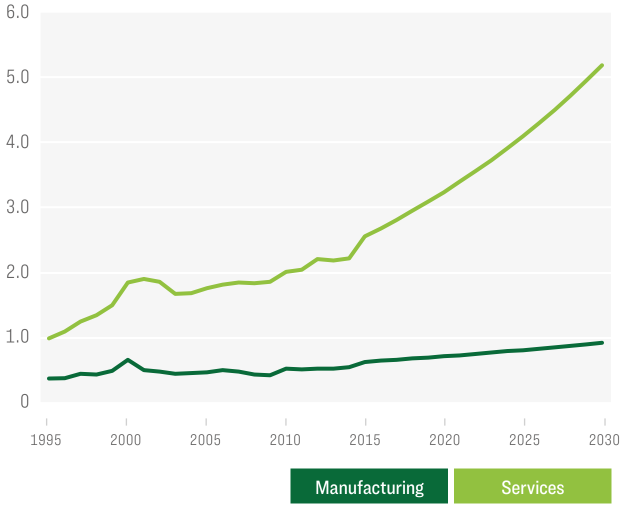


Table 2: Upside and downside risks to GVA projection

	Lower likelihood	Higher likelihood
Larger positive impact	**Major new business models –** new business models have yielded large new businesses in the past, e.g. Google and Facebook with digital advertising; Netflix with online subscriptions.	**Reward for contributing to sustainable development –** new goods and services, plus improved consumer trust and stakeholder engagement attracting investment and catalysing deployment.[8] **New platforms –** widespread adoption of technologies like blockchain or digital reality might provoke a range of related innovations, as the internet or mobile did before.[9]
Smaller positive impact	**Emergence of major new innovation centres –** an alternative technology centre might attain materially more of the scale which gives Silicon Valley such a distinctive influence in the tech sector.	**Improvement in skills –** if policy enables an increased supply of relevant skills, the sector will be able to grow more quickly.
Smaller negative impact	**Further decoupling of digital goods from economic growth –** if consumer welfare were to diverge further from formal economic output, with informal activity online growing in importance over time, this would reduce measured GDP and possibly employment, as well as tax revenues and other outcomes associated with formal economic activity.	**Wider secular stagnation –** any general slowdown in growth[10] will reduce the value of digital solutions, although the sector has shown an ability to grow through wider recessions (see the graph above, with no material deviation from trend around 2008). **Investment shock –** any major reduction in venture capital or other investments in tech, or the valuations that underpin those investments, could diminish growth. However, as appears in the graph above, the shock of the dotcom crash appears to have mostly resulted in the sector reverting to trend; not a major departure.
Larger negative impact	**Techlash –** widespread backlash spurred by the externalities to digital technologies would impede growth, with a substantial increase in consumer, regulator and wider public scepticism of ICT businesses. Such a backlash is arguably ongoing, but has so far had a relatively limited impact on the growth of the sector. This risk will be greater to the extent the sector is not seen as responsible and purpose-led. **Weak infrastructure –** in the event that there are large obstacles, not overcome politically or technologically, to the deployment of ICT and relevant non-ICT (particularly energy) infrastructure, this might inhibit the growth of the ICT sector globally, though this is already a factor in the present data and therefore the trend used for this forecast.	**Major obstacles to trade –** the ICT sector has a global supply chain. This can be seen, for example, in the fact that whilst R&D is highly concentrated in the US, manufacturing often occurs elsewhere. Barriers to trade would inhibit its ability to grow.

3.1.2.2 Projected contribution to employment

Further to GVA growth in the sector, employment is also expected to grow, with a trend exhibiting similar stability to GVA. ICT manufacturing employment grows by around 2% each year and ICT services employment by 4% each year. This implies that ICT services, in particular, will continue to see substantial increases in labour productivity over time.

The main additional upside and downside risk to this projection would be automation.[11] This is likely to be most significant for relatively routine work and may change the character of some employment. For example, routine work in ICT services, such as answering routine support requests, may decline in importance. However, some tasks within given jobs could grow in importance, e.g. the social element in customer relations in the same support roles.[12] The ICT sector is also a sector where there could be more opportunities for additional employment in the implementation of automation and the development of autonomous systems, e.g. in computer programming.[13] Digital technologies will also have an impact on employment in other sectors, which is considered in the appendix chapter on SDG 8.

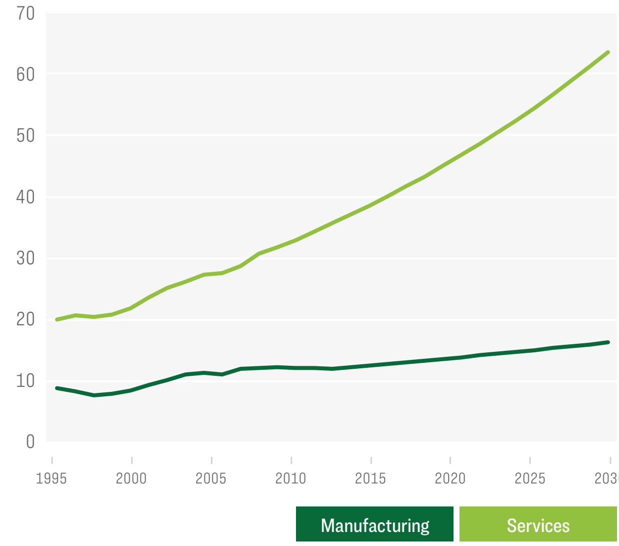
3.1.2.3 Projected contribution in terms of R&D spend

Alongside the growth in GVA and employment in the ICT sector, there is likely to be growth in R&D spend. However, R&D spending is more unstable over time, which may reflect a mix of measurement challenges, financial volatility and sensitivity to the policy environment, particularly in the US. Assuming that trends since 2005 continue,[14] there will likely be a 4% annual increase in services R&D above inflation and a 3% annual increase in manufacturing R&D above inflation. This implies €378 billion in ICT spending on R&D in 2030; an increase of 50% from €252 billion in 2019. In terms of the scale of investment over time, that would mean that the sector will invest over €3 trillion in R&D in the decade from 2020.

Again, this projection is subject to a range of upside and downside risks (Table 3). To some extent, these will reflect the broader risks to growth in the sector which are covered above, but there will also be some distinct risks to R&D investment in particular, which are explored here.

ICT Employment Contribution

000s



ICT R&D Contribution Projection

€m

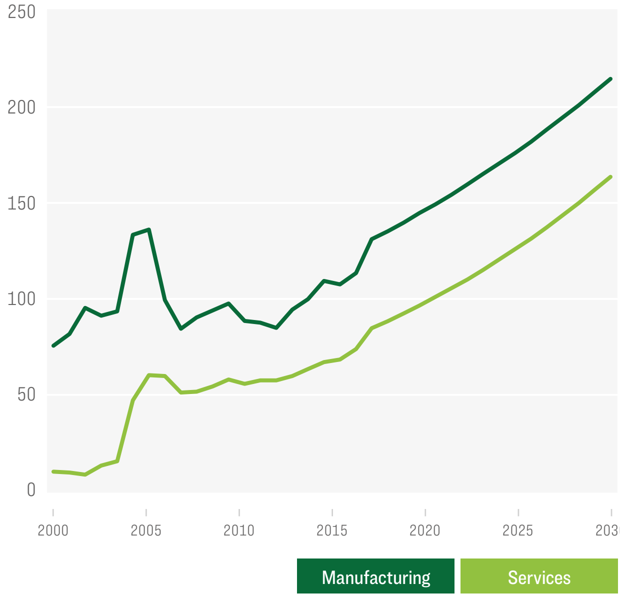


Table 3: Upside and downside risks to R&D projection

	Lower likelihood	Higher likelihood
Smaller positive impact	**Improvement in skills –** if policy enables an increased supply of the relevant science skills, R&D will be able to grow more quickly, though this may not particularly be reflected in an increase in spending.	**Changes in government policy –** increased incentives, e.g. in the tax system, might promote R&D spending, or shift its location.
Smaller negative impact	**Decline in IP system –** in the event that patents and other forms of IP were to become considerably more ineffective, or inflexible, that might undermine the transmission of knowledge and incentive to generate new innovations. However, IP may be less central to digital innovation than in other sectors, particularly given the important role of open source.	**Changes in government policy –** diminished incentives, e.g. in the tax system, might discourage R&D spending, or shift its location.

3.2 Negative direct impacts

This section first considers the current, or baseline, negative direct impacts of the ICT sector in terms of a broad range of ESG (environmental, social and governance) risks, emissions, and resource consumption. Consideration is then given to how these impacts may evolve to 2030 with specific focus on emissions.

3.2.1 Current negative direct impacts

3.2.1.1 Broad-based ESG risks

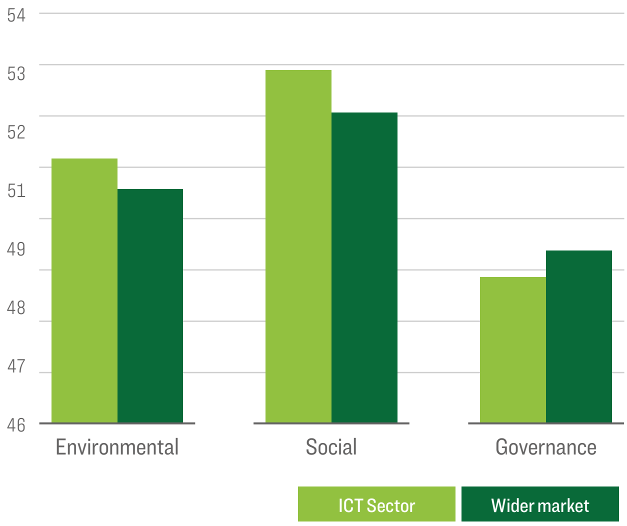
The ICT sector has been evolving its approach to responsible business over time. Organisations like GeSI are encouraging greater observance and standardisation across the spectrum of established environmental, social and governance (ESG) themes. Operating to best-in-class responsible business principles is increasingly important to all stakeholders, not least investors. Furthermore, it is particularly important for establishing credibility and freedom to operate for this sector at a time when digital technology is often held up as a cause of negative societal outcomes.

This section uses data provided by Arabesque to assess the comparative performance of the sector against broad ESG criteria. The Arabesque S-Ray tool produces a variety of sustainability scores that enable comparison between companies and sectors. Leveraging big data through the power of machine learning, the tool analyses around 7,000 of the world's largest corporations and combines over 250 ESG metrics with news signals from over 30,000 sources published in over 170 countries. To analyse the ICT sector, a sample of corporations have been selected that broadly map to the definition of the ICT sector used throughout this chapter, and split into the ICT manufacturing and services subsectors.

Based on analysis through the S-Ray tool, the ICT sector performs better than the wider market on environmental and social issues and below average on governance issues.

ESG score sector comparison

S-Ray average score



The environmental score reflects the greater than average performance of the sector in terms of the impact of products and services on the environment and deployment of mechanisms and policies for managing company environmental performance. The ICT manufacturing sub sector performs particularly strongly on environmental issues, outperforming the wider market on environmental management, resources use and the provision of environmental solutions.

The S-Ray analysis does indicate that the ICT sector faces some challenges on environmental responsibility relative to the wider market. The sector scores relatively poorly on environmental stewardship – reflecting below average performance on environmental restoration and biodiversity initiatives. For example, 35% of ICT sector companies use recycled or recyclable raw material, compared to 39% in the wider market. The sector also faces a challenge around environmental reporting. In the ICT services subsector only 10% of companies provide information on initiatives to restore the environment compared to 18% across the wider market. As the industry grows and its environmental impact potentially grows with it, these issues need careful consideration.

The ICT sector's positive score for social issues reflects the sector's better-than-average adherence to human and labour rights throughout business activities. For example, in terms of human rights, 40% of corporations in the ICT services sector abide by the main guidelines of the Universal Declaration on Human Rights, compared to 30% of the wider market. The sector also performs well in terms of product quality and safety.

The S-Ray analysis does, again, highlight various challenges the sector faces on social issues. Compared to the wider market the ICT sector scores poorly on product access – with fewer products specifically designed for lower-income categories, restricting access to some segments of society. ICT sector corporations are also less likely to run programmes to provide health care and affordable methods for people to own their own homes. Finally, the sector faces a diversity challenge with the average percentage of female managers at 38% in the sector, compared to 50% in the wider market.

Finally, the governance score reflects broadly average performance relative to the wider market across sub-categories. The analysis does highlight the higher-than-average leverage of capital across the sector, which may take away from a long-term focus on decision making.

These scores demonstrate that whilst the ICT sector faces a series of important challenges across ESG issues, the sector can be considered a leader in terms of broad ESG issues and there is therefore a strong foundation upon which to build to deliver even greater impact.

3.2.1.2 Baseline ICT sector emissions

The GHG impact of energy use by the ICT sector represents a significant contribution to global emissions and therefore to climate change. Emissions can be classified as:

- Scope 1 and 2: the emissions resulting from the activity of the sector itself;[15] and
- Scope 3: the emissions resulting from the sector's supply chain and the power consumption by consumers using ICT devices.

Baseline calculations for some or all of those Scopes have previously been undertaken by the IEA[16], and researchers at Huawei[17] and Ericsson.[18] These studies are generally based on a mix of corporate reporting, expert insight and multipliers for the numbers of key devices in operation. This report uses data on emissions intensity in the energy and manufacturing sectors, and the scale of the GVA contribution of the sector reported earlier in this chapter, alongside insights from those earlier reports.

Scope 3 emissions are reported less consistently by ICT businesses and depend on the pattern of consumption and distribution for the sector. Scope 3 emissions usually include:

- Upstream emissions: the emissions generated by businesses supplying intermediate inputs to the ICT sector i.e. prior to the direct emissions resulting from activity of the sector itself. In some cases, this will include other parts of the ICT sector, e.g. ICT manufacturers providing equipment to enable ICT services; and
- Downstream emissions: the emissions generated by businesses distributing ICT sector outputs to final consumers, including through the use of those outputs as intermediate inputs to their own production. This includes the emissions of non-ICT activities that serve the sector such as fleet distribution networks for ICT products.

There is limited data on the supply chain for the ICT sector, with marked inconsistencies in reporting even among large business. While analysis of emissions through the value chain could be considered, this would rely on data that is not readily available for the sector (given the nascent state of Scope 3 reporting). Earlier SMARTer2030 reports did not include procurement in the broader sense. This report therefore only includes separate modelling for Scope 3 around device use.

Manufacturing

Emissions for the ICT manufacturing sector are estimated globally at 470 Mt CO2 in 2019, based on calculations from IEA end use emissions data for the manufacturing sector more widely.

The goods produced by the ICT manufacturing sector generate further emissions through their power consumption once they are in use. For the purposes of this report, assumptions across a series of corporate reports (particularly Apple and Dell, which provide the most complete data, see Methodology appendix) have been compared and weighted based on projections in the existing literature. Those reports suggest that emissions relating to usage are equal to around 30% of manufacturing emissions, with this 'use-to-manufacturing ratio' declining slowly over time at around 0.7% a year as the share of devices with a lower use-to-manufacturing ratio (e.g. smartphones) rises. On this basis, the additional use emissions of manufactured ICT goods are estimated to be 137 Mt CO2 in 2019.

Services

Emissions for the ICT services sector are estimated at 204 Mt CO2 in 2019, which is comprised of 88 Mt CO2 from data centres and 116 Mt CO2 from transmissions networks. This is based on extrapolating from IEA estimates for short-term trends in data centre and transmission network power consumption and the estimate in its New Policies Scenario for the renewables share in energy consumption in 2030.

ICT sector total

Adding together the emissions in the manufacturing (production and use) and services sector, total emissions in 2019 were 811 Mt CO2. This is equivalent to 1.6% of global GHG emissions in 2019.[19]

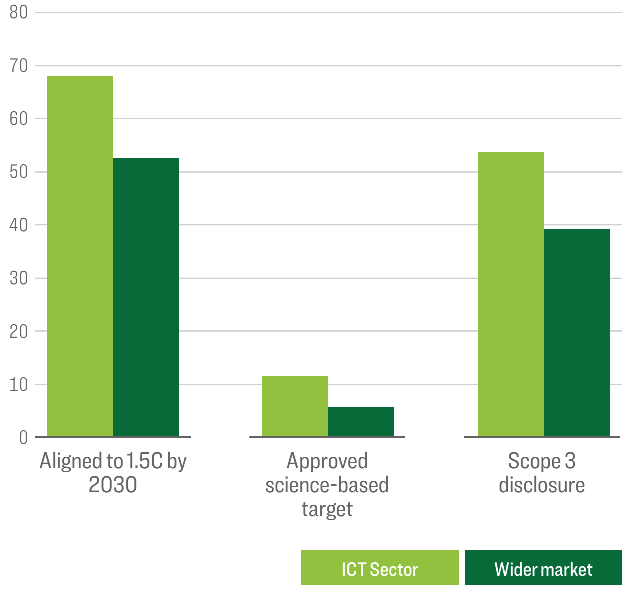
Table 4: ICT sector emissions summary, 2019

ICT sector	Emissions, Mt CO2
Manufacturing total	**607**
Manufacturing	470
Use	137
Services total	**204**
Services, data centres	88
Services, transmission networks	116
Grand Total	**811**

The Arabesque S-Ray Temperature™ Score tool provides a comparison of the ICT sector to the wider market on its commitment to a reduction in GHG emissions. The tool evaluates corporations based on their climate performance, including assessments of: (i) whether their activity is aligned with efforts to meet the most ambitious goal of the Paris Agreement to limit climate change to 1.5 ºC by 2030, (ii) whether the company has an approved Science-Based Target (SBT) for their greenhouse gas emissions and (iii) whether the company discloses Scope 3 emission information. Based on analysis from Arabesque, the ICT sector performs better than the wider market across each of these three dimensions.

Temperature score sector comparison

% of companies



Notes: n = 365 companies analysed in the ICT sector; 2356 companies analysed across the wider market.

More detail here: https://arabesque.com/s-ray/faqs

According to the analysis from Arabesque, nearly 70% of companies in the ICT sector (compared to 52% of companies across the wider market) are operating in a way that is consistent with meeting the most ambitious goal of the Paris Agreement to limit climate change to 1.5 ºC.

In terms of ICT subsectors, 59% of ICT services companies and 76% of ICT manufacturing companies are aligned to the 1.5 ºC target. This may reflect the requirement on manufacturing businesses to have an emissions to turnover ratio consistent with meeting the objectives of the Paris Agreement.

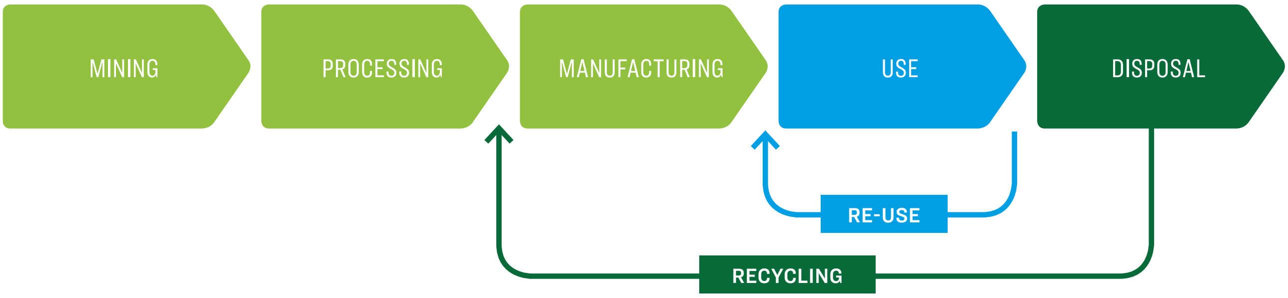
This ICT sector also outperforms the wider market in terms of the proportion of corporates with an approved Science-Based Target (SBT) for their greenhouse gas emissions. The proportion of companies around the world with an approved SBT has been rapidly increasing, from 1.3% in January 2017 to 5.5% in July 2019. This growth is even greater in the ICT sector, as companies with an approved SBT has grown from 2.4% of companies to 11.5% over the same time period. In terms of the subsectors, 14% of ICT services companies and 9% of ICT manufacturing companies had an approved SBT in July 2019.

Finally, the disclosure of Scope 3 emissions is an important indicator of commitment to reducing GHG emissions. Again, the ICT sector outperforms, with 54% of companies disclosing their Scope 3 emissions compared to 39% in the wider market. There is negligible difference between the subsectors.

Whilst this analysis clearly demonstrates the strong performance of the ICT sector relative to the wider market, there remains a need for the sector to deepen its commitment to reducing emissions, especially in view of its expected growth. Of course, the wider market has considerable progress to make if the business community is going to deliver the change needed to meet the objectives of the Paris Agreement and limit the damaging effects of climate change.

3.2.1.3 Current resource consumption

Alongside its contribution to global GHG emissions, the ICT sector makes further negative direct impacts through the consumption of a range of natural resources in the production of its goods and services. The process by which those resources are turned into goods and services includes a number of steps at which companies are seeking to intervene. This section considers the current efforts of the industry to manage its impact across three particularly challenging areas – the mining and extraction of rare materials, the use of plastics in manufacturing, and the disposal of e-waste.



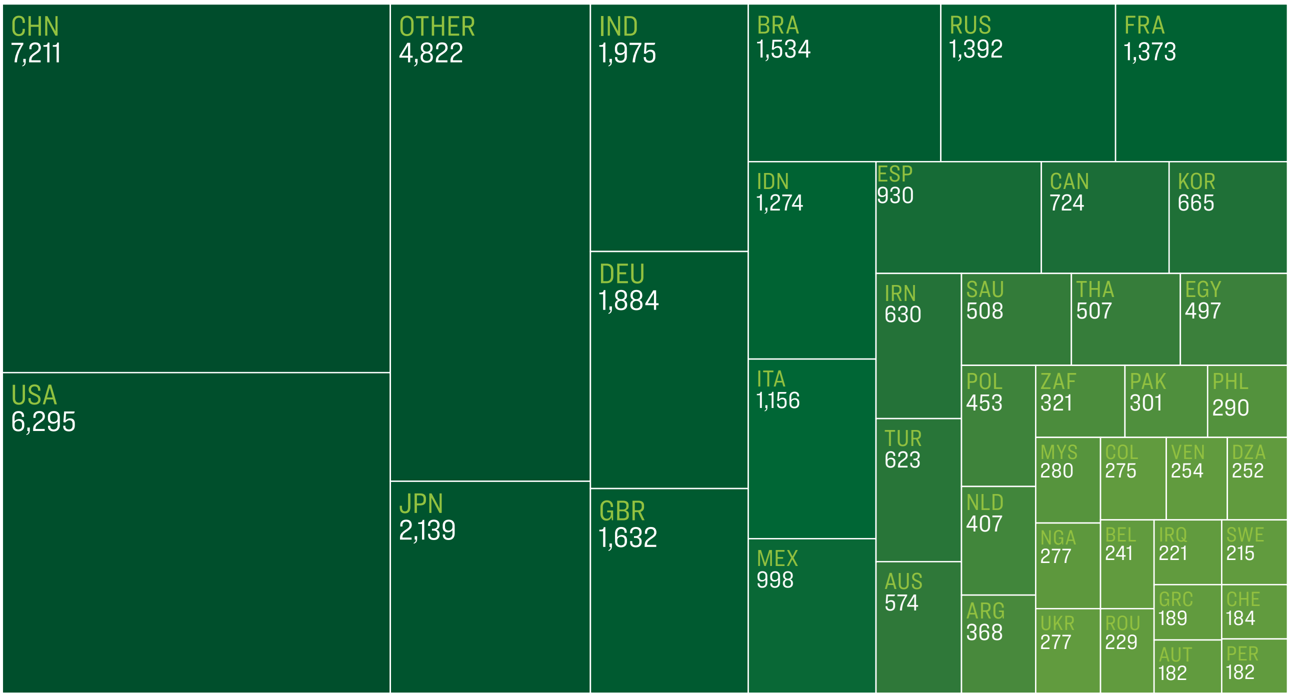
Mining and extraction of rare materials: ICT manufacturing is reliant on the extraction of rare natural minerals such as gold and palladium, reflecting a challenge to the sustainable management of natural resources (SDG 12.2). To help manage this, in 2008 the Responsible Business Alliance and GeSI collaborated to form the Responsible Minerals Initiative (RMI) to help companies across the ICT sector and beyond address responsible mineral sourcing issues in their supply chains. They devised a Responsible Minerals Assurance Process to offer companies and their suppliers an independent, third-party audit to help verify that minerals are sourced in line with current global standards.[20]

Perhaps an even greater challenge associated with the ICT sector supply chain surrounds the mining of rare natural minerals in conflict zone areas, with implications for SDG16. For example, cobalt is an important mineral for producing longer-life batteries and the Democratic Republic of the Congo (DRC) accounts for over half of global cobalt supply.[21] To ensure mineral extraction does not contribute to conflict or exploitation, the sector is further taking action to conduct due diligence in line with OECD Guidance,[22] for example, to eradicate child labour.[23] Similar due diligences processes have been designed by the OECD for a range of “conflict minerals” (Tantalum, Tin, Tungsten, Gold) and are being implemented through both regulatory intervention[24] and corporate action.[25]

Use of plastics in manufacturing: The ICT sector contributes to global plastics use through the manufacturing of its products, with resulting impacts on pollution (see SDG 14.1). According to estimates for the EU, the electronics value chain currently accounts for around 6% of plastics use.[26] The European Commission invited voluntary pledges to use or produce recycled plastics with a target of 10 million tonnes in products by 2025. Dell and HP have both signed up.[27] Other companies are investing in “closed loop” integrated recycling systems for their products, in which products released to the market are collected back after use, and the parts are either reused or recycled, thus reducing waste sent to landfill and the resultant plastic-related pollution. For example, Fuji Xerox Co., Ltd. has introduced recycling systems and take-back programmes across Japan, Thailand, Taiwan, China, Korea, Australia, and New Zealand.[28]

E-waste volumes have been studied by the Global E-waste Monitor.[29] After allowing for the small number of countries missing in that data there was around 46 Mt of e-waste produced in 2016, with e-waste broadly distributed with GDP but with the greatest volume in China. Companies such as Closing The Loop are working to reduce the global volume of mobile device e-waste, by recycling some of the 2 billion phones created every year. For every new phone purchased, the company collects and recycles one scrap phone in Africa.[30]

E-waste, 2016, kt



3.2.2 Projected negative direct impacts

3.2.2.1 Projected ICT sector emissions

In developing projections for the ICT sector emissions, the baseline together with two further factors have been taken into consideration:

- Sector growth: analysis is often conducted based on the growth of data usage, including in one existing forecast of emissions of the ICT sector to 2030.[31] However this creates issues by comparing very large increases in data transmission to improvements in efficiency, with the potential for highly divergent scenarios depending on those assumptions. For this report a projection is made on the basis of the ICT sector GVA trend which is: (a) relatively stable, as demonstrated earlier; and (b) representative of the economic activity that justifies ICT sector energy consumption commercially, particularly if the social cost of carbon is reflected in prices via taxation or other policy instruments.
- Changes in efficiency: analysis must consider both the emissions intensity of specific elements in the ICT sector (e.g. data centres) and, reflecting the forecasting approach employed in this report, the emissions intensity of ICT manufacturing and services as sectors.

The emissions impact of the ICT sector is estimated separately for manufacturing and services. In both cases, the GVA contribution is expected to grow and resulting emissions are a function of both the economic scale and the emissions intensity of GVA in each subsector.

Manufacturing

In the case of ICT manufacturing, a projection is made based on the wider trend in manufacturing energy intensity of GVA, weighted to the economies in which ICT manufacturing takes place, which will determine factors such as location based emissions intensity of energy. Calculations for this report suggest the typical rate of reduction in ICT manufacturing emissions intensity since 2003 (used as the baseline year after the end of the distortions caused by the dotcom boom) is 3% per year. If, despite the rise in manufacturing GVA, this trend growth rate is maintained, the overall impact will be a 25 Mt CO2 reduction in emissions from the ICT manufacturing sector from 470 Mt CO2 in 2019 to around 445 Mt CO2 in 2030.

Emissions resulting from the goods produced by the ICT manufacturing sector once they are in use are expected to fall. Usage is equal to around 30% of manufacturing emissions, with the use-to-manufacturing ratio declining slowly over time at around 0.7% a year as the share of devices with a lower use-to-manufacturing ratio (e.g. smartphones) rises. On this basis, use emissions can be expected to fall by just over 14 Mt CO2 between 2019 and 2030, to around 123 Mt CO2.

Services

In the case of ICT services, there are two components generally understood to be the most important in driving power consumption and thereby emissions:

- Data centres are becoming more efficient, to the extent that calculations for this report based on IEA estimates (for 2014 and 2020) suggest they are using less energy for every million euros of digital services value added at around 6% more efficient each year.
- Networks are increasing their energy consumption at a faster rate than the growth in services GVA; calculations for this report based on IEA estimates (for 2015 and 2021) suggest by around 5% each year. This can reflect both the rising volume of data transmitted to provide digital services and a shift from fixed line to mobile internet.

The net effect, combined with the trend in services GVA is a just under 131 Mt CO2 increase in GHG emissions from the ICT services sector, increasing from 204 Mt CO2 in 2019 to 335 Mt CO2 in 2030.

ICT sector total

Across both manufacturing and services, emissions are therefore expected to rise over time, growing by 92 Mt CO2. This reflects the growth of the ICT sector and trends that can increase GHG emissions, particularly the rising energy intensity of ICT services, which may, in part, reflect their rising data intensity.

Table 5: ICT sector emissions summary, 2030

ICT sector	Emissions, Mt CO2e
Manufacturing total	**568**
Manufacturing, direct and supply chain (scopes 1,2 and part of 3)	445
Manufacturing, use (part of scope 3)	123
Services total	**335**
Services, direct (scopes 1 and 2)	67
Services, supply chain (scope 3)	268
Grand Total	**903**

The imperative for the digital technology industry will be to realise gains in efficiency in order to ensure that its growth is compatible with meeting science-based climate targets. This will need to be achieved through improvements in the energy efficiency of economic activity in the ICT sector and investment in renewables to reduce the emissions intensity of the resulting energy consumption. This will allow the ICT sector to continue growing and contributing through innovative use cases to emissions reduction in the wider economy.

Overall impact

The overall impact on emissions resulting from these different components is therefore an increase of 92 Mt CO2 from 811 Mt CO2 in 2019 to 903 Mt CO2 in 2030. This represents a small increase in the share of the expected global total, but a fall versus the scale of the sector economic contribution as measured by GVA; in other words, a fall in emissions intensity.

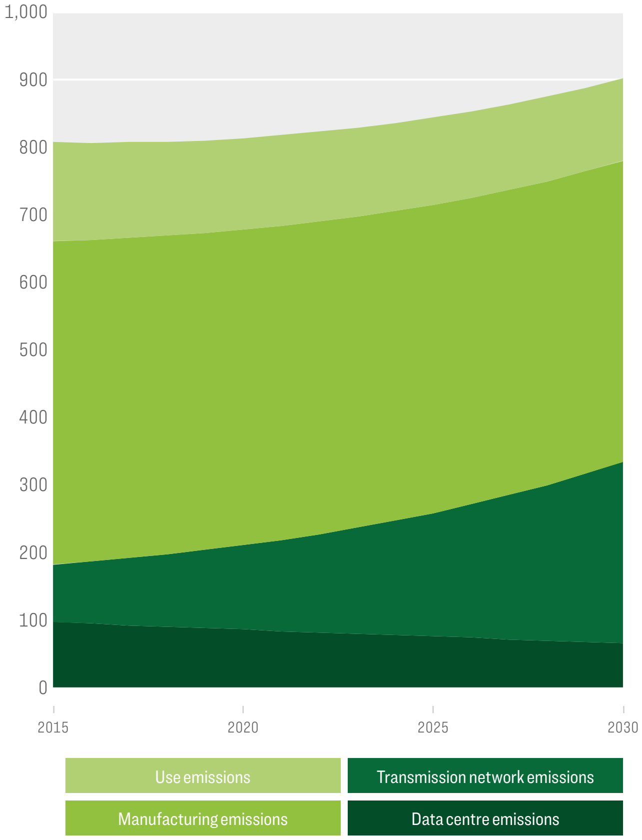
Table 6: ICT sector emissions summary comparisons

	ICT sector emissions, Mt CO2	ICT sector GVA, €bn	Emissions intensity, Mt / €bn	Global GHG emissions, Mt CO2e	Emissions share, % total CO2e
2019	811	3,784	0.21	50,625	1.6%
2030	903	6,083	0.15	53,194	1.7%

Note: 2019 world CO2 emissions extrapolated from 2017 and 2025 WEO values based on CAGR between those two years. The result is then divided by 65% to approximately account for non-CO2 greenhouse gases.[32] The overall growth rate of estimated global emissions from 2019 to 2030 in the NPS scenario is around half of one per cent a year. ICT Sector GVA as estimated in section 3.1 of this chapter.

ICT emissions by source

Mt CO2e



There are considerable uncertainties around this projection, which are laid out in Table 7. As for the economic footprint estimates, this report attempts to provide a reasonable central estimate and to consider the key uncertainties on a qualitative basis. One potential upside is the very real efforts of the industry to mobilise for decarbonisation. Most major ICT companies have plans to address emissions, for example:

- T-Mobile are committed to operating as a responsible business and to use 100% renewable energy by 2021. **See case study on T-Mobile's commitment to RE100.**
- Dell has reduced the energy intensity of its product portfolio by 64% since 2012, including a 78% reduction in the energy intensity of its servers, a 74% reduction in the energy intensity of its disk drives (as a function of capacity) and improvements in laptops to the point they require around $3 in annual electricity costs to power.[33]
- Samsung has a broad plan to reduce emissions in 2019, building on similar progress in 2018 to expand renewable energy use and reduce fluorinated gas used for manufacturing. These and other initiatives led to a total reduction in GHG emissions of 2.25 Mt CO2e in 2019.[34]
- The Swisscom Sustainability Strategy 2025 includes cutting 450,000 tonnes of CO2, totalling 1% of the entire GHG emissions in Switzerland.[35]
- TIM has taken a number of steps to generate ongoing energy savings in its data centres, including: adaptive cooling; real-time controlled and dynamic switch-off for servers, based on virtualisation mechanisms; and the production of energy from combined cooling, heat and power plants. There are similar efforts in networks with measures including re-engineering of exchanges, integrated decommissioning and network simplification, and diverse interventions to reduce the power consumption of radio base stations.[36]

Table 7: Upside and downside risks to direct emissions projection

	Lower likelihood	Higher likelihood
Larger positive impact	**5G share in data transmission –** besides the general potential for efficiency gains in networks, the 5G share in traffic in particular has the potential to increase efficiency[37] and grow faster than expected. This can reduce emissions to the extent legacy network capacity is retired.	**Major shift to clean energy –** most of the footprint results from electricity consumption. Emissions might be dramatically reduced to the extent countries and companies shift to clean energy. **Major increase in network energy efficiency –** the IEA notes that "by 2021 electricity consumption from data networks could increase by as much as 70% or fall by up to 15%",[38] which acknowledges that the growth in emissions modelled here will not necessarily occur. **Industry 4.0 –** use cases for digital technologies that could improve efficiency across manufacturing, e.g. using digital twins to reduce waste, could be employed in the ICT sector too.
Smaller positive impact		**Continued shift to efficient hyperscale data centres –** the ability to maximise the use of capacity through shared virtual machines and concentrate activity in efficient hyperscale facilities will reduce emissions.[39]
Smaller negative impact		**Multiplication of IoT devices –** there is likely to be a multiplication of connected devices, which will require energy in their manufacture and use, but also a very strong incentive to keep them energy efficient.
Larger negative impact	**End of data centre efficiency gains –** efficiency gains reflect a variety of drivers, but include increases in basic computing efficiency which the sector might struggle to maintain. **Diffusion of proof of work governance in blockchain –** data consumption by Bitcoin and Ethereum is considerable,[40] and might not be captured in the estimates above. Still, there seems to be a shift away from the energy intensive model. The Libra white paper, for example, specifically argued that it would adopt "a more energy-efficient approach to consensus than "proof of work" used in some other blockchains."[41]	**Large increase in data transmission volumes and limited network efficiency gains –** this is at the core of many estimates for dramatic increases in energy consumption in the future and might result from 5G encouraging more mobile data use. Besides creating an incentive to increase efficiency any resulting increase in power consumption would also increase the incentive for more edge data processing to moderate the impact.

3.2.2.2 Projected resource consumption

Historically e-waste volumes have been rising, but growing more slowly than manufacturing GVA. The tonnes of e-waste generated per dollar of ICT manufacturing GVA between 2014 and 2016 is declining at a rate of around 3% a year. If this trend over the two years were to continue, despite the growth in ICT manufacturing estimated earlier, the volume of e-waste could fall from 46Mt in 2016 to 40 Mt in 2030.

Policymakers can, and are, acting in order to drive reductions in the resource intensity of digital technology, for example through the EU Waste Electrical & Electronic Equipment policy,[42] but it is imperative businesses mobilise in order to promote responsible consumption across production to use and finally to disposal.

4 Enabling impact

Enabling impacts are the result of the increased adoption of digital technology that can change the path to achieving the SDG targets. Impacts can be either positive, e.g. improving GVA or reducing emissions, or negative, e.g. political polarisation and exploitation.

4.1 Positive enabling impacts

4.1.1 Enabled economic value

The significant projected increase in sector GVA is supplemented by the wider impacts of key technology use cases as considered elsewhere in this report.

The SDG-based modelling in this report has isolated economic impact where that impact is called out explicitly in the targets and indicators. This has resulted in estimates for GDP impact across manufacturing and part of agriculture, together making up c. 18% of global GDP. This modelling focuses on the impact on manufacturing productivity related to Industry 4.0 (SDG 9) and agricultural productivity related to precision agriculture (SDG 2). By 2030, increasing adoption of Industry 4.0 is expected to increase global GDP by €1,721 billion compared to a business-as-usual scenario. In the same year, precision agriculture is expected to deliver an additional €47 billion to GDP through its impact on agricultural productivity. This means that over this time frame, from 2019 to 2030, the expected increase in adoption of specific digital technologies in just these two sectors is expected to reach an additional €1.8 trillion to global GDP.

As noted in the executive summary, a key finding of the report is that on average, across our modelling of 30 SDG targets, c. 20% of expected progress against the SDGs can be attributed to digital technologies. This is a critical under-pinning to the projected, continued growth of the ICT sector which results in additional GVA to 2030 of €2.3 trillion.

Whilst this report does not explicitly model the total projected economic contribution, these two inputs could be used to infer that total enabled economic impact could be in the region of €6 to €10 trillion. This inference is based upon a) simple factoring up of the €1.7 trillion on the basis that it only covers 18% of the economy, and b) using our modelled 20% of incremental impact to apply to the total expected increase in GDP to 2030 on the premise that societal impact and commercial outcomes see greater convergence.

4.1.2 Enabled emissions reductions

The growth in emissions from the ICT sector over time can be compared to the abatement opportunities that arise from the increased adoption of ICT use cases considered in the Biosphere and SDG 13 appendix chapters. This decrease has been addressed in relation to:

- SDG 2: Precision agriculture;
- SDG 2: Reduced food waste;
- SDG 7: Smart Grid – improved management of renewable energy;
- SDG 7: Smart Grid – increased energy efficiency;
- SDG 9: Industry 4.0 – Predictive maintenance and supply chain optimisation;
- SDG 11: Intelligent transport systems; and
- SDG 15: Reduced deforestation.

Use case category	Mt CO2e, abatement opportunity in 2030
Precision agriculture	-174
Reduced food waste	-5
Improved management of renewable energy	-71
Increased energy efficiency	-365
Industry 4.0	-329
Intelligent transport systems	-388
Reduced deforestation	-2
Reductions in GHG emissions resulting from ICT use cases	**-1,336**

Note: total does not sum due to rounding; in this table and subsequent abatement analysis there is a shift in the unit of measurement from CO2 with respect to sector footprint to CO2e to reflect the inclusion of use cases where other GHG emissions are more relevant (e.g. in agriculture).

All of these gains in efficiency will be subject to a rebound effect. The rebound effect reflects the risk that improvements in efficiency might result in increased consumption which would undo such improvements, e.g. an improvement in the efficiency of cars makes it cheaper to drive and people therefore drive more.

While the systemic impacts of improvements in energy efficiency are complex, for the purposes of the analysis in this report, the share of the gains from improved energy efficiency that are likely to be counteracted by the rebound effect have been considered. Estimates vary by sector and based on the approach used (e.g. Wei & Liu find a very large rebound effect, driven in large part by labour mobility).[43] The analysis conducted for this report, follows the perspective of the global rebound effect for increased energy efficiency in Germany by Koesler, Swales & Turner to assume that "almost a half of any expected energy saving through improved energy efficiency in production will be taken by rebound effects".[44]

This is lower than the Wei & Liu study mentioned above, higher than an estimate for the US manufacturing sector at around 24%,[45] and similar to the results of a study assessing impacts in Sweden[46] which put the rebound effect at 40-70%. Rebound effects are generally expected to be higher in developing economies (where demand is generally less sated as incomes and consumption per capita are lower) but are much less well studied. On the other hand, other sectors, e.g. personal transport, are generally understood to have lower rebound effects, closer to 10% (again however, this is based on studies in developed economies).[47]

This assumption of a 50% rebound rate results in a net positive impact of 576 Mt CO2e reduction in GHG emissions between 2019 and 2030. This reflects the projected increase in emissions of the ICT sector of 92 Mt CO2 and expected reduction of emissions of 668 MT CO2e resulting from the expected growth in the ICT use cases listed above, whilst controlling for the expected rebound effect.

4.1.3 Broader societal impact

The increased adoption of ICT use cases can drive sustainable development across the SDG targets. Many of these use cases, e.g. increasing the share of births registered, may not have a discernible impact on global emissions and/or GVA, but will represent a wider benefit of the increased adoption of ICT. In addition to those social benefits, increased adoption will be associated with an increased demand for ICT equipment and services (to enable that increase in adoption) which will create both business opportunities for ICT businesses and externalities such as GHG emissions (via demand for enabling goods and services, such as data transmission). These will represent a contribution to the sector and the growth of its size (reflected in the forecast for ICT GVA growth), and contribution to GHG emissions (reflected in the forecast for emissions growth).

4.2 Negative enabling impacts

There are a number of concerns over the negative social impacts enabled by digital communications and which might inhibit progress towards SDGs. Examples can be grouped into 3 broad categories, which encapsulate some society focused SDGs: Good Health and Well-being (SDG 3); Reduced Inequalities (SDG 10) and Gender Equality (SDG 5); and Peace, Justice and Strong Institutions (SDG 16). Further commentary on these topics and others can be found in the SDG deep dive appendices.

- **SDG 3:** The ICT sector has an enabling wider impact on mental health, resulting from how people engage with each other online and cause disconnections from other social engagement.[48] Cyberbullying, or content promoting harmful practices such as suicide, anti-vaccination messages or poor body image will impact on peoples' well-being. Studies on the health risks associated with electromagnetic fields may be a further concern for the sector[49] although there is no well-established scientific evidence of long-term effects.[50]
- **SDGs 5 and 10:** the exploitation and trafficking of women and other vulnerable groups may be facilitated by access to online chat rooms, and by increasing the ease with which criminals transact anonymously online. The ICT sector might also exacerbate inequality due to disparities in access across individuals and countries, which is considered further in the SDG deep dive appendices.
- **SDG 16:** political polarisation and filter bubbles arise as users in increasingly ideologically-sorted online communities share content that agrees with their views, or denigrates those with whom they disagree. There is a concern that this is exacerbated by algorithms intended to increase engagement online, which promote content which elicits a strong emotional reaction.[51] The ICT sector will also face challenges relating to privacy, security, and data protection, considered further in the SDG deep dive appendices.

Across each of these examples, the sector needs to address emerging issues, both to avoid the consequences of a backlash, and in order to support broader progress on sustainable development. For further discussion on these topics, please see the relevant appendices.

5 Comparing direct to enabling impacts

To provide context to the size of the economic and GHG emissions of the ICT sector, a comparison to the enabling impacts is made below. It should be noted that this analysis is based on the use cases selected for this report, which were chosen in the context from the perspective of how digital technology can contribute to the SDGs rather than how digital technology drives GVA.

5.1 Economic

5.1.1 The economic multiplier

Analysis earlier in this chapter suggests that trend growth in ICT services and manufacturing will generate €2.3 trillion in direct economic impact between 2019 and 2030.

There is then a further €1.7 trillion economic impact associated with the growth of Industry 4.0 and €47 billion associated with the growth of precision agriculture. The disparity between the manufacturing and agriculture contributions reflects the fact that global agricultural output is lower than the value of manufacturing output, so the base for growth is considerably smaller. In addition to agriculture and manufacturing, the ICT sector is likely to drive a diffuse impact on productivity in the services sector, which would be additional to this impact and has not been modelled.

As noted above the manufacturing and agriculture sectors make up around 18% of GDP; a high-level extrapolation of these findings would suggest that the enabling impact of the ICT sector could be €8.8 trillion by 2030 – or nearly 4x greater than the expected economic impact of the ICT sector itself of €2.3 trillion. Together, this would equal over €11 trillion in incremental impact on the size of the global economy.

To draw another lens on this wider potential, analysis of the impact of use cases of digital technology throughout this report suggests that they contribute on average 20% to progress. As GDP is expected to be €30 trillion higher in 2030, this would imply an additional €6 trillion in economic impact will be driven by the enabling effect of the ICT sector, or a multiplier of 2.5x.

5.1.2 Comparison to previous studies

In the earlier GeSI SMARTer2030 report, estimates were presented for cost savings and revenue gains in the wider economy associated with the increased adoption of ICT through use cases as a proxy for economic impact. The results suggested that these “economic benefits” could amount to $11 trillion by 2030. This is similar to the upper scale of the enabling economic impact of digital technology, as suggested in the analysis above, albeit calculated using a very different methodology.

5.2 Emissions

5.2.1 Direct emissions to enabled reductions

The analysis set out in section 4 of this chapter indicates that the enabling impact of the ICT sector will reduce GHG emissions overall by 668 MT CO2e 2030. This is equivalent to seven times the expected growth of the ICT CO2 footprint in the same time period, even after accounting for a substantial rebound effect.

However, at the same time, the ICT sector and its growth supports, and is supported by, the growth of the wider economy. This general rise in output and consumption is associated with increased emissions. If the sector contributes to a wider dematerialisation and decarbonisation of the economy, then its growth can continue. If not, then its growth will be limited by the necessity to restrict GHG emissions. There is more on this topic in the Biosphere section of the report.

Table 8: ICT sector footprint comparison to enabled emissions abatement

	Mt CO2e, abatement opportunity in 2030
Increase in ICT sector GHG footprint	**92**
Manufacturing	-25
Use	-14
Data centres	-21
Networks	152
Reductions in GHG emissions resulting from ICT use cases	**-1,336**
Precision agriculture	-174
Reduced food waste	-5
Increased renewable energy capacity	-71
Increased energy efficiency	-365
Industry 4.0	-329
Intelligent transport systems	-388
Reduced deforestation	-2
Rebound effect	668
Total savings	**-668**
Net impact	**-576**
% ICT GHG footprint offset	**-727%**

The decarbonisation scenario

The sector could further increase its contribution to decarbonisation by reducing its own footprint, beyond the assumptions made for the analysis in this report. The sector could do this by:

- continuing to shift to renewable energy and improve the energy efficiency of the devices it manufactures;
- supporting and incentivising the supply chain to do the same, improving efficiency and adopting renewable energy; and
- implementing circular economy measures that reduce the requirement for resources extraction or manufacturing in the first place.

It can also increase its contribution to emissions abatement in the wider economy, including by:

- the development of new use cases that further reduce energy consumption in the wider economy; and
- supporting the adoption of use cases, particularly where they will abate emissions most effectively (e.g. targeting support for increased renewable energy in economies with heavy use of coal power; or measures to control deforestation in areas where it is taking place most rapidly).

The potential for these interventions to abate greenhouse gas emissions can be illustrated by considering a scenario in which:

- **Policymakers** institute carbon pricing and measures to address barriers to the adoption of low carbon technology, reducing the rebound effect to 10%.
- The **energy sector**, with any necessary support from policymakers, decarbonises in line with the IEA World Energy Outlook Sustainable Development scenario, rather than the New Policies Scenario used above, with the fossil fuel share in the energy mix falling from 67% in 2015 to 39% in 2030 (versus 55% in the New Policies Scenario).
- **Telecommunications companies** and the ICT manufacturing businesses in their supply chain act to arrest the rise in the energy intensity of the networks. This could require a mix of the wider implementation of measures which are already being undertaken by some telecommunications companies, with selected examples considered earlier in this chapter, and further targeted R&D.
- The **ICT sector generally** works with governments, other businesses and civil society to promote the adoption of the use cases described throughout this report, closing half the gap between projected adoption and 100% adoption. This would likely require targeting economies, demographics and sectors otherwise likely to be left behind. The ICT sector could also achieve a similar effect by targeting its R&D spend and thereby developing new use cases.

In such a scenario, instead of rising, ICT sector emissions would fall by 70 Mt CO2; the increased adoption of ICT use cases would lead to a 3,884 Mt CO2e reduction in GHG emissions (of which only 388 Mt CO2e would be lost to the rebound effect); and the net ICT impact on the change in annual emissions from 2019 to 2030 would be a nearly 3,566 Mt CO2e reduction, equivalent to around 9% of the 39,202 Mt global CO2e emissions for 2030 in the IEA Sustainable Development scenario (adjusted in line with the 35% non-CO2 share in total GHG emissions as in the earlier comparisons).

This illustrates the potential for action in the ICT sector to enable savings in GHG emissions, with 50 tonnes of GHG emissions abated in the wider economy through the adoption of ICT use cases for every tonne of emissions reduction in the ICT sector.

5.2.2 Comparison to previous studies

The earlier SMARTer2030 report provided an estimate for the abatement impacts based on a somewhat different approach with a lower rebound effect, higher adoption rates, more of the impact attributed to ICT and some sectors included that have not been included in this report (although the only one of those which is material to the earlier analysis is Smart Logistics). That estimate is closer to the ambitious decarbonisation scenario presented earlier in this chapter, but contains some remaining differences (particularly around attribution and coverage) and compares to total sector emissions, rather than the growth in emissions.

Conclusions

1. The ICT sector, as laid out throughout this report, has a critical role to play in enabling progress against the SDGs and is estimated to contribute to 20% of all progress.
2. This impact will support the forecast growth of the industry of c. 4% pa to 2030, contributing an additional €2.3 trillion a year to the global economy, increasing ICT sector employment by over 45% to nearly 80 million, and increasing R&D by over 50% to €378 billion.
3. The sector is expected to further enable economic growth in the broader economy of 2.5x – 4x this number, or up to €10 trillion by 2030.
4. A critical externality, emissions, is expected to grow by 92 Mt CO2 over the period, but this is less than the growth in GVA implying an improvement of emissions intensity of over 28%.
5. ICT sector emissions needs to be considered against the ability of the sector to abate the emissions in the rest of the economy which is estimated at over seven times the change in sector emissions.
6. Public commitments of key players in the ICT sector, together with previous studies, suggest that the emissions footprint could be managed down from this number with the appropriate external environment and interventions.
7. The long-term prosperity of the sector requires both a resolute focus on SDG progress, together with management of the challenges created, specifically in the areas of emission and resource management, but also around other societal issues e.g. inequality.

The next section develops the actions required by the ICT sector and sets them in the context of the broader commitments required by all stakeholders.

06

Actions to Deliver a SMARTer2030

Across each of the SDGs and through each of four impact functions, digital technologies can, and do, contribute to sustainable development. The expected increase in the adoption levels of existing applications will make a material difference, as shown by the projected numbers weaved throughout this report. However, despite this contribution, indications are that the world will fall well short of the 2030 targets. A step change in the development and deployment of digital technology is needed in response.

For all organisations, contributing to sustainable development is interdependent with long-term success. Evidence continues to mount that doing good is good for business.[1] Indeed, all organisations (not just business) face increasing pressure from their many stakeholders to articulate and demonstrate how societal impact is at the core of what they do.

In this context, with a greater sense of shared ambition within the ICT sector and between the ICT sector and other key stakeholder groups, digital technology can enable the transformation the world needs. This chapter reflects on the conditions for this transformation and proposes a number of commitments: for all, for the ICT sector, and for other key stakeholder groups.

Universal commitments

The integrative nature of the challenges targeted by the SDGs, their system-wide implications, and their importance to all requires a greater degree of both common purpose and action for all individuals and organisations. Purpose needs to be shaped by the SDGs, action by digital technology. This can be supported by dedication to four universal commitments:

01

Re-commit to the common purpose of the SDGs:

Re-commit to the 2030 Agenda: all parts of society must recognise the 2030 Agenda for Sustainable Development as their agenda, for their own future and for future generations. The Agenda exists, has been signed up to by all our governments on our behalf, but remains relatively unknown, poorly understood, and without ownership. Re-commitment is critical. This means educating everyone in the SDGs and their implications at school, at work, and in public life. It means making support for the SDGs public, and weaving this support into internal and external communications and interactions. Critically, as part of this, it means committing to addressing the climate crisis and actively working towards the net zero-carbon agenda.

TOP TIP

Deliver training on the SDGs both at school[2] and at work[3] and provide multiple ongoing opportunities to engage others in the 2030 Agenda.[4]

02

Define a specific role and contribution to the SDGs:

Call out a role in delivering the 2030 Agenda: we all have a part to play in contributing to the SDGs as individuals through our behaviour as consumers, employees and citizens. But material change needs organisations to direct the power of their core operation to galvanise collective action and drive progress towards the Goals. To do so, organisations must clarify their role in achieving the Goals and how it is core to their business model; in other words, enshrine a commitment to the SDGs in their purpose. This purpose must then be communicated across all stakeholders and must explain how a commitment to sustainable development will lock in long-term success, providing opportunities and mitigating risks.

TOP TIP

Run a 'materiality analysis' to consider which SDG targets are of most relevance to the organisation and key stakeholders, both in terms of aspiration and the most critical negative externalities, and build into an implementation road-map. Embrace science-based targets for the reduction of greenhouse gas emissions and to meet the goals of the Paris Agreement.

Embed your purpose and your role in the 2030 Agenda: as individuals, commit to specific behaviours that will drive positive impact, and as organisations, incorporate a stated purpose into strategy and operations, culture and values, and brand and stakeholder management.[5] This may be a modest change for some, a formalisation of an implicit component of the business, but for others it will be transformational. If the purpose defines why the organisation exists, then intended impact on the SDGs needs to be reflected in the most important decisions it makes.

TOP TIP

Identify the most critical decisions for the future and consider how these incorporate, reflect and deliver on a commitment to impact on the SDGs.

Maximise your impact through managed transformation: having articulated a commitment to the SDGs and embedded that commitment within key decisions, organisations face a need to manage a transition from 'embedding purpose' to transformation. Transformation must include new mechanisms for driving change through decision making, employee development, collaboration with other stakeholders, product and service development, evaluating success, and ensuring that the 'sense of impact' is baked into the organisation. Transformation must have a long-term focus and be invested in appropriately.

TOP TIP

Find ways to embed a continuous commitment to purpose within the business and operating model, develop links to commercial and employee performance and engage and empower stakeholders to drive towards transformation with priority actions and clear progress measures.

03

Underpin a commitment to purpose and SDG impact with transparency and collaboration:

Transparency is critical to progress: without a clear, robust and comparable understanding of the nature of impact, any organisation will be unable to manage their activities appropriately; intervene to scale; accelerate progress; and address poor behaviour and outcomes. To achieve transparency around impact, organisations need to identify their intended beneficiaries, and then link their core activities, through outputs of those activities, to outcomes (short-term effects of outputs on beneficiaries), and finally, into impact on the 2030 Agenda. Impact can also be described as the longer-term system-level changes resulting from their activities. This requires embracing the 'Theory of Change' approach practiced by third sector organisations around the world, and applying it in to new commercial and public policy contexts.[6]

TOP TIP

Run an exercise to distil the relevant activities of your organisation into a Theory of Change for all or part of the intended impact, and align success measures against each step from activities through to impact.

Establish clear metrics and targets: for all organisations, impact transparency means translating a clearly defined purpose into specific metrics, measures, and targets, against which decisions can be made. This cannot just be a feature of daily operations and limited to tracking carbon emissions and board diversity. Rather, to drive profound impact against the SDGs, organisations need to invest in the measurement and management of the clearly defined, intended impact of their core business model i.e. their product and service set, together with the greatest negative externalities. This progress must then be communicated to all stakeholders.

TOP TIP

Define an impact-focused Big Hairy Audacious Goal (BHAG) to clarify the intent and focus the minds of all stakeholders.[7]

Build partnerships and collaborate to deliver: in an increasingly interconnected and complex world, delivering change of any type is challenging. To drive change directed towards the SDGs will require sharing knowledge assets, particularly in terms of driving impact transparency. Change will be driven through partnerships of various kinds – between public and private sectors, between regulators, campaigning bodies and representative groups, between global, national, and local organisations. Only through collaboration can the aspiring vision of the SDGs be matched with the appropriate capabilities to deliver.

TOP TIP

Build partnerships with purpose based on shared commitments to measurable impact through core products and services, working with partners up and down the value chain, taking a systems perspective and with reference to the SDGs.[8]

04

Deploy digital technologies to deliver impact:

Digital technology can be deployed so that every organisation can support progress against the SDGs to:

- Provide the systemic understanding required for impact transparency;
- Provide the management information needed to make effective decisions;
- Catalyse impact on the SDGs through innovation, products, services and core operations; and
- Facilitate the collaboration required to maximise impact.

Every organisation has the opportunity to construct a forward-looking vision for the deployment of digital technology against each of these four dimensions, and develop a roadmap for delivery. Only by committing to progress against each and moving from 'digital transformation' to 'purpose-led transformation powered by digital', can organisations fulfil their potential to contribute to the SDGs.

TOP TIP

Develop a 'zoom-out' digital strategy that takes a 10-year view of the steps needed to develop and deploy digital technology for maximum impact and long-term success.[9]

In summary, these universal commitments require a clear commitment to the SDG Agenda, the embedding of that commitment into the core business to maximise their impact, the measurement and management to impact, and the intentional and visionary deployment of digital technologies to support this.

ICT sector-specific commitments

As the ICT sector grows and the digital technologies it develops and deploys increasingly pervade everyday life, it has a particular obligation and opportunity to transform in order to maximise its contribution to the achievement of the SDGs. As expectations rise across stakeholder groups, this transformation is not just for the sake of sustainable development – it is in order to protect the future of the industry and enable it to be successful into the long term. The ICT sector has a number of areas in which it can lead the way:

Lead on the universal commitments: as a large and influential sector of the global economy, it has the opportunity to act as an exemplar; collectively supporting and actively pursuing the 2030 Agenda.

Operate responsibly: ICT companies have a responsibility to call out their commitment to the common purpose and be seen as the responsible sector, working together to address common environmental, social, and governance (ESG) challenges in a comparatively progressive way across all recognised dimensions.

Call out the areas of greatest risk and opportunity: with the help of its trade bodies, the sector should identify, understand and call out the areas of greatest risk and opportunity in terms of its contribution to the SDGs, beyond operations and through core products and services. For example, the sector should call out the opportunity to eradicate the 'digital divide' and enable the drive towards net zero-carbon through digital technologies to enable greater growth and deployment of renewable energy sources.

Enable the development and deployment of digital technologies in countries without a mature ICT sector: it will be challenging to operate in countries that lack the infrastructure to support a transition to a sustainable, digitally-enabled economy. To drive achievement towards the SDGs, ICT companies should work precompetitively to consider how technology can be deployed in partnership with governments in these countries and how the sector can engage with public policy to address identified critical sustainable development challenges. Underachieving against the central tenet of "leave no one behind" is a very real threat related to further entrenchment of a digital divide.

Harness its unique role in enabling impact transparency: only digital technology can, at scale, monitor and track how organisations impact the wider world and gather the information required to help them take responsibility for their impact and enable decision making for sustainable development. Indeed, understanding an increasingly connected system is a precondition to understanding what is needed to drive impact. The ICT sector must help organisations understand how to adopt impact transparency as a means of enhancing impact and strengthening business models. This requires new data, massive computing power and new forms of distribution, deployment and application.

Urgently seek to decouple economic growth from environmental degradation: the sector will be at risk if it cannot find ways to ensure that the energy required to manage increasing volumes of data transfer and computing power does not further contribute to carbon emissions. Circular economy approaches must be taken forward to ensure that the proliferation of IoT devices and smartphones does not lead to an exponential growth in e-waste and depletion of natural resources. Only by working together with a broad range of stakeholders and investing in better understanding the context, cause, and effects of impact, can the ICT sector ensure that its growth does not hinder, but instead 'turbocharges' sustainable development.

Lead on cyber security and cyber ethics, both individually and collectively: the greater adoption of cognitive technologies and reliance of services on digital infrastructure is associated with increasing existential threats around cyber security and new ethical challenges. ICT companies are frequently the first adopters of new technologies, and thus must ensure they implement exemplary cyber security safeguards into their business practices and services. Collectively, the ICT sector has a critical role to play in working with government to develop cyber security and cyber ethics business norms, standards, and codes of conduct, and lead the way in demonstrating good practice. They have to take responsibility to ensure trust.

Other stakeholder group commitments

Alongside the ICT sector, other critical stakeholder groups include institutional investors, non-governmental organisations (NGOs), governments, intergovernmental organisations (IGOs), businesses and partner sectors, and citizens. Each group needs to embrace the Universal Commitments outlined earlier and consider further context-specific ways in which they can embrace digital technology and drive progress towards the SDGs.

Institutional investors

Commit to common purpose: as businesses themselves, institutional investors must commit to the common purpose of the SDGs in their own right. Establishing the link between this purpose, the business model, investment strategy, and ultimately returns, is particularly critical for the sector.

Contribute to impact transparency: investors can help by making clear demands on investee companies to provide evidence of their impact on the 2030 Agenda, and assist them in doing so. Investors can seek out, engage and support third party data and technology companies that facilitate the collection of data, its collation and analysis to illuminate SDG impact and help manage the organisation to long-term success.

Recognise and reward the positive impact of digital technology: investors can facilitate progress against the 2030 Agenda by engaging both the ICT sector and partner sectors to seek out, invest in, and influence organisations involved in the development and deployment of digital technologies that target impact.

Non-Governmental Organisations (NGOs)

Commit to common purpose: NGOs focused on sustainable development can, in some cases, further their contribution to the SDGs by adapting their purpose to the 2030 Agenda rather than merely bridging to them.

Support other organisations in their use of digital technology to drive impact: NGOs can drive effective practice, helping other organisations and holding them to account for how they are: (i) making a commitment to the common purpose of the 2030 Agenda, (ii) delivering against that commitment, (iii) maximising their positive impact and mitigating their negative impacts, and (iv) deploying digital technologies to do so. In playing a systemic leadership role, NGOs together with governments and IGOs can set standards for good practice in order to reward positive behaviour and challenge negative behaviour.[10]

Curate (digital) public goods to catalyse impact: NGOs can leverage public and philanthropic funding to support others in their pursuit of positive impact through the development and curation of relevant, digital public goods e.g. the curation of public data sets that provide clear and robust numbers against sustainable development indicators, enabling organisations to understand areas of need and identify and scale the interventions that work. NGOs and institutional development organisations can further develop and share innovative methodologies for others to deploy.

Build or catalyse multi-sector partnerships (MSPs): NGOs have an opportunity to convene actors across sector to consider how they can encourage each other and collaborate to drive towards achievement of the SDGs and deploy digital technologies to maximal effect. Multi-sector partnerships represent a vital means of formalising and driving this collaboration. NGOs can help design pathways for MSPs, other organisations, and the ICT sector to maximise their collective impact.

Government and IGOs

Commit to common purpose: governments are continuing to focus on the SDGs as a critical priority for both domestic and international policy.[11] All governments and IGOs should continually renew their commitment to the 2030 Agenda, define their national aspirations for achieving the targets and commit to tangible steps for achieving those aspirations. This needs to include an explicit and intentional approach to deploy digital technologies for impact. Alongside this, governments and IGOs must contribute to impact transparency, in collaboration with local government, and private sector partners.

Create policy and guidelines: governments face a clear expectation to create an enabling policy environment for the delivery of the SDGs. Indeed, around 30% of the SDG targets are explicitly directed towards policymakers. Policy making extends to creating an environment for allowing digital technologies to realise their SDG impact potential. This requires engagement with both the ICT sector and partner sectors. Government organisations at local, regional, national and supra-national levels are well positioned to grasp the opportunity of digital technology for sustainable development and facilitate its wider adoption.

Invest and procure for impact: as a significant procurer in every national economy, governments have the opportunity to direct their purchasing power towards the achievement of the SDGs. This power includes rewarding organisations who espouse the common purpose, and promoting positive behaviour across a range of sectors in the economy. Governments and IGOs can also direct their own capital investment toward the development and deployment of innovative digital technologies that can deliver impact.[12]

Convene for sustainable development: governments and IGOs have the opportunity to play a leadership role for the wider system, corralling different groups of actors to explore how they can address challenges for sustainable development. In particular, governments can use this power to invite digital technology stakeholders to come together to develop an environment for digital technology to benefit all, working collaboratively to develop digital infrastructure where it is lacking and drive the engagement of ICT companies with public policy.[13]

Business and partner sectors

Commit to the common purpose: across all sectors, businesses of all types have an opportunity to increase their chances of long-term success by putting societal impact at the heart of their business models.[14] As stakeholders increasingly expect the businesses they transact with to make a difference to the environment and society, delivering on these expectations becomes interdependent with long-term success. The 2030 Agenda adds a specific framing to this dedication that allows businesses to connect to the common purpose agenda and demonstrate their intent to contribute in terms that everyone can understand.[15]

Ensure impactful deployment of digital technology: both technology businesses and businesses in partner sectors make daily decisions about the development and deployment of digital technology in the pursuit of value. To realise the 2030 Agenda, businesses must embrace the use of digital technology in a way that maximises their positive impact and mitigates any negatives. This must encompass market facing products and services, as well as the core operations and functions of the business.

Amplify the sharing of best practice and knowledge transfer: businesses can play a progressive leadership role for the whole system by identifying and promoting examples of effective practice that deliver impact and by sharing failures. This is particularly true given the global nature of many businesses and their supply chains, and the size of the biggest business in comparison to countries. For this to be effective and sustained, it requires a sophisticated approach to impact measurement, which draws upon the transparency enabled by the digital economy. By explicitly recognising the impact of their activities, businesses infuse the sense of common purpose throughout the system, and encourage other actors to pursue similar ambitions.

Agree precompetitive industry action: businesses recognise that the impact they can make is often limited by the scope of their operation and the context of their industry environment. To deploy digital technology towards the common purpose, there is often greater opportunity through collaboration with those who may otherwise be competitors, to find ways in which collective action can ensure widespread benefit and which may not otherwise happen. This requires sharing IP, innovation capability and addressing digital divides.[16] Industry bodies around the world play a role in helping to broker and drive partnerships of this kind, drawing on links with the ICT sector.[17] Precompetitive industry action is particularly important to develop and deploy digital technologies in countries without a native ICT sector and limited digital infrastructure.

Citizens

Commit to the common purpose: all citizens have a duty to educate themselves on the 2030 Agenda. Citizens need to be cognisant of the tremendous challenges facing humanity and the planet, and their role in both addressing and exacerbating them. This requires striving to understand what it takes to realise the SDGs and how humanity can act to maximise the upside of our impact-focused activities and minimise the downside.[18]

Understand how digital technology can contribute: as consumers and users of digital technology citizens have a responsibility to immerse themselves in an understanding of the potential for digital technology to contribute to the SDGs. For the ICT sector and partner sectors to be able to develop and deploy digital technology for the greater good, citizens at large will need to understand and embrace the potential benefits of that technology and act as sophisticated consumers and users of it.

Strive to influence others to commit to the SDGs: all individuals can take responsibility for their own actions and have the power to influence the organisations and institutions with whom they interact both physically and online. As demonstrated by the continuing school strikes for climate, individuals have the power to use their voice, amplified and co-ordinated through online engagement, to help other stakeholders recognise the need to contribute positively to sustainable development.[19] Beyond online public campaigning, there are multiple moments at which citizens can encourage others to commit to developing and deploying digital technology for the 2030 Agenda, whether that is through our private technology usage, purchasing decisions of digital tools and products, or civic engagement on this issue. Everyone has a part to play.

Next steps for GeSI

This report has outlined both the huge potential for digital technology to contribute to the SDGs, as well as the significant gap that still exists for the achievement of the 2030 targets.

GeSI exists to bring the ICT sector together to deliver against a vision of a sustainable world through responsible, ICT-enabled transformation. This means working across the industry and with key stakeholder groups to make Digital with Purpose a reality.

To that end, there are a series of next steps that GeSI hopes to progress, with the support of its membership, on the back of this report.

- **Make the case for the 2030 Agenda:** GeSI will continue to call upon its members and all businesses to commit to the common purpose of the SDGs and recognise the interdependence of a commitment to sustainable development and long-term success.
- **Enable inclusive digital transformation:** GeSI will continue to work with its members and wider stakeholders to identify and plug gaps in the development and deployment of digital infrastructure to enable sustainable development for all and leave no one behind.
- **Understand and address negative externalities:** GeSI to work with its members to understand, in depth, the potential negative impacts of the increased adoption of digital technology and the necessary mitigating actions that will enable the sector to realise a radical ambition to drive the transformation needed to realise the SDGs.

Digital with Purpose - Delivering the SMARTer2030 Agenda: GeSI to work with its members and broader civil society to address the critical externalities, take forward the opportunities, and address the challenges laid out in this report.

Case Studies

CASE STUDY

AT&T

Introduction

AT&T is a media and telecommunications company, defined by four key elements: premium content, direct-to-consumer relationships, advertising marketplace, and high-speed networks. The Fortune 10 company's mission is 'to inspire human progress through the power of communication and entertainment'.[1]

AT&T has a well-developed approach to sustainability that is becoming increasingly important to its operations, its product and services, and the way it projects itself. Climate change is a particularly important theme within its broader sustainability agenda and in 2018 it was one of the largest corporate purchasers of renewable energy in the US.[2]

As part of its commitment to sustainable development, AT&T has now set a 10x goal to enable carbon savings of ten times the footprint of their operations by the end of 2025. In order to meet this goal, the company is focusing on improving the efficiency of its network and providing technology solutions to help AT&T customers reduce their own carbon footprint. AT&T has further collaborated with other companies to offer innovative, carbon-saving technologies that can have broad and meaningful impact across multiple SDGs, including SDG 7 and SDG 13.

At the end of 2018, AT&T's technology solutions enabled GHG reductions of over 17 million tonnes of CO2e whilst its carbon footprint was under eight million tonnes of CO2e, putting their 10x factor at 2.2x.[3] Encouraged by this progress, AT&T is confident that they can meet their 10x goal by 2025, whilst recognising a number of key trends that will play an important role to help meet their target.[4] To manage the GHG footprint of their operations, they have identified improving electricity efficiency in buildings and their network and investing in fuel-efficient vehicles as key focus points. AT&T also plans to further develop their recent renewable energy efforts; in 2018 they committed to delivering up to 820 megawatts of clean wind energy to the American power grid and will continue to invest in more large-scale renewable energy projects in the future.

To unlock new potential for GHG reduction, AT&T expects further technology advancement in areas such as 5G and IoT that will enable impact in emissions-intensive industries, such as energy, manufacturing and transportation.

AT&T has used IoT connectivity to enable more resource-efficient operations and to implement and scale carbon-saving solutions across a broad range of sectors:[5]

- **IoT-enabled building energy management systems:** AT&T IoT connectivity improves visibility of building equipment, allowing for preventative maintenance and proactive responses to reduce energy and carbon footprint.
- **Smart irrigation:** AT&T IoT connectivity enables a more efficient smart irrigation system which could reduce water- and energy usage as well as GHG emissions.
- **Energy-efficient frozen food:** AT&T IoT connectivity is being used to optimise the energy performance of cold storage facilities in order to reduce energy consumption and related GHG emissions.

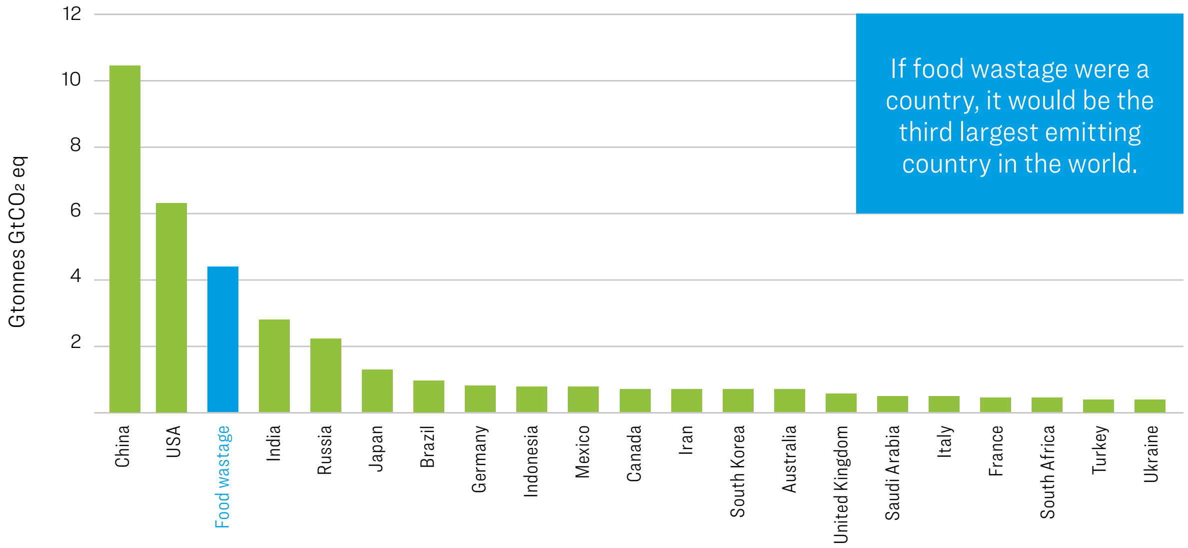
CASE STUDY

Use case – Grind2Energy[6]

The UN Food & Agriculture Organisation (FAO) reports that the total carbon footprint of food waste is around 4.4 billion tonnes of CO2 per year, which is more GHG emitted by any single country except for the US and China. With more than 1.3 billion tonnes of food lost or wasted every year,[7] AT&T has implemented several core elements of AT&T technology into Emerson's Grind2Energy to offer a solution that contributes to the targets of SDGs 2, 7, 11, 12 and 13. Collaboration between AT&T and Emerson has been critical in delivering a solution that produces impact.

Emerson's industrial food grinder converts food waste from grocery stores and restaurants into electricity or heat and fertiliser. AT&T connectivity helps to optimise the performance of this waste-to-energy generation system and eliminate GHG emissions associated with food waste in landfills, instead producing low-carbon energy sources. It also enables customers to optimise their waste pick-up process by presenting real-time data in a dashboard making it easy to manage and take meaningful action.

Total GHGs emissions excluding Land Use, Land-Use Change, and Forestry Top 20 of countries (year 2011) vs. Food wastage



If food wastage were a country, it would be the third largest emitting country in the world.

Source: WRI's Climate Data Explorer (4)

SDG Benefits

AT&T's solution has had a positive contribution to several of the SDGs.[8]

SDG 7: Affordable and Clean energy

In one year, an estimated 6,700 tonnes of food waste have been diverted from landfills, generating 1.3 million kWh of clean electricity, which would be enough electricity to power 125 homes for a year.

SDG 13: Climate Change

GHG emissions from the landfill were reduced by an estimated 5,000 tonnes of CO2e, which is the same as not consuming 570,000 gallons of gasoline. This translates as 84 tonnes CO2e abated per site.

SDG 11: Sustainable Cities and Communities

This solution helps to reduce the environmental footprint of cities with a focus on reducing urban waste. With the implementation of this technology in restaurants, grocery stores and stadiums, the resource efficiency of buildings can be improved which can go hand in hand with another of AT&T's technologies – the IoT-enabled Building Energy Management System.

Other impacts

This solution also contributes to SDG 2, Zero Hunger, by ensuring a sustainable food production system that minimises food loss. Leveraging this technology can also reduce pollution and waste generation which can help to 'halve per capita global food waste at the retail and consumer levels', a specific target of SDG 12.

Design

The process begins with industrial strength food waste grinders that are able to process the food into a liquid nutrient-rich slurry, pumping it into holding tanks that are then transported to waste management facilities. At this stage, the methane-generating waste is converted into biogas, a source of sustainable energy and fertiliser by anaerobic digesters.

The system utilises 16 industrial IoT sensors that give customers near real-time visibility to monitor and track key performance indicators of their food waste management system. For example, these sensors trigger alerts if the equipment is not functioning properly and when the tank is nearly full so that a truck can be dispatched for pickup. By incorporating IoT connectivity, more real-time data can be measured and therefore greater improvements can be made.

In particular, the increased visibility associated with IoT optimises the system performance in the following ways:

- **Maintenance:** remote monitor systems with built-in alerts allow information to be shared on equipment which isn't working properly or is broken, helping to prevent the pile up of waste and reducing the need for technician trips which can create more emissions.
- **As-needed hauling:** the frequency of pick-ups can be optimised by the capacity to monitor tank level and volume data in real time, reducing the emissions associated with truck transportation of waste.
- **Getting the mix right:** the system is able to track the flow rate and velocity of the slurry and adjust the water if needed to ensure optimal consistency for the anaerobic digesters to work efficiently.

User stories

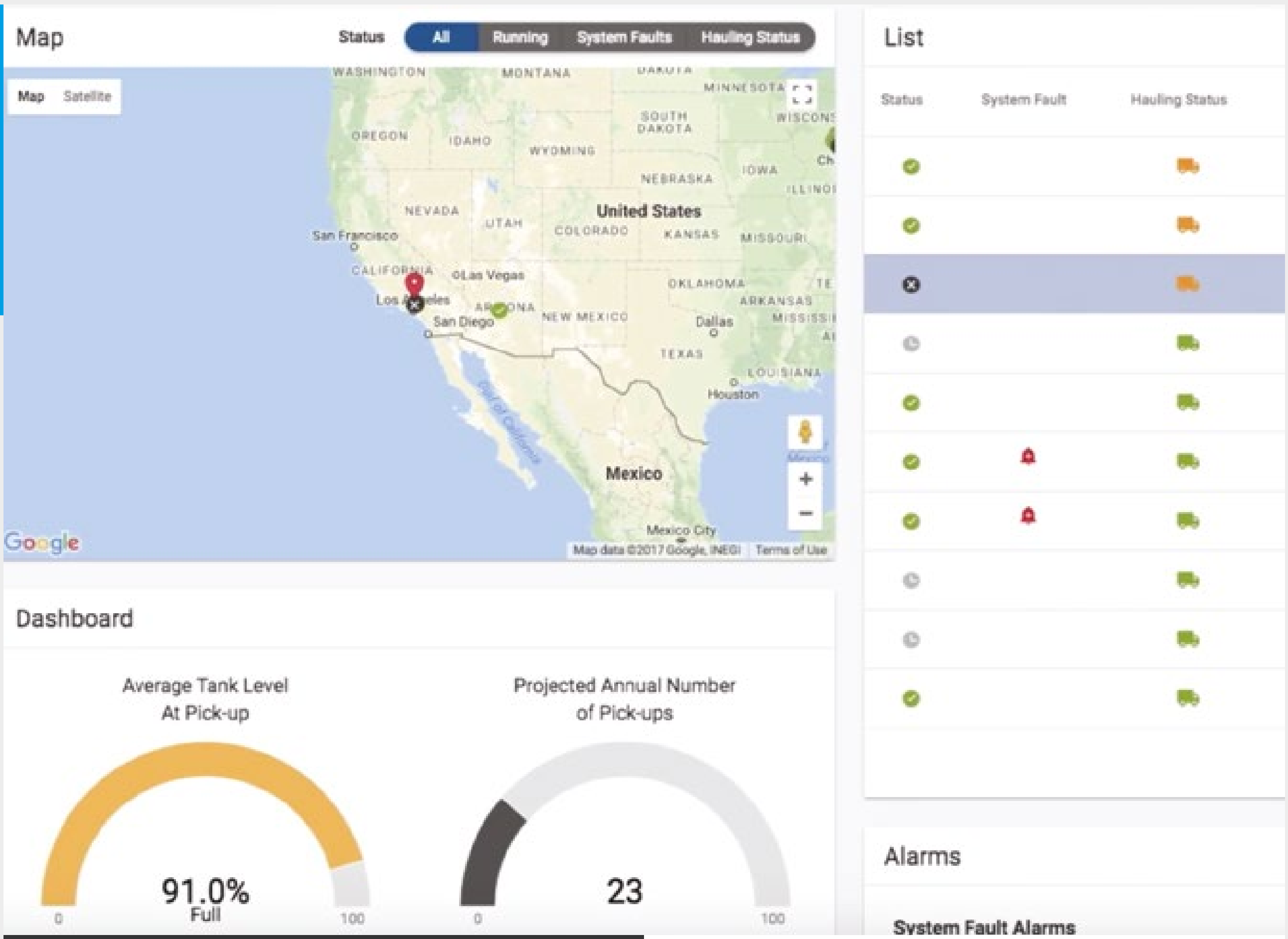
The Grind2Energy system, enabled by AT&T IoT technology, is being used by US universities. The University of Notre Dame, Indiana,[9] for example, has incorporated Grind2Energy at its Centre of Culinary Excellence (CCE), as well as in its two dining halls, capturing up to 99% of food waste from the CCE and reducing campus-wide waste by 10%, equivalent to over 300 tonnes of waste annually.[10] This translates to saving nearly 40 tonnes of emissions annually.

The system at the CCE was installed in January 2019 and in the dining halls in May 2019. By mid-2019 over 50 tonnes of food waste had already been diverted from these locations while creating over 10,000 kWh of electricity. This electricity generation and emissions reduction is equivalent to powering 12 homes for one month or 95,000 fewer vehicle miles driven.

Grind2Energy is currently utilised in back-of-house operations. However, the University hopes to expand use of the system further across the campus.

Scaling

Emerson introduced Grind2Energy in 2012 and started to collaborate with AT&T in 2016 to improve efficiency and scale its operations. Grind2Energy is now installed at grocery stores, restaurants and stadiums across the US, and AT&T has also recently installed this technology-enabled solution at their campus in El Segundo, California, to improve their own operations. AT&T is now working to increase adoption, by further implementing IoT technology to reduce Grind2Energy's operational costs in order to make the system more price-competitive. By increasing the application and usage of the Grind2Energy solution in the marketplace, AT&T can play an important role in helping customers to improve the sustainability of their actions.



> “ Before we had the IoT, we physically had to send somebody out to tables in the markets, open up the control panel, pull the data down. Everything was manual. Now, we can see how the systems are performing and track the data so much more easily.”
>
> — Doug Brokaw, director of sales, Grind2Energy

Wrap Up

With increased awareness of the need for sustainable development and given that the average price of transportation to landfills has increased almost 17% from 2010-2017[11] and is expected to rise further,[12] there is great potential for widespread usage of this technology in the marketplace to generate carbon savings and have real, meaningful impact on the SDGs.

This initiative, enabled by IoT, has had a clear contribution to the 10x goal and more widely to the SDGs having generated 1.3 million kWh of clean electricity and producing a carbon abatement factor of 84 tonnes CO2e per site.

> “ Making a difference in the communities where we live and work is a core value for AT&T. That’s why we are at the forefront of using innovative technologies – from IoT and 5G to the Grind2Energy solution and beyond – to help transform the lives of people around the world and protect our planet.”
>
> – Lori Lee, CEO AT&T Latin America and Global Marketing Officer

CASE STUDY

Introduction

Deutsche Telekom, present in more than 50 countries, is one of the world's leading integrated telecommunications companies, with 178 million mobile customers, 28 million fixed-network lines, and 20 million broadband lines. The company provides fixed-network/broadband, mobile communications, internet, and IPTV products and services for consumers. Deutsche Telekom also offers T-Systems, present in more than 20 countries, which provides integrated ICT solutions for business and corporate customers. T-Systems solutions include the secure operation of legacy systems, transformation to cloud-based services and innovation projects in areas such as data analytics, the Internet of Things, machine-to-machine communication and Industrial Internet.

Deutsche Telekom is committed to operating in a socially and environmentally responsible way, with a focus on CO2 emissions reduction, the circular economy, and expansion of broadband access. It also offers products and services that support a sustainable lifestyle and contribute to the SDGs.

The company's network infrastructure offers the technological foundation for innovational solutions to social and environmental challenges, and thus it makes the biggest contribution to SDG 9: Industry, Infrastructure and Innovation. However, many of its other products and services contribute to additional SDGs, including:

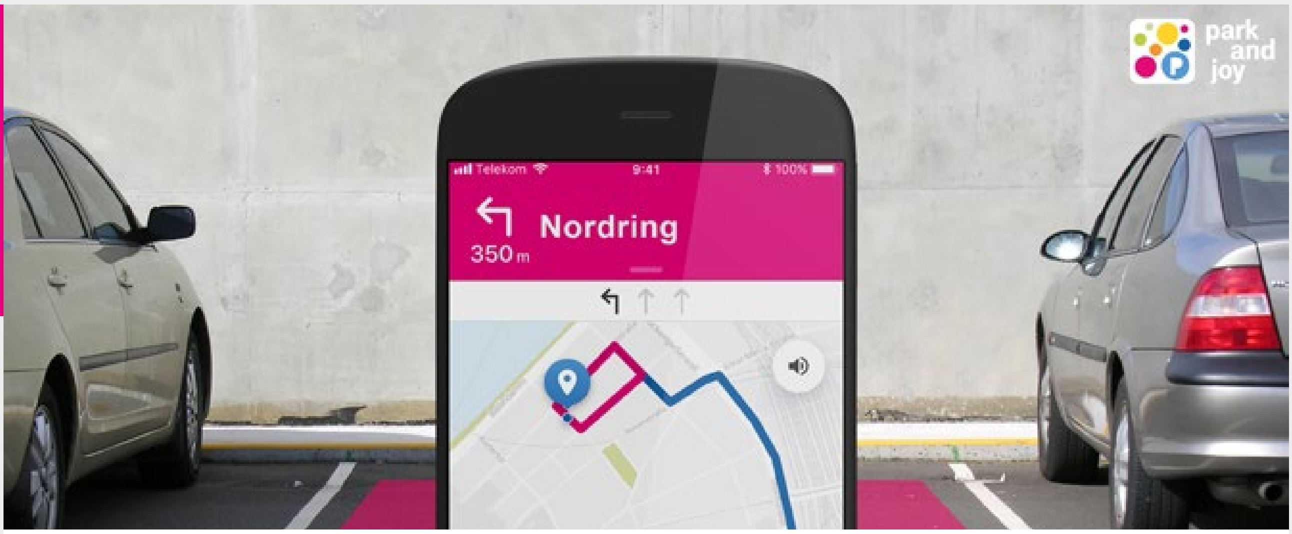
- E-health services that help improve medical care (SDG 3);
- Broadband expansion that gives many people access to digital educational media (SDG 4);
- Cloud solutions that reduce energy consumption and emissions (SDG 12 and 13);
- Smart home solutions that reduce energy consumption in the home (SDG 7 and 13);
- And, a range of Smart City solutions that reduce traffic, optimise street lighting and increase security in cities (SDG 11). One of these solutions, Park and Joy, is already having a demonstrable impact on traffic, congestion and emissions reduction within cities in Germany.

Park and Joy

Cities around the world are suffering from the effects of rising air pollution and carbon emissions. In cities, transport is often the main source of air pollution and emissions,[1] and traffic pollution problems are worsening world-wide, due to an increased number of cars on the road and limited ability to manage urban traffic flow and congestion.[2] Around 30% of urban traffic is caused by drivers searching for parking spaces, with drivers taking an average of 20 minutes to find a space – causing an additional CO2 output of 1.3 kg per search.[3]

Deutsche Telekom developed its mobile application, Park and Joy, to overcome the issue of urban traffic congestion caused by drivers searching for parking spaces. Park and Joy is a digital parking service that provides drivers with a seamless, end-to-end parking experience, allowing users to easily and conveniently find, park and pay for their parking space – all in 2 clicks. Park and Joy uses a combination of mobile data analytics and data from in-road IoT sensors to provide drivers with accurate, real-time information on available spaces, as well as optimised routing towards their chosen space. Park and Joy saves a large amount of time spent finding and driving towards parking spaces, and reduces urban congestion, air pollution and emissions. Park and Joy was piloted in the German city of Hamburg, and is now being rolled out to over 80 cities across Germany.

CASE STUDY



SDG Benefits

Park and Joy positively contributes to a number of SDGs, primarily SDG 11: Sustainable Cities and Communities and SDG 13: Climate Action.

SDG 11: Sustainable Cities and Communities

As Park and Joy is a digital parking service for urban areas, its primary impact relates to SDG 11, particularly Target 11.6: “By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality...” and Target 11.2 “By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all.”

Frauenhof based researchers conducted a year-long study on Park and Joy’s impact on urban traffic and air pollution in Hamburg, Germany, where the app was on trial. They found that with Park and Joy, parking search distance travelled per car reduced from an average of 1,396 metres to 521 metres – a reduction of 875 metres. Taking into account the carbon footprint of server and sensor production, installation and life cycle, as well as car emissions per kilometre, they also found that Park and Joy saves up to 240g of CO2 and 231mg of NOx per parking procedure, equivalent to a reduction in CO2 and NOx emissions of up to 63%. Park and Joy also helps prevent traffic jams and congestion caused by cars searching and idling in wait of parking spaces, again reducing urban air pollution.

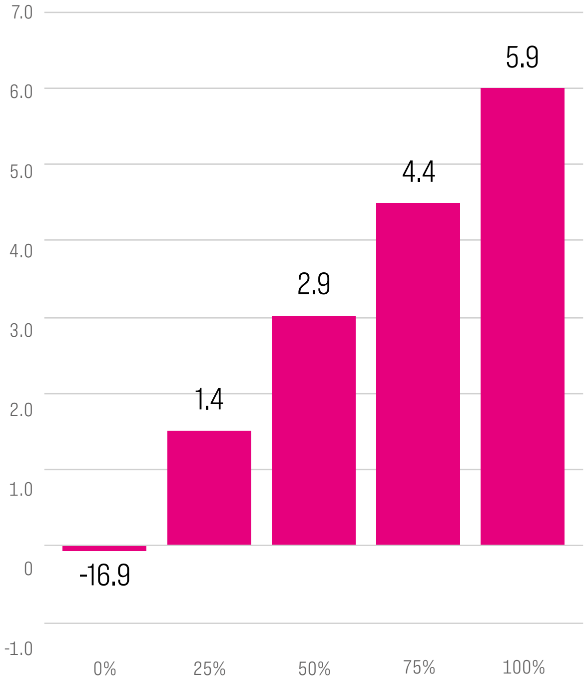
SDG 13: Climate Action

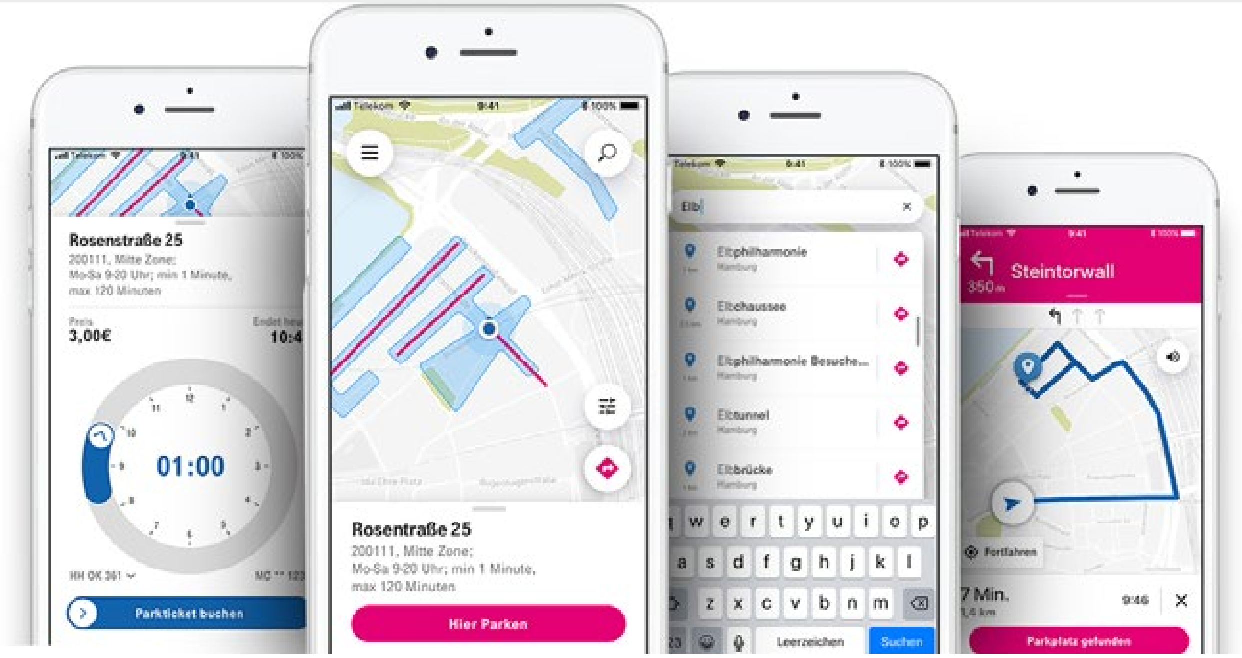
Since Park and Joy reduces the amount of harmful greenhouse gas emissions released into the atmosphere, it also positively impacts SDG 13: to take urgent action on climate change.

The researchers extrapolated the above data for 80 cities in Germany, each with a population of over 100,000 and together holding around 160,000 parking spots. Again, taking into account the carbon footprint of server and sensor production, installation and life cycle, and car emissions per kilometre, and under the assumption of 100% market penetration, they calculated an emissions savings potential of up to 84,000 tonnes of CO2 and 81 tonnes of NOx per year. The reduction that can potentially be achieved with Park and Joy strongly scales with the number of users of the service, and infrastructure has already amortised its emissions footprint at only 0.1% market penetration.

CO2 Savings through Park & Joy per year (Depending on market penetration)

(Kg CO2e per year) millions





Other impacts

A reduction in urban air pollution also contributes to SDG 3: Good Health and Well-being, as air pollution is associated with a number of health impacts, including lung cancer, stroke, heart disease and chronic obstructive pulmonary disease.[4] Park and Joy contributes specifically to Target 3.9 “By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.” Park and Joy also contributes to the ethos of SDG 12: Responsible Consumption and Production, through encouraging resource-use efficiency. Since Park and Joy promotes well-managed parking processes and allows local government agencies to increase their revenue from parking charges, the app also contributes to SDG 16: Peace, Justice and Strong Institutions.

How it works

In designing Park and Joy, Deutsche Telekom first considered the customer voice. When Deutsche Telekom asked customers what they would value the most from a digital parking services app, the two top priorities were a prediction of public parking availability and a real-time view of parking spaces currently available. So, Deutsche Telekom embarked on designing Park and Joy in order to do just that: to provide accurate, real-time information on parking space availability, and enable users to find, park and pay for a space of their choice at an affordable price.

Deutsche Telekom designed and trialled Park and Joy in the German city of Hamburg. Available geospatial data was first examined, e.g. data from Google Earth and data on the movement of mobile phone users. From these datasets, the app was able to predict parking space availability with up to 80% accuracy. However, 80% - despite being better than the pre Park and Joy average of 30% - was not good enough. If a Park and Joy customer experienced a wrong result that often, they could quickly stop using the app.

In order to increase accuracy, Deutsche Telekom installed in-road IoT sensors able to detect if a parking space was occupied or not. Due to the amount of data already available, the company only needed to install a few sensors per street, not on all parking spots, in order to get a more accurate and real-time picture of parking space availability. The IoT sensors increase the accuracy of parking spot availability predictions to 94-96%. Most sensors only send information on if the space is occupied or not, in order to maximise sensor battery longevity and reduce e-waste. However, in special cases (like handicapped parking) the sensors can also detect if the parking space user actually has handicap privileges. In addition to the data analytics and IoT sensors, Deutsche Telekom uses an AI-driven model to identify unusual occurrences in the city that are affecting parking space availability.

The combination of data analytics and IoT sensors makes it possible for Park and Joy app users to perform a targeted parking space search in an area of their choice, quickly find a suitable free parking space, and navigate towards it. Park and Joy users can also use the app to easily pay for parking, and to remotely top up length of park and payment.[5] Deutsche Telekom and T-Systems have been able to provide the entire solution – consisting of the Park and Joy app, infrastructure, platform, connectivity and rollout. The high computing power, which can be scaled even further, comes from a high-security cloud.[6]

User stories

A number of German cities have now rolled out Park and Joy, and some opinions of the app include:

Cottbus – formerly focussed around coal mining, is beginning to restructure into a modern day city.

“For the city Cottbus, Park and Joy is an essential project to digitalise the infrastructure, which makes our city more attractive to residents and visitors. At the same time, a high amount of emissions caused by parking search traffic can be prevented.”
- Mr. Holger Kelch, The Mayor of Cottbus

Dortmund – wants to be a leading smart city, with a focus on open data collection to enable mobility.

"Our cities are becoming more navigable, with less emissions and more connectivity between modes of transport. Above all, our goal is to make our cities more liveable for people. Digital technology can help us with that. For example, smart parking solutions based on available data and intelligent algorithms reduce traffic, improve transparency for citizens and not only improve the efficiency of parking, but bring a creative solution into daily life."
- Dr. Jan Fritz Rettberg, Chief Innovation Officer, City of Dortmund

Tübingen – a green party leads Tübingen city council, and therefore the city has a large focus on reducing the city’s environmental impact.

“Traffic caused by searching for a parking place is a major disruptive factor in inner cities. If it were possible to avoid the resulting detours, it would be an improvement in quality of life for all and a benefit to the environment. In Tübingen, we therefore want to provide real-time information about free and occupied parking spaces in the centre, through solutions such as Park and Joy.”
- Mr. Boris Palmer, Mayor of Tübingen

Moers

"The city of Moers wants to analyse the parking situation more intelligently. Only with this analysis, we succeed in avoiding unnecessary emissions through parking search traffic. For us, this is also an important contribution to reducing the environmental impact and relieving the burden on our road network. And of course, an intelligent parking system protects the nerves of motorists. "
- Christoph Fleischhauer, Mayor of Moers

Scaling

Park and Joy is currently aimed at individual consumers. However, Deutsche Telekom has plans to move into preparing dashboards for city administrators so they can have a real-time traffic map of their cities, in order to improve traffic control and give cities an idea of where they could reduce parking spots or convert unneeded parking spots into bike parking. The ultimate goal for Deutsche Telekom is intermodality – the inclusion of public and different types of transport (i.e. bikes) in the same service, to reduce overall use of and need for cars in the first place.

Park and Joy already has thousands of users in Hamburg, and is continuing to scale in Hamburg itself, with Deutsche Telekom aiming to install an additional 1,000 sensors across the city and integrate public transport information into the app.[7] Park and Joy is also being rolled out to over 80 additional cities in Germany. Outside of Germany, Deutsche Telekom has emerging partnerships with its first city in Europe, but its vision is much bigger. The company believes that it can help cities around the world to better understand parking, not just by rolling out the Park and Joy app, but by sharing the AI models that have been built around it. Deutsche Telekom wants to leverage its work to help other cities improve their own data models. By improving everyone’s data models, it will be able to achieve maximum impact on ‘parking prognosis’, mobility, and the environment.

Deutsche Telekom also expects to scale its impact through partnerships with car manufacturers, in order to be able to capture data from parking sensors directly into the on-board dashboards of cars. The company is also looking to combine its sources of data with data from the cars to build new models of parking availability. The company expects that this can be done even without installing IoT sensors in city streets.

Looking forward

Deutsche Telekom is open to discussing its models with all cities and believes it can help in all situations. The company ideally wants to work worldwide in order to achieve a global positive impact. The company sees Park and Joy as the ‘proof-point’ that systems such as this can have a big effect, and so is open to sharing its knowledge with any cities, mayors, town planners, traffic and street management officials and Chief Digital Officers who are interested.

CASE STUDY

Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

Introduction

EIT Climate-KIC is a knowledge and innovation community, supported by the European Union and established in 2010.[1] It brings together diverse actors including cities, NGOs, think tanks, researchers, educators, entrepreneurs, and innovators to catalyse the system transformation needed to achieve a prosperous, inclusive, and sustainable climate-resilient society through innovation.[2]

The convening power of EIT Climate-KIC means partners across business, academia, cities and non-profits can join together to create networks of expertise, researching and innovating together.[3] Over 400 formal organisational partners across 25 countries are involved, making it Europe's largest public-private organisation with the purpose of catalysing systemic change in areas of human activity that have a critical impact on GHG emissions and resilience, e.g. cities, land use, materials and finance.[4]

EIT Climate-KIC has almost a decade of successful climate innovation experience illustrated by a range of education programmes that empower participants with knowledge and best practice. EIT Climate-KIC also runs a successful accelerator programme supporting entrepreneurs to transform their ideas into climate-positive businesses.[5] So far, over 1,400 climate-positive companies have been incubated, raising over €930 million in external investment, and creating over 2,000 full time jobs.[6] Additionally, EIT Climate-KIC has leveraged €3.4 billion of private finance for its full range of innovation activities in policy, education, urban transformation, materials, finance, agriculture and forestry.

EIT Climate-KIC takes a system innovation approach to incubation, to make integrated, co-ordinated interventions in economic, political and social systems along whole value chains. The innovation experiments are discrete, but assessed in terms of their individual contribution to EIT Climate-KIC's missions, and their synergies with other activities in the portfolio to drive wider change. Innovation experiments are triggered in response to the identification of problems by cities, industry, investors, governments, or citizens. EIT Climate-KIC is then able to connect the demand for solutions with a supply of innovative ideas through providing the funding and support required to scale.

One example of the EIT Climate-KIC innovation approach is described alongside, demonstrating the powerful impact digital technologies can have on achieving the 2030 Agenda. WINnERs is an established example of how digital access enables new business models. It improves the resilience of agriculture practice by incentivising small-scale farmers in Africa to change their traditional farming patterns.

CASE STUDY

WINnERs

WINnERs (Weather Index based Risk Services) offers risk management services to create sustainable supply chains from the smallholder to the global retailer in food production and supply chain operations. The project models weather and climate risk exposure through state-of-the-art technology, investing in smallholder farmers to improve farming practices and creditworthiness, sharing risk across supply chain actors with weather and climate index-based insurance services, and promoting supportive regulatory environments for insurance products in developing countries.

Smallholder farmers typically have been unable to create long-term deals with buyers, as they cannot guarantee crop yield year-on-year. This is due to factors such as weather disruption, poor environmental conditions and a lack of capital to purchase fertilisers and pesticides to improve the likelihood of a successful crop. Farmers are often unable to access finance to break out of this cycle.

At the farm level, the likelihood of an extreme weather event and its severity can be predicted across areas as small as 5km2. This information is then integrated into agricultural insurance contracts that share risk between the various actors of a particular supply chain.

The project also focuses on improving the well-being of smallholder farmers who often bear the brunt of the risk when it comes to farming. WINnERS partnered with the WFP Farm to Market Alliance to offer its services, improved inputs, training, finance and guaranteed market access, to participating farmers' organisations. Insurance contracts are established between farmers, traders and end-buyers, rather than the traditional model of farmers being linked only to traders. International buyers are the ultimate policy holders, instead of individual smallholders, which can reduce farmers' risk and expand reach. Offering insurance to connect these previously unconnected parties increases trade and improves the efficiency of the global agricultural market. The new business model therefore improves the resilience of the entire value chain.

EIT Climate-KIC contributed to WINnERs through funding and incubation support, helping with prototype finalisation, product implantation, and impact studies. The scheme was first rolled out in 2016 in Tanzania[7] where insurance has reached 25,000 farmers, and has since expanded to other countries including Zimbabwe, Uganda and Ghana.[8] The programme has been so successful that the United Nations World Food Programme has been able to buy at least $120 million agricultural product each year from smallholder farmers.[9]

CASE STUDY

SDG Benefits

Although WINnERs delivers systemic transformation in the agriculture sector (SDG 2), the solution has positive contributions to several other SDGs, given that some of the world's most abject poverty is concentrated in farming communities.[10]

SDG 2: Zero Hunger

By guaranteeing an income for farming communities, WINnERs will help end hunger and ensure access to sufficient food throughout the year for those in vulnerable situations, reducing malnutrition and ensuring the sustainability of food production systems.

SDG 1: No Poverty

WINnERs will help reduce extreme poverty through provision of a more stable income, acting as a social protection system, and ensuring access to the basic financial services required to improving economic standing.

SDG 8: Decent Work and Economic Growth

Imperial College London estimates the project will contribute 2% to Tanzanian GDP through increasing maize production, and across sub-Saharan Africa the impact on maize yield is projected to improve GDP by 2.6%, equating to an approximate economic benefit of $62.9 billion.[11]

CASE STUDY

How it works

The key underlying innovation in the WINnERS project is the creation of a weather index-based risk service which offers insurance to farmers and global food buyers against weather and climate-driven risks.

There are multiple elements leading to the index-based risk service in the WINnERs programme that include:

- Specialist tools, e.g. machine learning, are used to collect and analyse climate data to predict the likelihood of extreme weather events occurring in small geographic areas up to 5km2
- Crop modelling simulations translate weather data into agricultural risks, such as drought and crop yield loss[12]
- Agricultural risk data is used to build insurance contracts to ensure weather and climate risks are fairly distributed across the supply chain, to outline incentives to actors for establishing long-term relationships. The contracts trigger individual relationships amongst buyers and single farms, which means the risk of crop loss is then shared[13]
- Impact assessments. Researchers seek to measure the impact of the WINnERS projects on the well-being of participating small holder farmers[14]
- New insurance frameworks. Researchers ensure insurance frameworks are contracted, regulated and supervised.

Scaling

WINnERs is planning rapid expansion. In 2019, the project secured over €1.5 million in funding from the Climate Resilience Fund and the African Development Bank.[15] The fund will go towards improving the financial inclusion of women in Tanzania, and to expanding the geographical reach of WINnERS. By 2022, the programme aims to roll out schemes across an additional 10 African countries.

WINnERs has had a direct positive impact on thousands of farming households across Sub-Saharan Africa[16]:

> **“I think all crops should be backed by this kind of insurance because it is a game changer. Farmers will be sure of borrowing each year”**
>
> - Alex Mubiru, Country Manager Tanzania, African Development Bank.

Source – The Citizen, 30 July 2019, Dar Es Salam

CASE STUDY

Introduction

T-Mobile is a mobile telecommunications company, providing wireless voice and data services. The firm is redefining the way consumers and businesses buy wireless services through leading product and service innovation. Through its Un-carrier campaign, T-Mobile has laid out a strategy focused on customer experience, a culture that values diversity and inclusion, and a responsibility for communities and the environment. The company is leading the rollout of 5G networks throughout the US by building its network and expanding its coverage year on year.

T-Mobile is committed to making sustainability a fundamental part of its strategy, culture and activities, and has committed to use 100% renewable energy for all its operations by 2021. This commitment is the driving force behind the company reaching an ambitious carbon emission reduction target, alongside implementing energy-efficiency savings in facilities and networks.

According to Chad Wilkerson, Director of Sustainability & Infrastructure Sourcing at T-Mobile, T-Mobile's focus on sustainability is not solely "on buying green energy, but [on] taking a whole-systems approach to sustainability".[1]

CASE STUDY

T-Mobile's second wind farm, Solomon Forks, located in Colby KS and operated by ENGIE US Wind

Sustainability strategy for 2021

As part of their commitment to sustainability, in 2018 T-Mobile became the first telecommunications company to join RE100, a collaborative, global initiative uniting more than 100 influential businesses working to massively increase demand for, and delivery of, renewable energy. Organisations joining RE100 commit to a public goal of sourcing 100% of their global electricity consumption from renewable sources by a specified year. T-Mobile has now committed to using 100% renewable energy by 2021, disclosing its progress annually.[2]

The company's commitment to 100% renewable energy usage and minimising its ecological footprint through a systems-approach to sustainability has manifested in four broad areas: (i) renewable energy, (ii) efficient networks and operations (iii) device recycling and waste reduction and (iv) sustainable employee practices and facilities.

i. Renewable energy

T-Mobile has a number of initiatives to reduce the carbon footprint of its operations. Central to this aim is its portfolio approach to its renewable energy program, with an energy mix of several wind and solar projects through a power purchasing agreement (PPA) financial structure. In 2019, T-Mobile reduced emissions by over 300,000 metric tons through a wind farm project in Oklahoma, and combined with a similar wind farm in Kansas, added 320MW of new green energy capacity, accounting for a projected 41% of total energy needs by its goal year of 2021.

The company has also pursued a portfolio approach to its renewable energy programme. In addition to the two large wind farm projects it has added to its energy mix several solar projects through the PPA financial structure. It has also diversified its project size and locations. While the company started with wind projects based in the centre of the country in the 150MW range, T-Mobile has since worked on solar projects that range from 15MW-250MW, from Texas to Virginia.

Additionally, T-Mobile through the Puget Sound Energy "Green Direct program", is powering its Bellevue, Washington headquarters with 100% renewable energy, whilst its data centres in Wenatchee, Washington are consuming 100% hydro-electricity. By 2021, T-Mobile plans to use over 3,000 GWh of renewable energy annually, utilising over 900MW of renewable energy capacity.

ii. Efficient networks and operations

To reduce its carbon footprint further, T-Mobile undertook in-depth research and built capabilities to boost energy efficiency and reduce energy usage across the entire business, prioritising the optimisation of its network's operations. Even though data flowing through T-Mobile's network has increased by over 49 times in the last six years, using energy-efficient technologies has allowed its energy intensity to decline by 97%.

Efficiency gains in cell towers have been made primarily through improvements in heating and cooling. By implementing new methods of efficiently controlling the on-site temperature of cell towers, T-Mobile is reducing the amount of propane, diesel and electricity needed for power. Other innovations in lighting controls, power factor improvements and on-site solar technology are continuously being developed to improve the performance and reliability of cellular equipment.

iii. Device recycling and waste reduction

T-Mobile delivers substantial positive ecological impact by incorporating sustainability into the management of the electronic devices of its customers. Of the 3.9 million used devices and accessories collected by T-Mobile in 2018, T-Mobile reused or resold 96% of the hardware. The remaining 4% is responsibly recycled by its partners. As a result of this effort, over 14 million customer devices have been reused or resold since the programme's inception in 2008. For every one million devices that are recycled, 35,284 pounds of copper, 772 pounds of silver, 75 pounds of gold and 33 pounds of palladium are recovered which can be used again in new devices, preventing over-extraction.

Beyond recycling consumer phones, T-Mobile reduces material waste in its own operations. Over 86% of its customers are billed online, saving natural resources by decreasing paper use. T-Mobile is also minimising its environmental footprint by recycling or composting waste produced by its headquarters, annually downsizing on printers, and eliminating paper cup use from many of its customer care centres.

iv. Sustainable employee practices and facilities

T-Mobile is committed to ensuring its sustainable internal practices extend to its workforce. It encourages carpooling and energy-efficient commuting by providing location-specific benefits to its employees. T-Mobile also offsets the carbon impact of its air travel, by working on a reforestation project that supports reforestation in Haiti and Madagascar – an effort that has resulted in more than 1.2 million trees planted to date. T-Mobile has also collaborated with the Nature Conservancy for the #TreeMobile campaign, which donated enough to plant more than 300,000 trees in locations in North America, Latin America and Asia.[3]

Finally, T-Mobile is showcasing its commitment to sustainability at its corporate headquarters where it has achieved LEED Certification from the U.S. Green Building Council on one of its buildings and it is pursuing a certification for a second building.

CASE STUDY

SDG Benefits

T-Mobile's sustainability strategy has direct positive impacts on the 2030 Agenda:

SDG 3: Good health and well-being

Using less diesel and other non-renewable energy sources in radio cell towers emits fewer pollutants into the air, reducing respiratory infections and contributing towards SDG 3.

SDG 7: Affordable and clean energy

T-Mobile directly supports SDG 7 with its transition to 100% renewable energy usage, for example by signing long-term PPAs to power its facilities and operations with a portfolio of green energy including wind, solar, and hydroelectricity and increasing the energy efficiency of its business operations.

SDG 11: Sustainable cities and communities

With device recycling in all stores, a number of LEED Certified buildings, lowered emissions and pollutants from cell towers and a long-term PPA with local Puget Sound Energy Green Direct energy deal to power its headquarters, T-Mobile is doing its part to create more sustainable cities in all the locations where it operates.

SDG 12: Ensure sustainable consumption

Reusing precious metals in old phones prevents the unnecessary extraction of additional resources, and the emission of GHGs. Additionally selling over three million used devices annually, reducing thousands of tonnes of waste through recycling and composting and eliminating unnecessary plastic in packaging are examples of responsible production and consumption, contributing to the goal of a circular economy and supporting SDG 12.

SDG 13: Climate action

By transitioning to 100% renewable energy, T-Mobile directly answers the call of SDG 13.

T-Mobile is committed to making sustainability a fundamental part of its strategy, culture and activities, and has committed to use 100% renewable energy for all its operations by 2021.

CASE STUDY

verizon✓

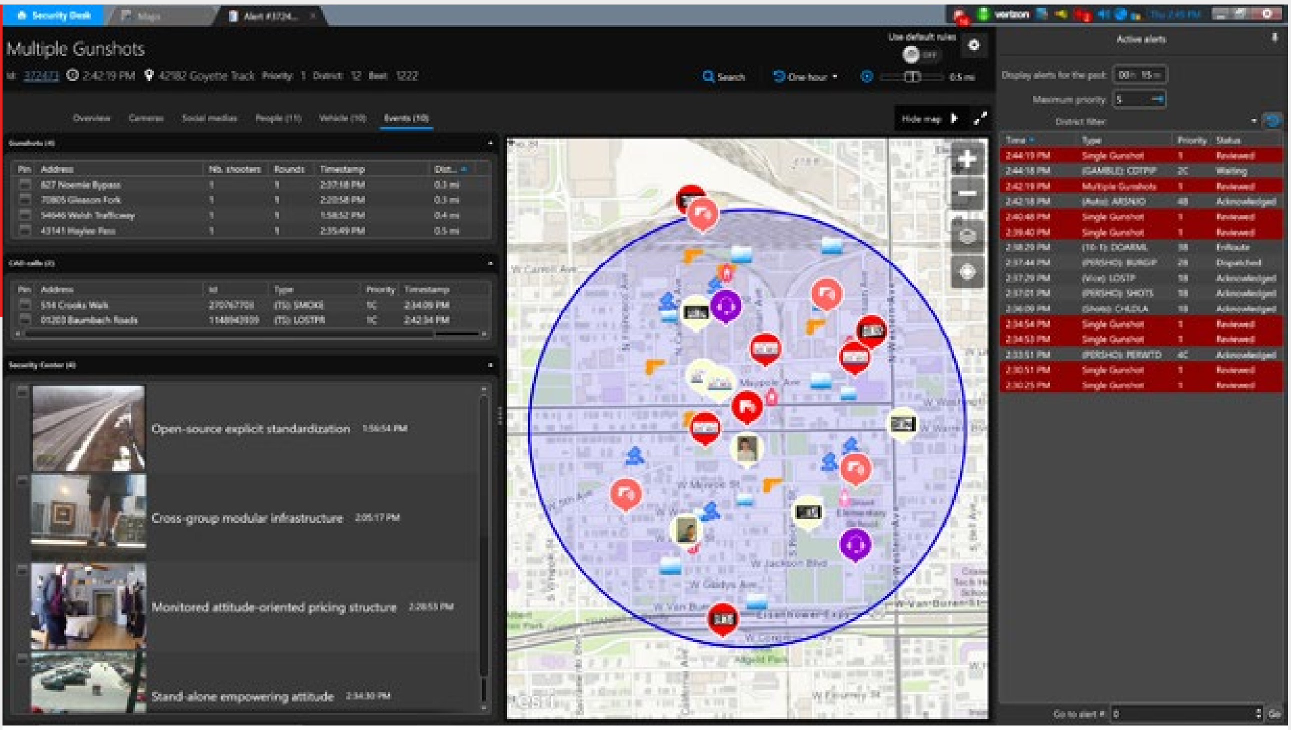
Introduction

Verizon is a US provider of innovative communications and technology solutions that improves consumers' lives and ways of working. Through these solutions, Verizon aims to deliver its promise to "make the world better than yesterday". The company was the first in the world to launch a commercial 5G mobile network, alongside a commercially available 5G-enabled smartphone, in April 2019.[1]

Verizon sees digital solutions as enablers for the achievement of the Sustainable Development Goals (SDGs), and in 2018 set particular aspirations to help progress SDG 4: Quality Education, SDG 8: Decent Work and Economic Growth, and SDG 13: Climate Action.[2] It has made ambitious pledges towards addressing its carbon footprint – committing to go carbon neutral in its Scope 1 and Scope 2 emissions by 2035.[3] Verizon's efforts were recognised when it was named one of the top 100 most sustainable companies in the US.[4]

As the world's population becomes increasingly urbanised, with over 70% of the population estimated to be living in cities by 2050,[5] cities must harness digital technologies to protect and provide for residents and to help manage their environmental impact. Verizon has developed a set of Verizon Connect and Smart City Solutions to enable communities to stay connected and safe; key aims of SDG 11. The solutions centre on the collection and analysis of data, providing stakeholders with increased knowledge of their communities, their vehicles, and a better ability to respond to their needs.[6] Some current examples include:

- **Fleet Management:** Verizon Connect utilises automation and connected data to produce telematic services and solutions, allowing drivers to be safer, more efficient and more productive. Customers who use Verizon Connect's products and have an internal program established around it, e.g. use the data to coach drivers or run optimised routes, have experienced a 13% decrease in idle time and an 11% reduction in harsh driving events, which lead to reduced fuel consumption (SDG 13), fewer accidents and greater safety (SDG 3).[7]
- **Intelligent Lighting:** Verizon Intelligent Lighting is a networked lighting control system that enables remote control, monitoring and diagnostics for street and area lighting. The implementation of intelligent lighting reduces energy consumption (SDG 7) and therefore reduces the carbon footprint of cities (SDG 13). It can also increase safety in areas of particular risk. Using the system, pilot cities have saved up to 20% of energy on street lighting.
- **Intersection Safety Analytics:** an integrated managed solution to detect interactions among motorists, pedestrians, and cyclists by collecting, processing, analysing and correlating behavioural analytics data. It has improved road safety (SDG 3) in cities that have implemented it.
- **Intelligent Traffic Management:** IoT sensors in roads gather real-time data to reduce traffic, commute times and emissions (SDG 13).
- **Real-Time Response System:** a solution designed to improve public safety in urban areas. This is explored in detail below.



Real-Time Response System

Description of the initiative

First responders[8] are trained to react to critical events in a short space of time.[9] The use of public safety technologies could help first responders reduce fatalities in cities by up to 10%.[10] Verizon invests its efforts to help with first responders and disaster recovery, from building a Responder Private Core for first responders to keep them better connected and provide them priority access during emergencies, to deploying mobile cell sites to areas that need enhanced coverage as a result of natural disasters.

Verizon's Real-Time Response System (RTRS) is one of Verizon's solutions for first responders, designed to collect and provide essential data to improve decision-making in critical moments.

RTRS integrates data from a swathe of sources to provide one accurate and real-time view of the city for first responders and city agencies. The solution can then identify patterns and trends to provide insights for users, for example providing an alert if a gunshot is identified. Additionally, these insights can inform changes to improve response time to an incident. In the example of an identified gunshot, insights from RTRS could be used to change traffic signals from red to green, allowing first responders to be routed efficiently to the scene.

SDG benefits

The RTRS solution targets three SDGs in particular:

- **SDG 3 – Good Health and Well-being:** Improving the reaction time to accidents and emergencies in urban areas can reduce fatalities caused by road traffic accidents, a target under SDG 3. When Genetec (who operated a legacy version of the solution) introduced the system in Chicago in 2017, it reduced response times to events in the city's two most at-risk districts by 24% and 39% respectively.[11]
- **SDG 11 – Sustainable Cities and Communities:** The solution increases urban security and the efficiency of emergency services within cities, having a positive impact on SDG 11. In addition, in the case of natural disasters, RTRS can be used to provide a clearer picture of changing conditions, improving urban resilience to these situations.
- **SDG 16 – Peace, Justice and Strong Institutions:** RTRS equips law enforcement agencies to better deal with crime and violence, promoting peaceful urban societies as outlined by SDG 16.

CASE STUDY

How it works

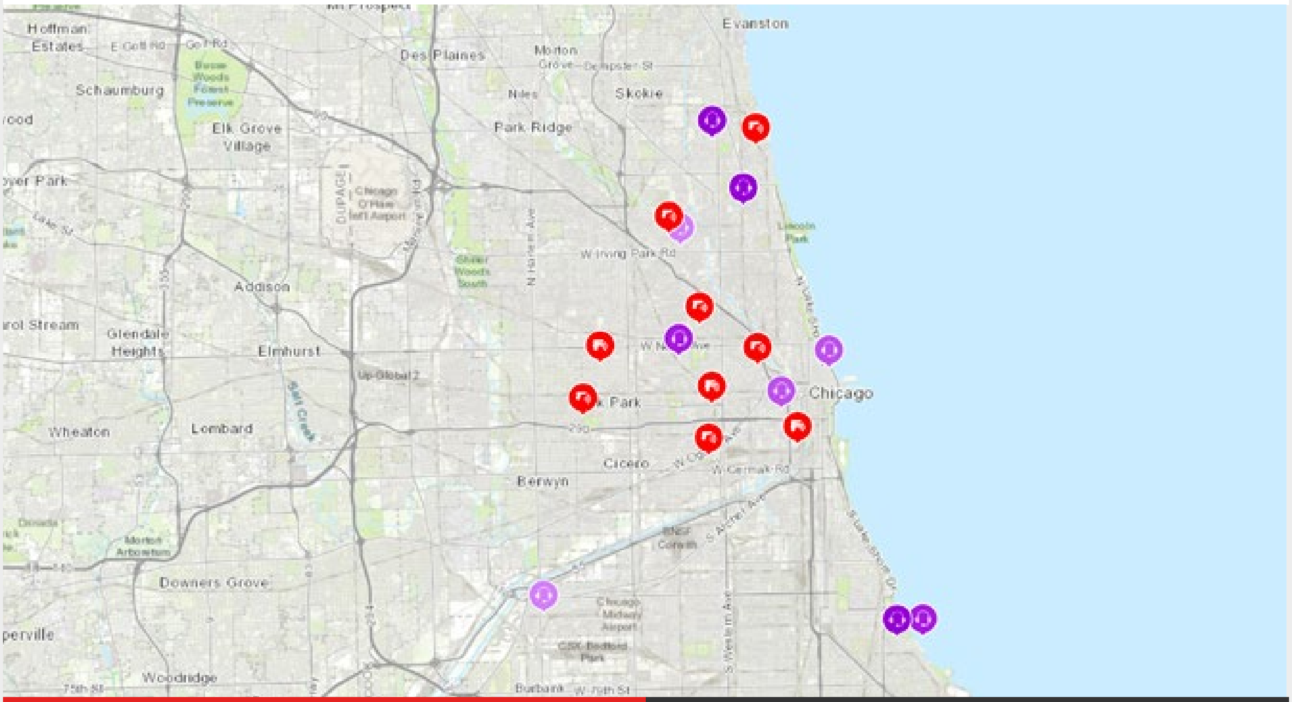
RTRS collects data from a number of sources, including video sensors, record management systems, and third party datasets, using Verizon's fibre-optic 4G LTE and, soon, 5G mobile networks. The solution correlates data, based on time and location, and user-defined rules (e.g. if a license plate shows up multiple times within a specified time) to then deliver alerts to the central system. It can also send relevant information to connected vehicles, communicating real-time information to first responders in the field.

The disparate data sources are assimilated on a single interface, hosted on the AWS GovCloud, where further analysis is undertaken. The RTRS interface not only allows users to monitor events as they arise, but also to make informed decisions based on the insights returned, for example, determining the most appropriate emergency service or team to dispatch to an incident. Additionally, the interface allows users to plan for future events in the city and to analyse the effectiveness of public safety policies.

Scaling

Cities can adopt this technology to enhance public safety capabilities, and connect previously isolated sources of information. Collating data into one interface offers clarity about new public safety measures and incident patterns, allowing more informed responses to high-risk areas. As RTRS is hosted on the cloud, it requires minimal in-house IT investment and support and can be scaled as needed.

As this is a relatively new solution, Verizon is in discussions to roll out RTRS with a number of potential partners.



User stories

> " A unified solution that provides a common operating picture enhances situational awareness and allows better planning, detection, response and prevention of incidents."

- Jason Friedberg, Business Development Manager, Genetec Inc. (former Chief of Police at Bucknell University)

User stories

> " When I was an acting Chief of Police, connecting information from our disparate systems to get a clearer picture of a situation was a difficult and time-consuming task which often could lead to delays in responses."

CASE STUDY

Looking forward

As Verizon continues its nationwide deployment of 5G in the US, it will be able to support the creation of new products and services to promote further progress towards the SDGs. A number of solutions are being developed and trialled internally. However, Verizon will also partner with companies that are developing promising technologies to deliver change with 5G in the future. For example, the following companies are part of Verizon's 5G First Responder Incubator Program, and may provide a view into the future first responders:

- Qwake Tech designed C-THRU, a product that uses computer vision assisted AR to guide firefighters through an active fire with low to no visibility. 5G allows command and control to see a firefighter's exact location; this improves the safety and efficiency of firefighters, to promote safer living spaces for all (SDG 11).[12]
- Aerial Applications is working with Verizon's Skyward drone automation platform to improve the future of public safety. Aerial is looking to use 5G to optimise the performance of its AI-driven analytics of drone videos. This could allow near real-time insights to be delivered by drones, improving situational awareness, and the ability to respond, during natural disasters and emergencies (SDGs 3 and 11).[13]
- BlueForce Development has developed software for body-worn sensors and smartphones that can communicate the location and status of individual police officers to command and control, as well as other officers. This solution provides near-immediate feedback to improve the coordination of efforts and the operational efficiency of police forces (SDG 16).[14]
- Adcor Magnet Systems is developing solutions with smart sensors and AR that provide airborne, ground-based and sea-based situational awareness using 5G, therefore improving public safety efforts (SDG 3).[15]
- Kiana Analytics is working to enhance physical security at airports, campuses and large public venues by analysing human behaviour, e.g. movements through an airport, using location-based services, advanced analytics and 5G (SDG 3).[16]

Wrap up

In recent years, central government debt has remained high, or risen in some cases, in many developed countries,[17] which has stretched the capacity of emergency services. In Europe, for example, the number of police officers per capita has been declining since 2007.[18] Emergency services must therefore innovate to increase their efficacy and uphold the aspirations of SDG 11 and 16. Verizon's RTRS provides the means to improve the efficiency of public safety services, through more coherent and comprehensive access to data.

It is evident from this example and the 5G-enabled solutions that Verizon and its partners are working to deliver, that digital technologies will be increasingly central to providing safe and lasting communities. They will enable residents to thrive, whilst limiting cities' impact on the world around them.

SDG Deep Dives

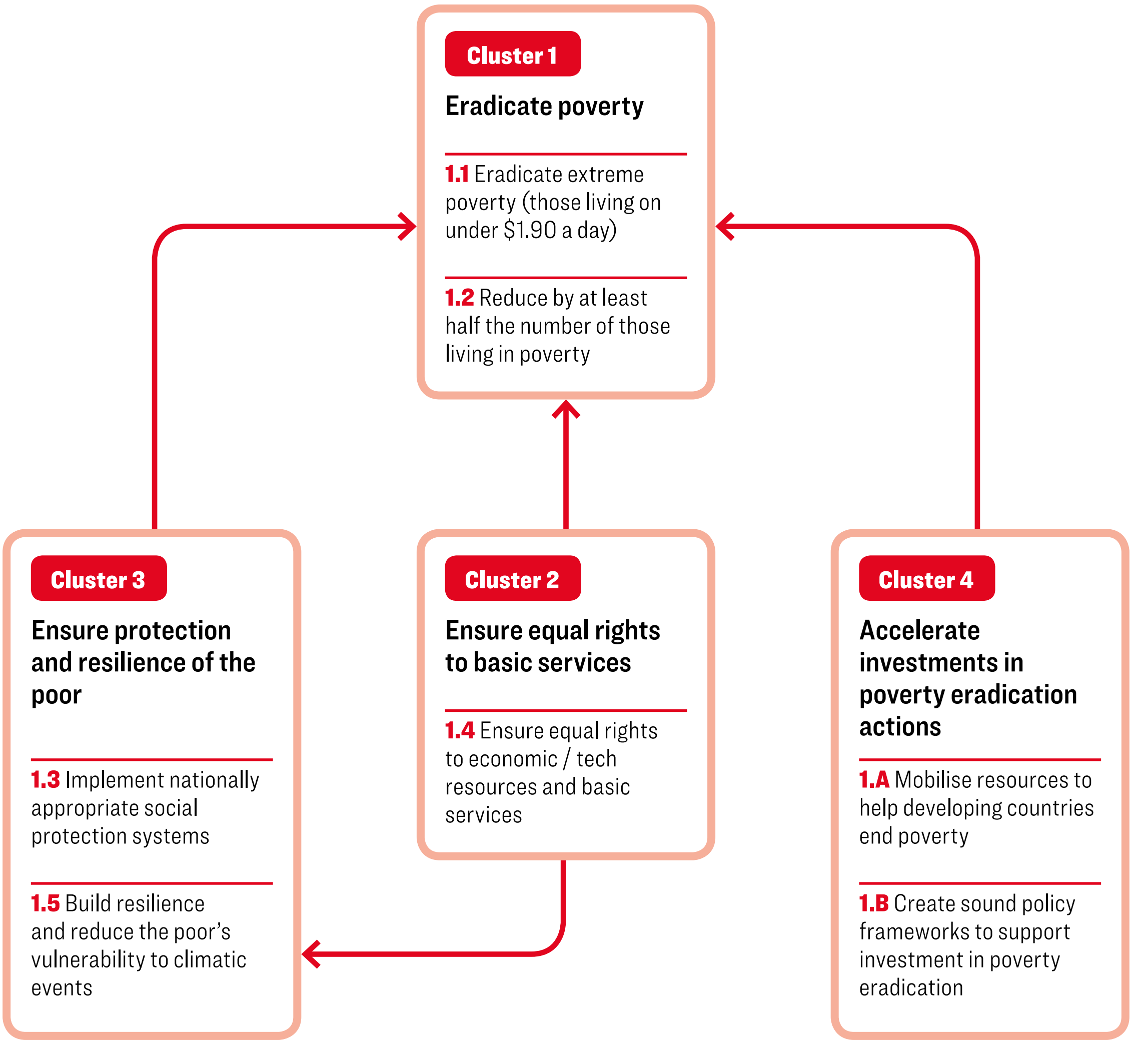
Digital technologies can have a transformational impact on our ability to meet the 2030 Agenda; of the 169 SDG targets, 103 are directly influenced by digital technologies.

SDG 1 DEEP DIVE

No Poverty

SDG 1 aims to end poverty everywhere through ensuring equal access to basic services, protecting and improving the resilience of the poor and accelerating investments in poverty eradication. In 2018, 8.6% of people around the world were living in extreme poverty and the UN reports that on the current trajectory, around 6% of the global population, or half a billion people, will be facing severe hardship in 2030.[1] The problem is not just one of individual suffering. Poverty leads to instability, inequality and mass-migration[2] and is an urgent, pressing and fundamental challenge for the world to address. Further, Climate Change will disproportionately affect the world's most vulnerable populations deepening and extending the problem by contributing to increasingly harsh living conditions and food scarcity.[3]

SDG 1 System



Cluster 1

Eradicate poverty

1.1 Eradicate extreme poverty (those living on under $1.90 a day)

1.2 Reduce by at least half the number of those living in poverty

Cluster 3

Ensure protection and resilience of the poor

1.3 Implement nationally appropriate social protection systems

1.5 Build resilience and reduce the poor's vulnerability to climatic events

Cluster 2

Ensure equal rights to basic services

1.4 Ensure equal rights to economic / tech resources and basic services

Cluster 4

Accelerate investments in poverty eradication actions

1.A Mobilise resources to help developing countries end poverty

1.B Create sound policy frameworks to support investment in poverty eradication

The core aim of SDG 1 is to eradicate poverty (Cluster 1). This is enabled by ensuring equal rights to basic services (Cluster 2), such as health and education. Access to basic services also contributes to improving the protection and resilience of the poor (Cluster 3), which can in turn help drive the eradication of poverty, for example through social security payments. Finally, progress will be further enabled by accelerating investments in poverty eradication actions (Cluster 4), such as international aid to the least-developed countries.

The role of digital technologies in delivering SDG 1

There are a small number of important use cases that demonstrate a direct role digital technologies will play in enabling the achievement of SDG 1. For example, AI and cloud technology help to identify the spread and dimensions of poverty across regions, informing tailored and specific poverty interventions. For individuals, digital technologies can assist those in, or close to, poverty to save money, establishing a security net in the case of unexpected economic or climatic events. Blockchain solutions can improve the utility and security of basic services through essential insurance payments that can be expedited in near real time to communities stricken by disaster, and the digital ledgers secure once-vulnerable land rights.

In terms of actually eliminating poverty however, there is less of a direct relationship between the application of digital technologies and the relevant targets than there is for other SDGs. Poverty comes in many forms, as acknowledged in Target 1.2,[4] driven by a combination of macro and micro-economic factors, policy decision making and individual circumstance. In particular, there is a relationship, albeit much contended, between economic growth and the reduction of poverty.

Over the past few decades, economists have clashed over the driving forces of poverty reduction. For some in the tradition of neoliberal economics influenced by economists such as Milton Friedman, economic growth provides a 'trickle down effect'.[5] Economic growth, stimulated by reduced tax burdens, incentivises increased investment and industrial expansion. Through these short-term economic gains, it is argued, society as a whole should eventually stand to benefit.[6]

Others, however, including Joseph Stiglitz[7] and Jeffrey Sachs[8], have pointed to the uneven distribution of the 'trickle-down economy' across countries, sectors and demographics. Whilst almost all national economies have grown over the last five years, a wide income gap between the wealthy and the poor continues to persist. In 2016, 50% of the world's population shared in just 10% of the wealth.[9] In African countries, particularly those rich in natural resources with a dominant resource extraction industry, wealth generated by major corporations continues to have a limited impact on the wealth of the broader population.[10]

For these economists and policymakers, eliminating poverty relies on much more than economic growth. Rather, the wide range of issues represented by the SDGs present a set of challenges that can be addressed to contribute to eliminating poverty. For example, significant efforts should be made to provide essential and reliable support through basic services, e.g. health and education, and infrastructure.[11]

Government policy and investment is critical to eliminating poverty. Social safety nets have a clear and positive relationship to reducing poverty, and are required to protect the most vulnerable in society. In a study conducted by the World Bank, safety nets were shown to reduce poverty gaps by 45%.[12] But funding these interventions requires substantial public revenues, requiring an enabling environment for business, good governance and effective, fair taxation.[13]

Importance of digital technologies to target attainment

	TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1	**Eradicate poverty**		
🟧	**1.1** Eradicate extreme poverty (those living on under $1.90 a day)	Digital technologies can aid policymakers and NGOs in identifying and responding to poverty and help individuals build security against poverty through financial access and advice. However, eradicating poverty is driven through a variety of factors, including public policy and investment.	🟢 ↘
🟧	**1.2** Reduce by at least half the number of those living in poverty		🟢 ↘
2	**Ensure equal rights to basic services**		
🟩	**1.4** Ensure equal rights to economic / tech resources and basic services	Digital technologies help connect the ‘unconnected’ to basic services, particularly through innovative platforms, mobile money and digital identity (SDG 16). Digital technologies, additionally, play a large role in improving access to health, education, water and energy (SDGs 3, 4, 6 and 7 respectively) but this is explored in the corresponding SDG deep dives.	🟠 →
3	**Ensure protection and resilience of the poor**		
⬜	**1.3** Implement nationally appropriate social protection systems	Digital technologies can be integrated with social protection systems to improve the reach of social security nets. However, the target is primarily centred on public policy and investment.	N/A
🟩	**1.5** Build resilience and reduce the poor’s vulnerability to climatic events	Digital technologies can help build resilience to climatic events. However, this is explored in SDG 13 owing to similarities in the targets.	🔴 ↗
4	**Accelerate investments in poverty eradication actions**		
⬜	**1.A** Mobilise resources to help developing countries end poverty	Digital technologies are ancillary in mobilising resources to end poverty in developing countries. This is driven primarily by aid.	🟠 →
⬜	**1.B** Create sound policy frameworks to support investment in poverty eradication	Digital technologies have a limited impact on creating policy frameworks.	N/A

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

🟩 High impact
🟧 Moderate impact
⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

🟢 Positive progress
🟠 Limited progress
🔴 Negative progress

Cluster 1

Eradicate poverty

The number of people living in extreme poverty is dropping but at a slowing rate, particularly in South Asia and sub-Saharan Africa. By 2030, 87% of extreme poverty will be concentrated in Africa.[14] Evidently, there needs to be specific focus on these regions. More broadly, there may be far more people living in actual poverty globally depending on the basic costs of living in countries.

Basic mobile connection allows individuals to more easily provide financial support to people in extreme poverty, contributing towards a basic income for the most needy communities. AI combined with mobile apps offer money management services for low-income households, reinforcing positive habits to protect against poverty. Finally, digital technologies offer the ability to identify and monitor poverty at scale, informing anti-poverty initiatives.

The complexities of poverty mean that many of the other SDGs contribute towards the achievement of this cluster. Access to, and the quality of, basic services (SDGs 3, 4, 6 and 7), for example, are key factors to address to reduce poverty. Government initiatives also can help guide individuals out of poverty. Social safety nets, for example the Bolsa Familia in Brazil, are key contributors to reducing poverty.[15] Equally, offering support for moving back into work may be particularly important for tackling poverty in some developed countries.[16]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile payments facilitate direct transfers to those in extreme poverty The rise of mobile money - paired with a large evidence base on cash transfers - provides the ability to give cash directly to those in poverty.	**Example:** GiveDirectly is an NGO that raises funds to send cash directly to extremely poor households. Representatives collect recipient enrolment data digitally, using multi-step verification, independent audits, and automated verification checks to increase efficiency. After a household is enrolled, the organisation sends two transfers to each recipient's mobile money account. The recipient can then withdraw the transfer through a local mobile money agent and choose for themselves what they need most.[17] Cash is one of the most thoroughly researched development interventions.[18] Over 165 studies show the impact of cash transfers across a range of outcomes, including education, income, assets, consumption, food security, and psychological well-being. This research also shows no impact on spending on 'temptation goods'.[19]	Digital Access	Importance to SDG Role of digital technologies Scalability
Crowdfunding websites enable collective and explicit philanthropy Crowdfunding websites humanise and individualise fundraising. Donors see a tangible connection between their contributions and the issue at hand, and may be more inclined to donate to a specific cause, rather than a charity.[20]	**Example:** JustGiving is a platform that allows individuals to raise money for a personal cause, e.g. a volunteering trip to a developing country, or money to pay for essential surgery, in addition to donating to a charity. $4.5 billion has been raised via the platform since its inception in 2001.[21]	Digital Access	Importance to SDG Role of digital technologies Scalability
Direct transfer of benefits to the poor using mobile phones Governments are able to directly deliver social security payments and benefits to the poorest in society via mobile transfers. Through this, benefits can be delivered with speed and there is much lower risk of payments not reaching the intended recipient.	**Example:** The Indian Ministry of Finance established the 'JAM trinity' to deliver direct benefit transfers ('DBT') to the bank accounts of poor citizens through mobile phones. This system catalysed a large uptake in bank accounts and connected 590 million people to the DBT scheme in 2018.[22] Previously, the Indian government operated subsidy schemes for essential goods and services that were executed by intermediary suppliers. Through corruption and leakages, this meant that much of the benefit was lost before it reached the end consumers. Direct mobile transfers remove intermediaries from the delivery of subsidies, providing the full benefit to India's poor.[23]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Cloud-based platforms can return insights on the spread of poverty and efficacy of anti-poverty projects Levels of poverty can be assessed at localised levels within regions through data collection on cloud platforms. This allows for a greater understanding of the makeup of poverty within a region to inform prescriptive alleviation methods.[24]	**Example:** Guizhou province in China has developed a poverty dashboard that monitors the level and geography of poverty in the province through real-time data from 84 indicators. The system also monitors poverty-alleviation projects, to consider whether the projects are having the desired impact or not. Through this, the effectiveness of anti-poverty measures can be analysed.[25]	Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Personal finance applications assist with money management Fintech companies and incumbent banks are offering mobile apps to help customers manage money. Increased transparency over spending and upcoming bills can prevent users from going into debt.[26]	**Example:** Pariti provides users with an overview of all of their financial accounts. Users also input their upcoming bills and expenses and set a target for saving. The app is then able update users on their predicted spending and whether they will go over budget in a given time period, encouraging users not to overspend and to set aside a safety net.[27]	Digital Access Cognitive	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Identify areas of poverty through satellite image recognition AI is used to analyse high-resolution satellite imagery and other data to identify poverty-stricken areas. This can better guide efforts to combat poverty by government organisations and NGOs.	**Example:** Stanford University researchers used AI to analyse daylight satellite imagery and household surveys in Uganda, Tanzania, Nigeria, Malawi and Rwanda to recognise patterns indicative of poverty and establish the distribution of poverty throughout the countries.[28]	Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AI drives automated financial advisors to assist the poor with saving Saving is particularly difficult for the poor and those with less disposable income.[29] However, savings can provide a safety net to prevent households from falling into poverty.[30] Automated and personalised reminders can encourage households to save money.	**Example:** Juntos is a mobile 'financial coach' that encourages families to save money in their bank accounts. It sends personalised text messages to members to remind them when to save or to prompt them to save more. It aims to assist the "newly banked" members of society who may have not saved much historically.[31] Initial text conversations give insights for iteration and then AI crafts customised, automatic responses to the user going forward. A pilot study showed a 40% positive discrepancy in account balances and savings in comparison to the control group.[32]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 2

Ensure equal rights to basic services

Access to basic resources, including electricity, clean cooking fuels and improved water sources, is steadily increasing. For example, global access to electricity has risen from 77% in 2000 to 87% in 2016.[33] However, much of the world still lacks access to basic services. 30% of the global adult population do not hold an account with a financial institution nor use a mobile money service.[34] In addition, nearly 70% do not have access to land registration systems[35] preventing them from using secured property to take out loans, start businesses and grow crops for self-subsistence.[36]

Digital technologies help to address these challenges by connecting the unconnected. Mobile devices can be used to bring basic financial services to the unbanked. Blockchain applications can help simplify the insurance process so local communities are better able to protect their land from corruption and conflict.

Whilst digital technologies can contribute to their proliferation, access to basic services relies on strong national institutions. Unstable and corrupt governments exacerbate poverty and typically are unable, or unwilling, to provide the base level of support required by citizens.[37] In developed countries too, governments face an ongoing challenge to provide sufficient public services, particularly in the face of growing national debt.[38] Renewed political focus on, and investment in, universal basic services is therefore required to achieve these targets in SDG 1.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile money allows the unbanked to access financial services Mobile money, particularly in developing countries, is a highly effective way of distributing basic financial services. Around 70% of the global population has a mobile phone connection.[39] As such, mobile money applications are used to bypass physical banks and reach those in remote or underdeveloped regions.[40]	**Example:** M-PESA is a mobile money digital wallet.[41] It allows money transfers, payments and withdrawals. It targets base of the pyramid as opposed to higher income groups. It provides a range of financial services, including loans and international transfers, to over 30 million users in ten countries.[42] In Tanzania M-PESA lowered financial exclusion by 50%, giving local communities access to essential services.[43] Since 2008, it is estimated that access to mobile money lifted 2% of Kenyan households out of extreme poverty.[44]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Blockchain can expedite insurance claims for small-hold farmers Blockchain-integrated insurance processes increase the trust between insurance underwriters and policyholders. This allows insurance claims to be processed in near real time, giving immediate resources to those who need it, e.g. small-hold farmers following a natural disaster.[45]	**Example:** Aon and Oxfam are using Blockchain to deliver affordable insurance to rural populations in Sri Lanka. The technology automates insurance products and simplifies the claims process for farmers. Weather data indices are fed into the claims process to automate tasks and eliminate the need to send out a claims adjuster. This should allow farmers to receive compensation without needing to submit a claim, potentially rescuing them from poverty in the event of a disaster.[46]	Blockchain	Importance to SDG Role of digital technologies Scalability
Blockchain and digital access are used to construct land registries and to verify legitimate land ownership records Digitising land records is a powerful way to reduce land rights disputes by legitimising land claims. Blockchain can store immutable and permanent records for land ownership and property exchanges.[47] This is significant in areas where land grabbing is common and public records are easily lost or subject to alteration.	**Example:** BenBen is a company building a land registry in Ghana to secure property rights. Traditionally, owing to a paper registry system that was unenforceable in court, Ghanaian land owners were unable to leverage their property for loans from banks or rely on the law to protect their property rights. BenBen and BigchainDB are using blockchain technology to build a land registry that records verifiable land transactions.[48] **Example:** The government of Pakistan's Punjab province embarked on a digital journey with the World Bank to transform how it managed land records. Manual bookkeeping was replaced by a digital system handled by 144 modern land record centres. Within five years, the project digitised all land records for over 55 million landowners across the province of Punjab, and made digitalised land title information easily accessible online. As a result, the time needed to complete a transaction dramatically decreased—from two months to just 50 minutes.	Blockchain	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Interaction with other SDGs

Eradicating poverty has wide-reaching implications for the other SDGs. The eradication of poverty will reduce inequalities (SDGs 5 and 10) and empower people to pursue economic opportunities.[49] Further, as poverty is reduced, the burden on basic needs and services will be reduced, as more people are able to gain access to food (SDG 2), health services (SDG 3) and education (SDG 4).[50]

The eradication of poverty, and improved access to basic services will also bring economic benefits. Poverty is a drain on society – the impact of poverty cost was calculated to cost the UK 4% of GDP in 2016.[51] Therefore, reducing the reliance of the global population on poverty will likely bring increases in economic growth and empower more people to find work (SDG 8).

Negative externalities

Negative impact of digital technology adoption on this SDG

Digital divide: As the global uptake of digital technologies continues, there is a risk that the so-called 'digital divide' will grow, leaving the unconnected and the poor behind. Those in poverty are often last to adopt digital technologies and so cannot share in the same benefits that the rest of the world enjoy. 10% of the world's population is not covered by mobile broadband[52] and still only 50% of individuals use the internet.[53] In cities, this may lead to further isolation of those relying on physical interactions and cash payments, who are often some of the most impoverished in society, e.g. the homeless and street vendors.[54] While the use cases described above can drive positive change, they still require at least basic levels of connectivity, which is still an issue for many in poverty.

'In-work' poverty: The rise of large multi-national technology companies, e.g. FANGs in the western world and BATs in China,[55] has created dominant, global organisations. While these and other companies are creating thousands of jobs, the challenge of 'in-work' poverty continues to grow.[56] In the five years after Amazon established fulfilment centres in San Bernardino – offering employment opportunities for the 15% of the population out of work – poverty rose by nearly 5%.[57] Recent calls for unionisation amongst Amazon workers have highlighted dehumanising working conditions.[58] As technology companies continue to consolidate their reach, displacing incumbent companies and jobs, there could be knock-on effects for local communities.

E-waste: In developing countries, between 400,000 and one million people die annually from diseases caused by mismanaged waste.[59] A proportion of this is attributable to e-waste, which is difficult to recycle and often abandoned in landfills.[60] The problems stemming from this are twofold. First, the toxic chemicals from e-waste can leak into soil and groundwater in the surrounding area, inhibiting agriculture and hampering access to basic services, e.g. drinking water and sanitation.[61] Second, it creates incentive for waste picking. While this provides employment for some members of the local community, it is dangerous and poorly paid. E-waste can exacerbate the poor standard of living for communities already suffering from poverty.

Rise of payday loan providers: Following the financial crisis of 2008, there was a rise in usage of 'payday loan' providers, particularly in the US and the UK. Online providers, e.g. Wonga in the UK, delivered money quickly and easily to users, who were struggling with their cash flow, through a short application process.[62] The ease of access to these lending sites through digital platforms has driven demand – 5.4 million payday loans were taken out in the UK in the year to June 2018.[63] However, the loan providers did (and in many cases still do) charge high interest rates, burdening families with heavy debts, closely linked to rises in poverty and inequality.[64]

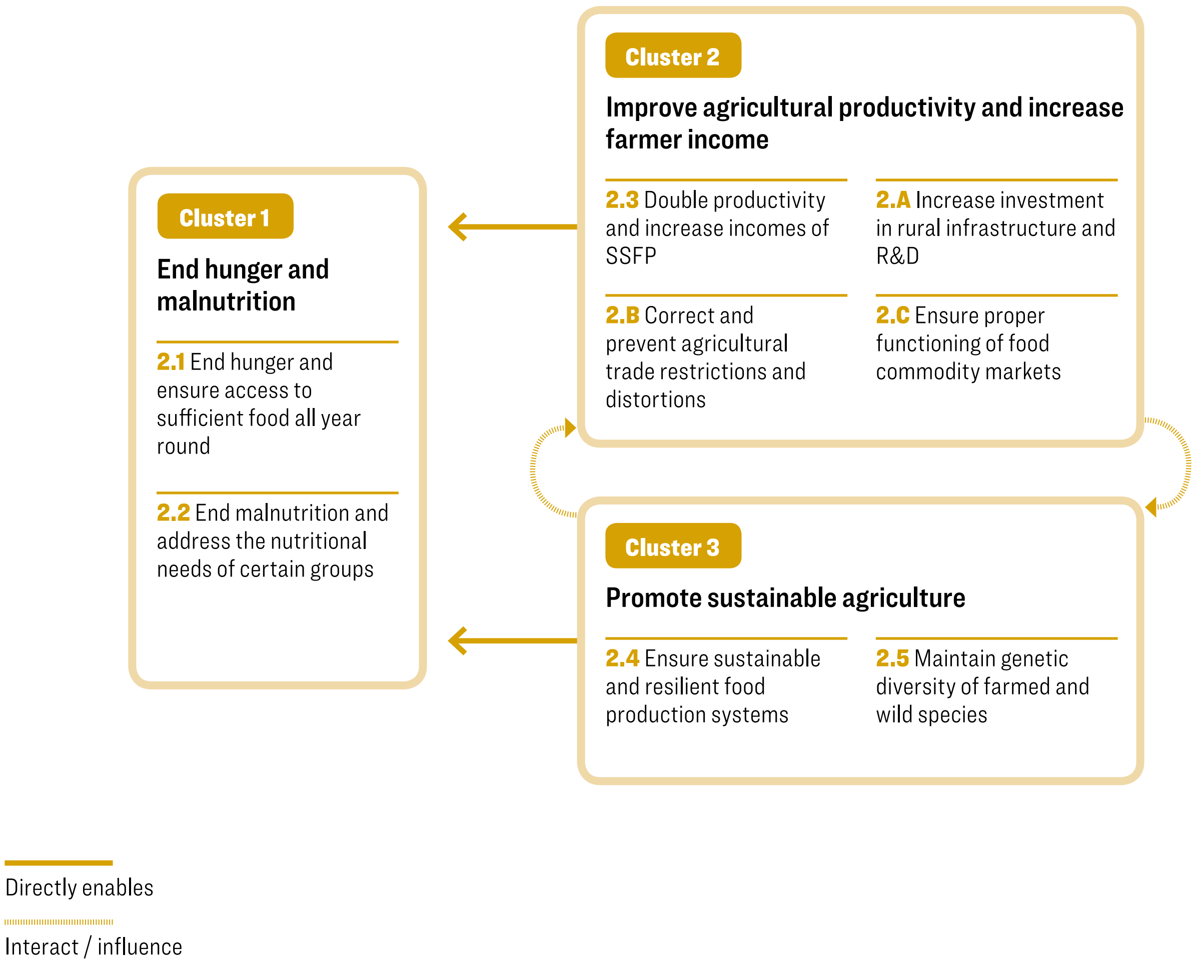
SDG 2 DEEP DIVE

Zero Hunger

Extreme hunger and malnutrition remain a key barrier to sustainable development and create a trap preventing people from participating fully in society and the economy.[1] SDG 2 aims to end hunger and malnutrition both directly and indirectly through ensuring increasingly productive and resilient food production systems and increasing the incomes of the small-scale food producers who provide up to 35% of food output globally,[2] and up to 80% of food output in developing countries.[3]

Since 2015, increases in conflict, drought and climate-change-induced disasters have caused world hunger to steadily rise, reversing a decade of progress.[4] This trend is predicted to continue, with the global number of people at risk of hunger projected to increase from 10% today to 20% by 2040.[5] Meanwhile, due to population increases, the global agricultural sector will need to feed an estimated two billion additional mouths by 2050, which would require a 70% increase in food production.[6] These challenges are further exacerbated by rapid land degradation and urbanisation, which has caused one third of arable land to become unproductive. Agriculture is also responsible for a large proportion of freshwater withdrawals and carbon emissions – with climate change in turn putting further pressure on remaining farmland as well as the natural resources farming depends upon.[7] In order to ensure nutritious food can be provided to all for generations to come, SDG 2 demands the world to quickly rethink the way food is grown, distributed and consumed – and digital technologies have the ability to catalyse this shift.

SDG 2 System



SDG 2 can be subdivided into three interrelated clusters that together embody the social, economic and environmental dimensions that must be achieved in order to eradicate hunger.[8] Core to the aim of SDG 2 is the social dimension, ending hunger and malnutrition in all forms (Cluster 1) which must be achieved through both the economic dimension of improving agricultural productivity and increasing farmer incomes (Cluster 2) and the environmental dimension of promoting sustainable agriculture (Cluster 3). Managing interdependencies will be key to SDG 2, as achieving food security and increasing productivity whilst concurrently ensuring food systems remain resilient and sustainable will be challenging to achieve.[9]

The role of digital technologies in delivering SDG 2

Digital technologies are necessary to steer global food production to a more productive and sustainable path – both through direct interventions, i.e. autonomous irrigation systems, and enabling interventions, i.e. improved understanding and utilisation of farm data. In developed countries, digital technologies are already transforming agribusiness, with autonomous farm equipment, robotics and artificial intelligence transforming the efficiency and productivity of farming activities. Digital platforms combined with IoT farm sensors and other data sources are able to monitor farm, weather and market conditions in real time, in order to provide data-driven insights to farmers to enable precision farming activities, saving resources and optimising yield. Such platforms also enable farm management software that leads to optimised business and operations management across the agricultural value chain. However, in developing countries, agriculture arguably remains the last remaining analogue industry, with farmers not yet benefitting from the digital technologies mentioned above and work remaining largely manual and tied to seasons. Though autonomous equipment and robotics are hard to afford for these small-scale food producers, other basic and enabling digital technologies will transform productivity. Internet connections and mobile platforms can accelerate the flow of information, connecting the once unconnected farmers to basic farming and pricing advice, as well as more personalised, AI-driven advice based on localised weather, satellite and market information. Digital access also connects farmers to digital marketplaces, credit, insurance and finance for farm inputs. Basic sensors enable farm condition monitoring in order to improve yields and enhance water-use efficiency. Digital technologies also have a role to play in reducing hunger and malnutrition directly, through education, R&D of nutrient-rich foods, and predictive targeting of areas at risk of hunger.

Whilst digital technologies are essential for achieving SDG 2, they must be supported by enabling policies and activities. For example, extending the use of digital technologies to rural areas will require investment in basic rural infrastructure, such as roads and electricity.[10] Policy and investment is needed to ensure quality farm inputs and machinery are available to all. In order to ensure agriculture remains sustainable as productivity increases, agroecology policies that take integrated approaches to farm, woodland and water management are required. Land management techniques such as crop rotation are also critical. Addressing hunger and malnutrition will also rely on enhanced efforts to end conflict, government policies and education, and co-ordinated efforts to reduce food price volatility.

Impact projection to 2030

Precision agriculture

The use of digital technologies in agriculture has the potential to drive productivity, ultimately increasing efficiency by reducing the number of inputs required per unit of output. The types of technology used in an agricultural setting will depend on the size of the farm and level of development, though the goal of increasing productivity is the same. For example, a smallholder farm in a developing country might rely on mobile phones and data access to provide basic information, whereas a large farm may implement IoT sensors and AI to monitor and automatically react to changes in crop health so as to optimise yields.

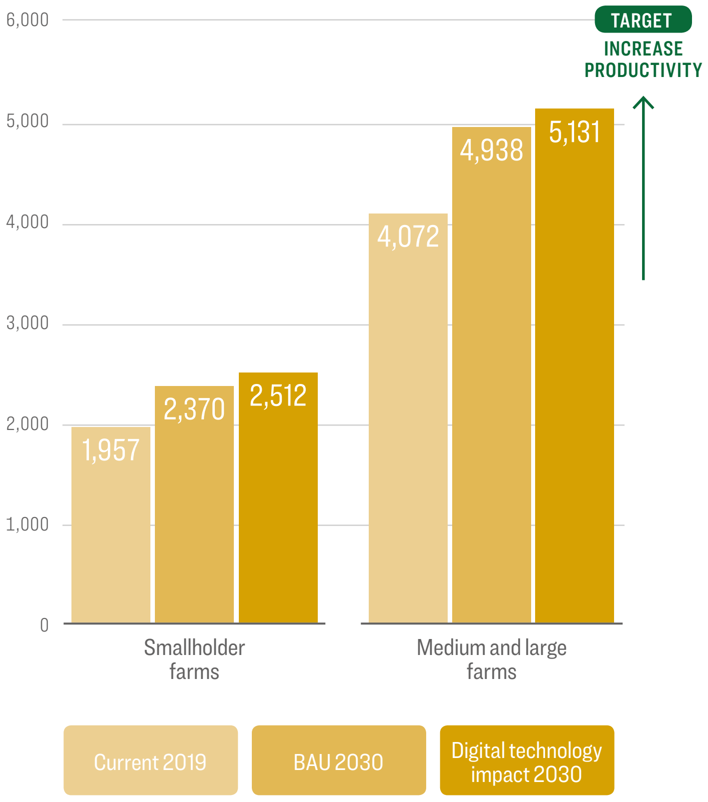
2.3 Double the agricultural productivity and incomes of small-scale food producers

Agricultural productivity has the potential to improve the incomes of many smallholder farmers, particularly in developing parts of the world. Cereal yields are an important measure of agricultural productivity: cereals make up around 45% of calories consumed per capita per day globally,[11] and include important crops such as maize, wheat and rice.

For smallholder farms, defined by the FAO as farms that operate an amount of land falling in the bottom 40% of the cumulative distribution of land size at national level, current cereal yields are around 1,957 kilograms/hectare (kg/ha). Comparatively, cereal yields for larger farms are estimated to be 4,072 kg/ha. It is expected that larger farms have higher yields than small farms, given that they are able to benefit from economies of scale.

Based on expected changes in production and harvested land area, global yields will increase to around 2,370 kg/ha for small farms and 4,938 kg/ha for large farms (around 22% growth each). Digital technologies to improve productivity could improve this to 2,512 kg/ha and 5,131 kg/ha for small farms and larger farms respectively, with the relative impact being greatest for small farms (6.0% vs. 3.9%).

Cereal yield (kilograms per hectare)



2.4 Ensure sustainable and resilient food production systems

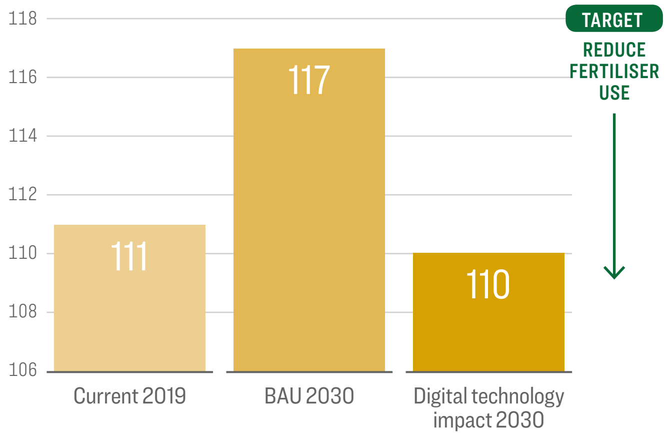
Nitrogen is vital to plants, but in excess can become a pollutant to both air and water. Currently, around 111 million tonnes of nutrient nitrogen are used globally on crop production in fertilisers. Historically, growth in the use of nitrogen nutrients in fertiliser has shown a strong positive correlation with crop production. If this trend continues with future crop production estimates made by the OECD and FAO, global use could increase to 117 million tonnes globally in 2030 (6% growth) under a business-as-usual scenario.

By increasing efficiency, digital technologies in agriculture are estimated to reduce this projection to 110 million tonnes under the same level of crop production, 1% less than current levels. As a result, CO2e emissions could be reduced by 0.05Gt in 2030 compared to the business-as-usual scenario.

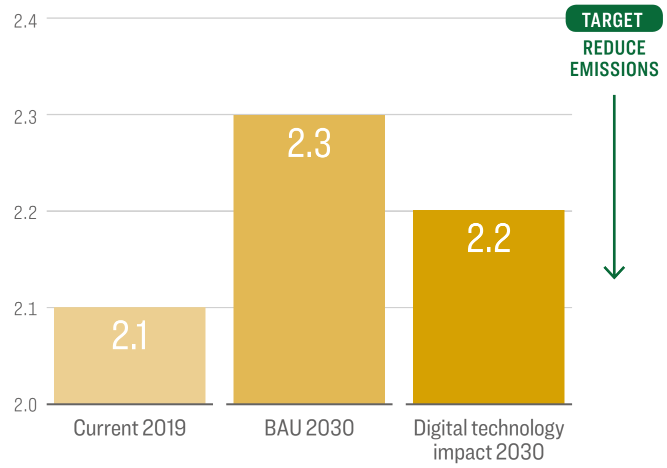
The digestive process of livestock, known as enteric fermentation, produces methane that currently equates to around 2.1Gt of CO2e per year globally. Digital technologies that enable the automated monitoring of livestock using connected sensors to alert farmers to changes could reduce the risk of disease and improve the efficiency with which meat is produced, ultimately reducing total emissions from enteric fermentation.

By 2030, under a business-as-usual scenario emissions from enteric fermentation could increase to 2.3Gt of CO2e per year globally due to increased production (10% increase). This estimate assumes that the animal mix will remain constant, i.e. production of chickens vs. cows will proportionately stay the same as current levels. Digital technologies could improve productive efficiency and reduce this figure to 2.2Gt of CO2e per year globally (5% reduction on the business-as-usual scenario), having a positive effect on the environment and improving the long-term sustainability of agriculture.

Synthetic fertiliser (nitrogen nutrient) use, million tonnes



GT CO2e from enteric fermentation



Importance of digital technologies to target attainment

	TARGET PRIORITISATION	DIGITAL TECHNOLOGIES INFLUENCE ON TARGETS	PROGRESS MARKER
1	**End hunger and malnutrition**		
🟧	**2.1:** End hunger and ensure access to sufficient food all year round	Digital technologies can assist with connecting food to those who need it, and in targeting areas of hunger. However, this target also requires policy coordination, conflict mitigation and improvement of physical food delivery, especially given that most of the world's hungry are in rural or conflict areas with limited digital connectivity.	🔴 ↗
🟧	**2.2:** End malnutrition and address the nutritional needs of certain groups	Digital technologies can disseminate information about proper nutrition, diagnose malnutrition and help develop nutrient-rich food. However, policy and aid coordination as mentioned above will be of high importance.	🟢 ↘ *
2	**Improve agricultural productivity and increase farmer income**		
🟩	**2.3:** Double productivity and increase incomes of small-scale food producers	Doubling agricultural productivity relies heavily on digital technologies and their ability to provide growing and weather advice to farmers, and monitor and optimise yield. Digital technologies will also play a role in improving farmers' incomes, through connecting them to finance and e-marketplaces.	🟢 ↗
⬜	**2.A:** Increase investment in rural infrastructure and R&D	Digital technologies will have impact through improving R&D, but more critical to achieving this target will be improving core infrastructure in rural areas, through increasing investment flows.	🔴 ↘
⬜	**2.B:** Correct and prevent agricultural trade restrictions and distortions	Digital technologies have limited direct impact on correcting and preventing agricultural trade restrictions and distortions.	N/A
⬜	**2.C:** Ensure proper functioning of food commodity markets	Digital technologies will be play an important role through increasing the availability of data, and through enabling better monitoring and prediction of food market fluctuations. However, proper functioning of food commodity markets overall cannot be achieved without the proper policy frameworks, governance and infrastructure.	🟠 →
3	**Promote sustainable agriculture**		
🟩	**2.4:** Ensure sustainable and resilient food production systems	Digital technologies have a substantial impact on disseminating information about sustainable farming, as well as monitoring and optimising sustainable farming practices.	N/A
🟧	**2.5:** Maintain genetic diversity of farmed and wild species	Digital technologies can help analyse and discover new gene varieties, and monitor current levels of genetic diversity. However, policy coordination and well-managed seed banks will also be key to enabling this target.	🟠 →

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

- 🟩 High impact
- 🟧 Moderate impact
- ⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

- 🟢 Positive progress
- 🟠 Limited progress
- 🔴 Negative progress

*NB – although stunting and malnourishment are going down, obesity is rapidly increasing

An estimated 821 million people – approximately one in nine people globally - go to bed hungry each night, 70% of whom live in rural areas and often depend on agriculture for their livelihoods.

Cluster 1

End hunger and malnutrition

An estimated 821 million people – approximately one in nine people globally - go to bed hungry each night,[12] 70% of whom live in rural areas and often depend on agriculture for their livelihoods.[13] Hunger is also intimately linked with conflict, with 60% of the world's hungry living in countries currently affected by the resulting disruption to both agriculture and trade.[14] In terms of malnourishment, stunting has been decreasing in nearly every region since 2000, although an estimated 149 million children were stunted in 2018 – three quarters of whom lived in countries affected by conflict.[15] Around the world, 49 million children under five were affected by wasting, and another 40 million were overweight.[16] Nutritious and healthy diets are intimately linked to health outcomes, with diet being the number one risk factor behind the global burden of disease,[17] and poor nutrition causing 45% of deaths in children under five.[18]

Digital technologies can connect individuals to humanitarian aid for food purchasing, and to tailored and general advice about nutrition and healthy eating habits. They can also enable medical professionals to more accurately and efficiently diagnose malnutrition, in order to improve treatment outcomes. Artificial intelligence and big data analysis can be applied to crop genes, to improve nutrient content in staple crops; or to historical conflict, drought and weather data, to predict areas of hunger and malnutrition and enable a faster, more effective and sustainable humanitarian response.

Hunger and malnutrition is a complex societal issue, interdependent with poverty and conflict and closely interlinked with education and health outcomes. Co-ordinated efforts to end hunger should include enhanced efforts to end conflict and forced migration, as well as the building of rural infrastructure, as energy, poverty and lack of transport infrastructure in many regions remain a fundamental barrier to reducing hunger and ensuring food availability.[19] Outside of ending conflict and investing in infrastructure, governmental actions including federal nutrition programmes, public education, food stamps and living wages will also play a role in ending hunger.[20] Removal of subsidies for unhealthy food and decreasing the prices of healthy food will also be important– as poverty and poor nutrition are closely interlinked – and prices of key food crops could increase by 50% to 120% as early as 2030.[21] Finally, ending hunger also relies heavily on ensuring enough food is produced and that food production systems remain resilient to climate change – which will be covered in Clusters 2 and 3.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile platforms quickly disseminate information about malnutrition and advice on eating habits Mobile phones can share nutritional information and education with hard-to-reach areas and groups. Information can be targeted, for example advice on micronutrient consumption for pregnant women; or general, for example advice on healthy eating, i.e. five a day, to reduce risk of obesity. Gamification can make engaging with healthy eating more engaging and memorable.	**Example:** One of the FAO's digital services mobile apps, "e-Nutrifood", aims to tackle undernutrition by providing quality information on production, conservation and consumption of nutritious foods, as many inhabitants of rural areas do not receive adequate information concerning the nutritional value of different foods.[22]	Digital Access	Importance to SDG Role of digital technologies Scalability
Digital platforms can connect those with food waste to food banks or charities, enabling wasted food to go to the hungry Around a third of all food produced is wasted or lost before it reaches the plates of those who need it.[23] Digital marketplaces, enabled through mobile and cloud platforms, have a large role to play in terms of connecting food that would otherwise be wasted to charities and food banks for the homeless and hungry, reducing both hunger and food waste at the same time. However, this use case is largely an urban phenomenon.	**Example:** Liberty Global's FoodCloud directs surplus food from retailers to local charities for distribution, collecting and sending data through SMS and/or its app (all stored on cloud network). In 2017, this resulted in 6,818 tonnes of food saved and donated to charities, and €20.45 million in savings for these charities, enabling them to feed more people.[24]	Digital Access Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

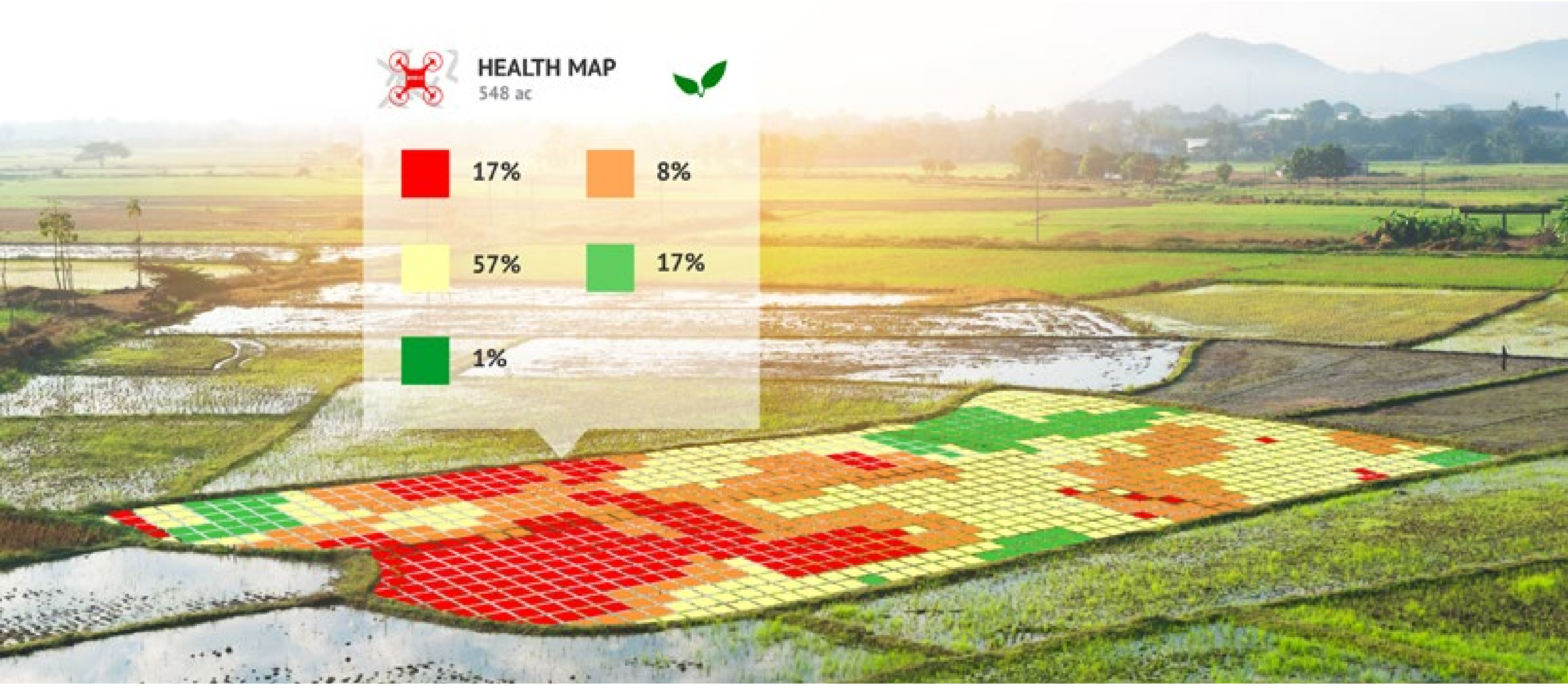
Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Blockchain enables fast, direct cash transfers to end beneficiaries, for the purchasing of food Research has shown that direct cash transfers to those in need can be the most efficient way to distribute humanitarian assistance for food purchasing. However, distributing cash directly depends on local financial institutions, who often impose high fees or operate through a complicated network of intermediaries. Blockchain offers a promising solution, as its distributed ledger technology is able to facilitate cash transfers directly to the beneficiary, reducing third party fees and protecting beneficiary data.[25]	**Example:** Building Blocks, a World Food Programme initiative, implemented blockchain technology in two refugee camps in Jordan in 2017. The technology enabled 100,000 refugees to purchase groceries by scanning an iris at checkout, instead of paying for food with easily losable food vouchers. This eliminates up to 98% of the pre-existing financial transaction fees, and helps the WFP feed more people, more securely.[26]	Blockchain	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Rapid data analysis enables discovery, engineering and introduction of nutrient-rich staple crops Five crops – rice, wheat, maize, millet and sorghum – provide about 60% of human food energy needs. However, they lack the full range of nutrients and vitamins needed for healthy development. Rapid data analysis of genes to identify nutrient producing genes, combined with biotechnology techniques such as CRSPR (gene splicing and editing) can enable these crops to be mutated with nutrient-rich genes, causing the overall nutrient content in crops to increase.	**Example:** Vitamin A deficiency is a significant public health problem, and is particularly severe in populations where white rice is the staple food, as white rice contains no micronutrients. The Golden Rice Project used gene scanning, as well as bio engineering techniques, to insert beta carotene, a Vitamin A producing carotene, into white rice. This resulted in Vitamin A rich "Golden" rice, which will soon be released to populations that need it.[27]	Cognitive	Importance to SDG Role of digital technologies Scalability
Artificial intelligence enables faster and more accurate diagnosis and optimised treatment of malnutrition Apps, especially those which analyse images of the patient, can improve doctors' diagnoses of wasting and stunting, enabling faster treatment of malnutrition.	**Example:** Child Growth Monitor is a project bringing together Welthungerhilfe, a German private aid organisation, and Microsoft to help address malnutrition amongst children. They have developed an AI-powered smartphone app that can scan children (height, body volume and weight ratio, as well as arm circumference) and instantly detect malnutrition.[28]	Digital Access Cognitive Cloud	Importance to SDG Role of digital technologies Scalability
Satellite imagery analysis and AI analysis can be used to identify, predict and target areas of malnutrition Modelling can be applied to data such as historic drought or conflict data, as well as current food price and food stock data in order to predict emerging areas of malnutrition or hunger, and pre-plan or target necessary humanitarian efforts.	**Example:** The World Food Program manages the Vulnerability Analysis and Mapping system, which analyses satellite data to gauge rainfall and vegetation and assess the food needs in communities. The system also offers interactive visualisations of food price information to inform assistance efforts. This enables faster identifications and targeting of areas with increased food aid needs.[29]	Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher



Cluster 2

Improve agricultural productivity and increase farmer income

Improving agricultural productivity is an essential component of eradicating hunger and achieving sustainable development. Agricultural productivity has been increasing steadily year on year, with a global value add per worker of $3,540 in 2016, compared to $1,410 in 1991.[30] However, with available farm acreage estimated to increase by just an additional 4% from now until 2050, simply expanding farmland to plant more crops or raise more livestock will not be an option.[31] Rather, it is estimated that 80% of the needed agricultural output growth will come from improved productivity, as opposed to expanding farmland.[32]

Improving rural people's livelihoods and small-scale food producers' incomes is also central to ending hunger and promoting sustainable agriculture.[33] Agriculture is the single largest employer in the world, providing livelihoods to 40% of the global population and is the single largest source of income and employment for poor rural households.[34] Small-scale farms also make up a significant 88% of the 570 million farms globally, and produce a significant amount of global food output.[35]

Digital technologies can improve farmer income by connecting farmers to digital agricultural marketplaces, where farmers can purchase farm inputs and sell their crops, as well as receive reliable pricing information. They can also help farmers gain easier access to credit, through faster and more secure determination of credit risk. Digital technologies can increase agricultural yield by communicating basic advice to farmers via mobile platforms. Digital platforms can further combine farm level IoT sensors with other datasets, enabling targeted advice on planting etc. to farmers in order to maximise yield. Finally, autonomous machines can vastly improve farm productivity, by their ability to, unlike a farmer, work on multiple fields at once as well as through the night and through key seasons, such as harvest time.

Aside from digital technologies, rural infrastructure, improved access to resources and securing of farm land rights will also improve productivity and incomes. For example, roads are essential for the transportation of farm goods and for connections to markets, and electricity is often essential for the operation of the aforementioned digital technologies, even for simple activities such as charging a mobile phone.[36] Without extensive investments in basic rural infrastructure, the world's chief food producers are hindered from fully participating in the local economy and digital economy.[37] It should also be ensured that small-scale farmers are provided with the resources they need, such as affordable, quality seeds and farming equipment. Setting prices and leasing equipment through networks of producers' organisations or farming cooperatives have been proven to increase farmer yield.[38] For example, the FAO developed financial instruments to target producers' organisations in Niger, enabling them to provide well-priced inputs through their local cooperative network to over half of the agricultural villages in Niger, and increasing sorghum and millet yields by 100 and 81% respectively.[39] Finally, government policy interventions, such as titling land and tenure rights to women and indigenous farmers, and multilevel coordination of food prices through price controls and buffer-stock policies, will also be important.[40]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile platforms connect farmers to education and advice on how to improve yield Distributing agricultural knowledge and advice to remote rural areas can be costly. Mobile platforms are able to deliver such advice and training in a more effective and efficient manner, and have been found to improve farmer knowledge and yield as a result. Mobile platforms can also give farmers access to social networking platforms, where farmers can share experiences and learn from each other.[41] A study in Kenya found that sending SMSs with agricultural advice to smallholder farmers increased yields by 11.5% relative to the control group.	**Example:** In Tanzania, The International Fund for Agricultural Development (IFAD) used mobile phones and emails to provide rural farmers with information and advice, as well as connections to others in the market chain. After one agricultural season, the initial investment of $200,000 contributed to a gross increase in income of participants of more than $1.8 million.[42]	Digital Access	Importance to SDG Role of digital technologies Scalability
Mobile platforms can enable farmers to share and aggregate food deliveries, improving efficiency of first mile delivery The "first mile" of agriculture refers to the stage where farmed good are delivered to local markets. In developing countries, the first mile is often expensive and time-consuming for small-scale farmers, who deal in low volumes, lack adequate, up-to-date information on pricing, and often live far from marketplaces.[43] Mobile platforms offer an opportunity for farmers to drive efficiencies in first mile deliveries, by aggregating and sharing transport, or connecting farmers to closer wholesale buyers instead of further away markets. This improves incomes of small-scale food producers.	**Example:** Digital Green's Loop is a mobile phone application that improves Indian smallholder farmers' access to markets by aggregating their produce via transporters already working in or near those communities. Transporters collect and take the aggregated goods to wholesale buyers or markets. Digital receipts ensure farmers receive the correct amount for their goods. The app reduces costs and improves market access for farmers, and reduces opportunity costs by saving farmers 4-8 hours of time per market trip, and overall helping 3000 farmers sell over $1 million worth of vegetables.[44]	Digital Access	Importance to SDG Role of digital technologies Scalability
Mobile platforms connect remote communities (buyers and sellers) to digital agricultural marketplaces Digital technologies are helping to grow agricultural marketplaces from physical, to physical and digital. Thanks to digital access, remote, rural farmers are actively participating in the economy they were once excluded from.[45] Digital agricultural marketplaces can enable access to insurance and financing, and purchasing or leasing of farm equipment and inputs that help improve farm productivity. They can also allow farmers to buy and sell products more easily and at better prices, thus increasing the income of farmers.[46] Farmers can also access timely and reliable information, going from being dependent on the information provided by middlemen to being independent negotiators and dealmakers.[47]	**Example:** A consortium of private and public sector organisations have launched the Patient Procurement Platform (PPP), a digital platform offering high-quality seeds, other inputs, insurance and financing and access to a reliable market. Over the next three years, PPP aims to engage 1.5 million farmers across 25 countries with $750 million worth of local and international buying contracts.[48] **Example:** Produce Pay is an online platform which provides next-day payments for up to 80% of produce shipped, and has so far financed 250+ farmers and distributors.[49]	Digital Access Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Mobile platforms connect farmers faster to micro-credit and loans Many small-scale farmers lack access to traditional and reliable credit, with the global demand for smallholder finance estimated at $450 billion, compared to the current global supply of $20-30 billion. However, mobile platforms can enable faster access to credit and other financial services.[50]	**Example:** The Grameen Foundation is developing digital solutions to smallholder financing. In Kenya, they worked with Musoni, a 100% cashless microfinance institution, to develop Kilimo Booster: a mobile-based agricultural loan designed for smallholder farmers. Kilimo Booster enables loans to appear in farmer's accounts within 72 hours and offers flexible repayment terms corresponding to harvest cycles. In three years, $2.2 million worth of loans have already been distributed.[51]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT sensors or cameras monitor farm data in real time to enable precision farming activities that optimise yield IoT sensors are able to monitor various environmental conditions, such as water, soil nutrient levels, crop health etc. in real time. Data gathered can be transmitted to mobile or cloud platforms, where farmers can use the data to ascertain the exact amount of water, fertiliser or other input to apply to their crops in order to optimise crop yield.	**Example:** Bell and the University of Manitoba have launched an IoT in Agriculture initiative focused on finding ways to improve food production through managing the location and performance of farm machinery, remote analysis of soil samples, field conditions, seeding rate and crop health, and monitoring of storage and processing operations.[52]	IoT Digital Access	Importance to SDG Role of digital technologies Scalability
IoT sensors can also monitor farm animal health to improve productivity IoT sensors monitor the health conditions of livestock, alerting farmers to changes, reducing risk of disease and improving productivity and efficiency of meat production. This also ultimately reduces total emissions from enteric fermentation.	**Example:** In Germany, Deutsche Telekom's "Cow that texts the farmer" solution involves sensors on farm animals, that are able to send SMS alerts to farmers if the animal is in labour or heat, or if their health changes. This solution results in faster insemination of the cows, leading to greater livestock product through time and cost savings and more live births.[53]	IoT Digital Access	Importance to SDG Role of digital technologies Scalability
Blockchain has the potential to increase farmer's access to financial risk protection for crop failure Millions of smallholder farmers remain unprotected against financial and agricultural risk. Smallholder farmers in Africa are particularly vulnerable to drought induced crop failure – and sometimes remain uninsured as insurance tends to insure the event (drought) rather than the crop failure itself.[54] Blockchain has the potential to be used to provide secure and low-cost insurance for crop failure.	**Example:** ICS, a Dutch NGO, Agrica, an east African social enterprise serving 30,000 farmers in three African countries and EARS, a remote sensing company with experience implementing drought index insurance solutions, are researching the development of a low-cost drought-index insurance product supported by blockchain. Predicted impact is that blockchain will enable cost reduction and automation of insurance and payment processes, thus reducing the complexity of the chain.[55]	Blockchain	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Rapid data analysis enables discovery, engineering and introduction of crops that can produce higher yields Machine learning, big data analytics and cloud computing come together to rapidly scan crop genes, in order to identify new genes and mutations that cause crops to produce higher yields. These varieties can then be engineered and introduced, thus boosting overall productivity per acre.	**Example:** Benson Hill Biosystems is a biotech that uses big data analytics and cloud computing to improve the productivity and quality of crops, in order to feed the world's growing population. Their crop design platform, CropOS^{TM} has three applications: reveal, breed, and edit. Reveal is a data scanning tool that identifies and designs novel genes that could make crops healthier and more productive. Breed combines proprietary and public data with machine learning to predict crop varieties that will, for example, produce a higher yield. Edit leverages cloud-based machine learning to create a genome editing system designed specifically for crop improvement.[56]	Cognitive Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Centralised digital platforms analyse agronomic data to provide tailored advice to farmers to optimise productivity Digital platforms can gather agronomic data from precision monitoring technology and IoT sensors, weather stations, farm machinery and other sources. They then can conduct rapid and detailed analyses on this data, to provide farmers with more tailored and precise advice on yield improvement.[57] A study of 3,380 American farmers found that those implementing data-driven precision farming techniques reported an average cost reduction of 15% and an increase in average yields of 13%.[58]	**Example:** HPCC Systems partnered with Proagrica to create a scalable and secure farmer platform able to consume, consolidate and analyse big data from any source: from soil and animal sensors to satellites. The platform is able to provide real-time insights to help farmer to changes react quickly, forecast productivity effectively, and maximise profits and yields.[59]	Cognitive IoT Cloud	Importance to SDG Role of digital technologies Scalability
Predictive models analyse various forms of data to predict future trends, and offer forward-looking advice Models can analyse historical crop yield and market data to predict trends and provide specific, forward-looking advice to improve practices and yield.	**Example:** aWhere, a Colorado-based B Corporation, leverages elegant 3D curvilinear functions, ground station observations, and satellite observation to create over 1.7 million complete daily 'virtual' weather stations across the earth at a resolution of five arc-minutes (nine km). aWhere then uses many algorithms including machine learning to forecast production, monitor disease, and analyse in-time opportunities in order to advise farmers, help adapt to weather variability, and increase yields and profits (increase economic resilience). aWhere also monitors details of the growing conditions for all cropping areas around the world, which helps analysts across all segments of each agricultural value chain foresee price volatility and respond accordingly. Although aWhere monitors growing regions throughout the world, their platform is able to deliver localised information.[60]	Cognitive Cloud	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT and AI-enabled autonomous machines react automatically to changes in crop and soil health to optimise crop yield Tractors, combines, and other mechanisation technologies have long been used for farming activities. However, advanced farm management tech and innovations such as self-driving tractors or harvesters are transforming farm productivity in new ways, 24/7, and bring the world closer to almost fully automated farm management. Automated IoT sensors can also react to changes in crop health with no need for farmer intervention, thus optimising resource-efficiency and boosting yield.	**Example:** Deutsche Telekom's Telematics on the Farm solution autonomously enhances the coordination of farm vehicles. Status information about all connected agricultural machines is transmitted to the cloud in real time and is then logically linked and analysed on a central web platform.[61] The platform collates and analyses fleet data, and automatically sets fleets on the quickest routes, avoiding unneeded fleet movements and protecting the farmland. This solution can boost productivity by up to 15% resulting from reduced fuel consumption, associated CO2 reduction, more efficient deployment of machinery, quicker harvesting and larger yields.[62]	IoT Cloud Cognitive Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 3

Promote sustainable agriculture

Sustainable agricultural practices can contribute to the overall health of the biosphere and play an important role in climate adaptation and mitigation around the world.[63] However, increased agricultural production and productivity, if not sustainable, can result in land degradation, reduction in biodiversity, freshwater withdrawals, water pollution and overall increased climate vulnerability, putting long-term food security in jeopardy.[64] Currently, the trend in agriculture is towards unsustainability. Since the 1900s, some 75% of crop diversity has been lost from farmers' fields, with just 30 crops now providing 95% of human food and energy needs.[65] Agriculture accounts for 70% of all water withdrawals, often up to 95% in some developing countries.[66] Global nitrogen fertiliser usage has increased by 800% over the past few decades, and large amounts now move into aquatic ecosystems.[67] Agriculture is also responsible for a huge share of global greenhouse gas emissions, with today's food system responsible for 20-30% of global carbon emissions.[68] Agriculture is also particularly vulnerable to climate- and weather-related disasters, which are increasing in frequency due to the acceleration of climate change, and so the adaptive capacity of farmers should be improved.

Digital technologies can communicate advice on sustainable farming practices, as well as alerts on upcoming weather events. They can also enable monitoring of biodiversity in and around farmland on a large scale, as well as monitoring of conditions on a single farm or even by crop on a smaller scale. Big data analysis and predictive modelling can inform farmers about current or future climatic events, improving farmers' adaptive capacity to such events. Finally, autonomous farm machinery, operational both on traditional farms or in vertical, indoor farms, can optimise resource-use efficiency, thus reducing the overall impact of farming on the biosphere.

Many land management techniques can also be implemented to improve resilience of agricultural systems, and limit agriculture's negative impacts on the biosphere. For example, crop rotation and enhancing organic matter in soil conserves biodiversity, improves soil health and reduces potential damage of exposure to pests, diseases or climate events.[69] Similarly, agroecology policies, which are cross-sector approaches that integrate crops, trees, livestock and fishery management to enhance biological synergies and resource-use efficiency, are a growing resilience and climate adaption method. Over 30 countries have already developed public policies that support agroecology.[70] Effective water management policies will be essential to allocate water amongst competing sectors, namely agriculture, mining, industry and cities.[71] Digital technologies can monitor the impact and implementation of these policies, and in some cases have direct impact in operationalising them, for example, water-use policies.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile platforms connect farmers to education and advice on sustainable farming practices Similarly to above, mobile platforms are able to deliver advice and training on sustainable farming practices in a low-cost way. Weather alerts and advice can also be distributed via mobile platforms, in order to strengthen farmer's adaptive capacity to such events.	**Example:** FAO is developing Early Warning and Early Action services, and Weather and Climate Services for Agriculture and Food Security through using mobile applications to disseminate warnings and sustainable farming advice to farmers, to build up climate change resilience and adaptive capacities.[72]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT sensors and satellite imagery analysis can monitor the biodiversity of farm areas to ensure threats are prevented Digital technologies can monitor the biodiversity of plants and animals in and near agricultural areas, in order to identify plants or animals at risk of extinction, for example. Farmers and governments can use this information to quickly respond to such biodiversity threats.	**Example:** EMPRES – The Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases, analyses satellite imagery to monitor desert locust swarms migration and warn rural populations in Africa and Asia to avoid infestations of these insects, which threaten agriculture and biodiversity. The Event Mobile Application provides animal disease reporting and early warnings of disease outbreaks to relevant local authorities.[73]	IoT Cognitive	Importance to SDG Role of digital technologies Scalability
IoT sensors or smartphone cameras monitor farm data, and enable precision farming activities and conservation of resources Sensors and smartphone cameras can monitor a variety of crop, soil and environmental data parameters and relay levels back to farmers. This in turn enables precision farming activity, which optimises the use of resources such as pesticides, fertiliser, energy and water; and improves overall sustainability of farming.	**Example:** AgTech company Yara launched YaraIrix, a smartphone tool for precision farming. YaraIrix measures chlorophyll levels using a smartphone camera combined with one of two hardware devices. This enables precise measurements of the nitrogen needs of crops and makes it easier for farmers to apply the correct amount of fertiliser, reducing overall amount of fertiliser applied.[74]	IoT Cognitive Digital Access	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Rapid data analysis enables discovery and introduction of crops more resilient to climatic events, such as droughts or floods As mentioned above, machine learning, big data analytics and cloud computing can also come together to rapidly scan crop genes, in order to identify new genes that have the potential to improve resilience to climatic events.	**Example:** Phytoform labs uses gene scanning, gene editing and automated laboratory practice to deliver new, natural plant varieties that are able to withstand varied climate conditions and disease.[75]	Cognitive	Importance to SDG Role of digital technologies Scalability
Centralised digital platforms analyse crop, weather and pest occurrence in real time in order to alert farmers to issues Digital platforms can gather agronomic data from IoT sensors and weather stations. They then can conduct rapid and detailed analyses on this data, to provide farmers with more tailored and geographically specific advice and weather alerts in order to improve farmers' resilience to climatic events.[76]	**Example:** Zenvus, a Nigeria-based precision farming firm, has created an intelligent sensory system with a digital platform that measures and analyses soil and farm data like temperature, nutrients, and vegetative health to help farmers apply the right fertiliser and optimally irrigate their farms, reducing input waste and improving the sustainability of farms.[77]	Cognitive IoT Cloud	Importance to SDG Role of digital technologies Scalability

Lower ■■■■■ Higher

Predictive models analyse weather and satellite data to predict future weather events and offer advice for risk mitigation Digital technologies are able to collate trends from historical weather in order to predict future weather events and provide forward-looking advice to farmers to strengthen adaptive capacity to possible future events. They are also able to analyse satellite data on farmland, and predict the expected crop yield, factoring in weather, soil and natural disaster data and predictions. These predictions can enable farmers affected by climate disasters to receive insurance payouts faster, improving their resilience and adaptive capacity to climate change.[78]	**Example:** The CGIAR Platform is leveraging massive amounts of big data combined with innovative computational analysis to create AI systems that can predict the potential outcomes of future scenarios for farmers, in order to share critical insights back to farmers to help them increase their efficiency and reduce risks of yield loss due to climatic events. Much of the work done by CGIAR focuses on smallholder farmers in the developing world, and thus contributes directly to this cluster. For example, they told Colombian rice planters to delay planting due to predicted weather scenarios, and those that did delay planting were able to avoid torrential rains that would have destroyed their crop and affected their incomes.[79]	Cognitive Cloud	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT and AI-enabled autonomous machines optimise resource-use efficiency in farming Autonomous farming combines IoT farm sensors, automated farm equipment, image recognition and machine learning algorithms. Together, these functions deliver precision farming and automated farming techniques, i.e. irrigation, which drastically reduce water, energy, fertiliser and pesticide usage and optimise resource-use efficiency.[80]	**Example:** AT&T's PrecisionKing IoT solution connects water-level sensors to water pumps, to enable automated irrigation in rice paddies. The sensors are placed across farmers' fields where they monitor water levels every hour, 24 hours a day. The sensor data is transmitted to a management system that can be programmed with customised parameters to automatically signal the pumps to turn on or off. This technology has the potential to save 80,000 US gallons of water and 0.28 metric tons of CO2 per acre of farm land.[81] **On a more fully autonomous scale,** Small Robot Company applies robotics and AI to farming, using small robots for various farming activities such as seeding and weeding. The efficient, autonomous robots reduce farm emissions by 90% and chemical usage by 95%.[82]	IoT Cloud Cognitive Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability
Indoor, vertical farming optimises space and resource utilisation, and is less vulnerable to climate change Indoor farms cultivate plant or animal life, often vertically, indoors, in order to remove the risk of exposure to unpredictable weather events, and optimise exposure to "sunlight" and other factors needed for growth. Similarly to what can occur outdoors, IoT sensors can measure water and nutrient levels, causing automated systems to react with needed water or nutrients. Produce can also be harvested by machines. Vertical /indoor farming has been cited as a more sustainable alternative to outdoor farming, due to lower water usage per kg of food, higher crop yield per square metre, and reduced need for transportation from rural to urban areas.[83]	**Example:** Huawei has applied digital technologies to smart, indoor greenhouse operations, which increase irrigation efficiency by 70%, lower labour costs by 90% and improves overall farm efficiency by 60%.[84]	IoT Cloud Cognitive Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Digital technologies are necessary to steer global food production to a more productive and sustainable path.

Interaction with other SDGs

Ending hunger and malnutrition is integrally linked to achieving other society-focused SDGs, such as ending poverty (SDG 1) and ending conflict (SDG 16). Ending hunger and malnutrition will have a positive effect on reducing maternal mortality and deaths in children under five, as well as on reducing obesity and non-communicable diseases associated with poor nutrition, all targets encompassed within SDG 3.[85]

Increasing agricultural productivity and farmer incomes will have a profound effect on reducing poverty (SDG 1) as well as hunger, as extreme poverty and hunger is predominantly rural, and smallholder farmers and their families make up a very significant proportion of the poor and hungry.[86] It will have positive reinforcements on inclusive economic growth (SDG 8 & 10), as agriculture represents almost 50% of total employment in poor countries,[87] and on reduction of gender and other inequalities (SDG 5 and 10), as many small-scale food producers are women, indigenous people or other marginalised groups. However, boosting agricultural productivity, if done in an unsustainable way has the potential to negatively impact all of the biosphere-related SDGs and jeopardise long-term food security, by accelerating deforestation and land conversion (SDG 15), increasing freshwater withdrawals (SDG 6), increasing nitrogen fertiliser runoffs and ocean eutrophication (SDG 14) and increasing carbon emissions (SDG 13).[88]

It is therefore critical that SDG2 is delivered sustainably. Sustainable agricultural practices can contribute to terrestrial ecosystem health and biodiversity (SDG 15).[89] They can also limit marine and nutrient pollution (SDG 14) and reduce freshwater scarcity (SDG 6) and emissions (SDG 13).[90] Resilience of agricultural systems can also impact societal SDGs, through reducing climate-induced food shortages that in turn reduces conflict (SDG 16), improves resilience of the poor to natural disasters (SDG 1), and reduces health problems caused by soil and water quality issues (SDG 3).[91]

Negative externalities

Impact of widespread use of digital technologies on achievement of SDG 2

Sector decline: The digital revolution has caused younger generations of farmers to become enticed by new technologies and more modern sectors. Many “will work with their mobile phones, computers and/or iPads, but they will not pick up the hoe or machete of their fathers and mothers”.[92] Therefore, if agriculture remains analogue in developing countries, many younger generations might leave their family farms for more modern work in cities, putting farm labour in crisis.[93]

Water and land contamination: Increased demand for digital technologies in general leads to increased mining of the metals and minerals that the technologies rely on, such as cobalt. Mining has well-known effects and implications on agriculture. For example, the growth of mines increases tensions over control of land and water, which increases conflict and disrupts food supply chains.[94] Mining also generates significant negative externalities, such as water pollution, which can permanently render agricultural land infertile.[95]

Impact of using digital technologies to achieve SDG 2

Inequalities: The uptake of digital technologies within agriculture is currently uneven, as education, healthcare and basic infrastructure are often more important to developing countries than sophisticated agricultural technologies[96]; and this uneven uptake is negatively affecting agriculture. The adoption of automation and analytical technologies has largely only been witnessed on large, developed country farms, rendering them more productive and able to price out smaller farms, in both developed and developing countries, whose incomes are then also affected.[97] Autonomous farms and farm machinery could also have negative consequences for rural livelihoods, if rural people lose jobs to such machines and are unable to gain employment in new, unfamiliar sectors.[98]

Harm to the biosphere: Agriculture already has a large impact on the biosphere SDGs, for example, as a leading cause of freshwater withdrawals and land conversion. Digital technologies have the potential to mitigate such environmental impacts, yet the adoption of digital technologies themselves can have additional negative implications, both on the biosphere SDGs in terms of increased emissions and energy usage, and on society, in terms of widening inequalities.[99]

3 GOOD HEALTH
AND WELL-BEING

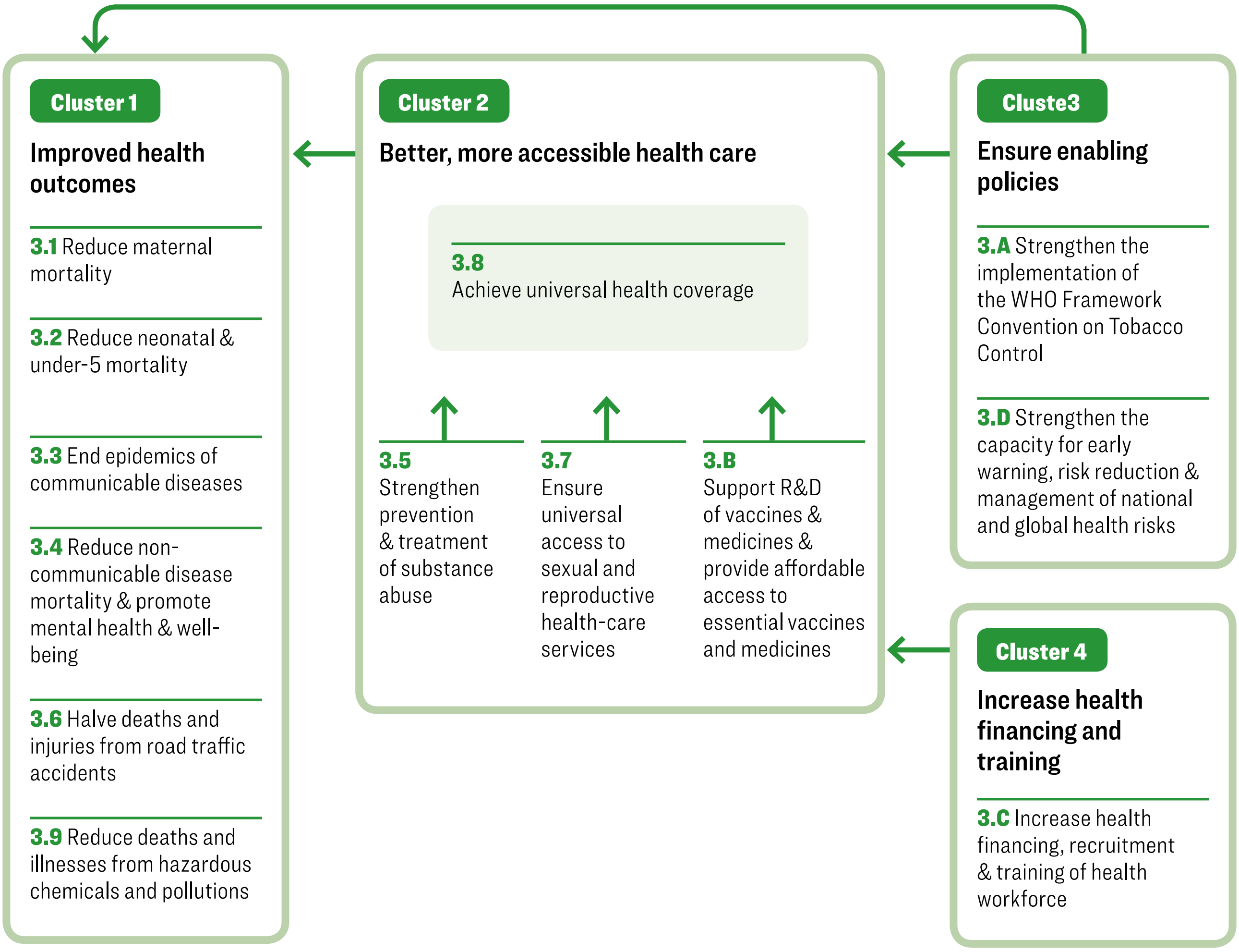
SDG 3 DEEP DIVE

Good Health and Well-Being

SDG 3 seeks to ensure health and promote well-being for all at every stage of life. The goal aims to achieve this by improving health outcomes, ensuring better and more accessible health care and increasing health financing. Eradicating a wide range of diseases and addressing both persistent and emerging health issues are critical to the attainment of this goal.

Healthy people are the foundation for healthy economies, thriving societies and sustainable development.[1] According to Jeffrey Sachs, “well-being should be of paramount concern for all of society, engaging government, companies, schools, health care systems and other sectors of society,”[2] given that “the topic of well-being is essentially a topic of what’s important”.[3]

SDG 3 System



Cluster 1

Improved health outcomes

3.1 Reduce maternal mortality

3.2 Reduce neonatal & under-5 mortality

3.3 End epidemics of communicable diseases

3.4 Reduce non-communicable disease mortality & promote mental health & well-being

3.6 Halve deaths and injuries from road traffic accidents

3.9 Reduce deaths and illnesses from hazardous chemicals and pollutions

Cluster 2

Better, more accessible health care

3.8 Achieve universal health coverage

3.5 Strengthen prevention & treatment of substance abuse

3.7 Ensure universal access to sexual and reproductive health-care services

3.B Support R&D of vaccines & medicines & provide affordable access to essential vaccines and medicines

Cluste3

Ensure enabling policies

3.A Strengthen the implementation of the WHO Framework Convention on Tobacco Control

3.D Strengthen the capacity for early warning, risk reduction & management of national and global health risks

Cluster 4

Increase health financing and training

3.C Increase health financing, recruitment & training of health workforce

Improving health outcomes (Cluster 1) can be achieved through better and more accessible health care (Cluster 2) which relies upon the provision of universal health coverage as well as specific key services. Ensuring enabling policies (Cluster 3) enables better and more accessible health care and contributes to better health outcomes. Better and more accessible health care is also enabled by increased health financing and training of the health workforce (Cluster 4).

The role of digital technologies to deliver SDG 3

Digital technologies play a crucial role in achieving SDG 3.There are many low-cost digital solutions which have already been deployed and show potential for further scalability. For example, greater digital access helps to connect individuals through new channels of communication, improving access to health care professional advice, diagnoses and support. Digital access also connects researchers, enabling the discovery of new drugs, vaccines and interventions, such as lifestyle changes, for treating communicable and non-communicable diseases. Connected devices increase patient-provider connectivity and communication, allowing health care to be accessed and delivered in new ways, especially in geographies where there is a shortage of health professionals in the population.

The use of digital technologies to achieve SDG 3 also relies on future-looking, cutting-edge innovations. For instance, health care providers are able to monitor and track the supply of medicines and vaccines through the processing of real-time data, which can drive better health care outcomes and care coverage. The rise of digital technologies, with the power of the cloud being critical, has led to data-enabled interventions where AI can analyse specific patient- and disease data, producing tailored insight, prescription and even intervention. Whilst some nascent technologies which show great transformative potential have yet to prove their impact and scalability in both the developed and developing world, with the right digital infrastructure and policies, they have the capacity to become mainstream and disrupt health care systems worldwide to deliver real impact. It should also be noted that digital technologies support social enablers such as quality education, improved sanitation and informed lifestyle choices which are also important determinants of health.[4]

Achieving SDG 3 is also dependent upon coherent policy, public finance support and effective governance. In 2013 the WHO put forward a new approach called 'Health in All Policies' [5] to encourage health to be considered in all policy decisions. This promotes strong and effective whole-of-government, multi-sectoral, and multi-stakeholder partnerships which have the potential to play an important role in achieving SDG 3.

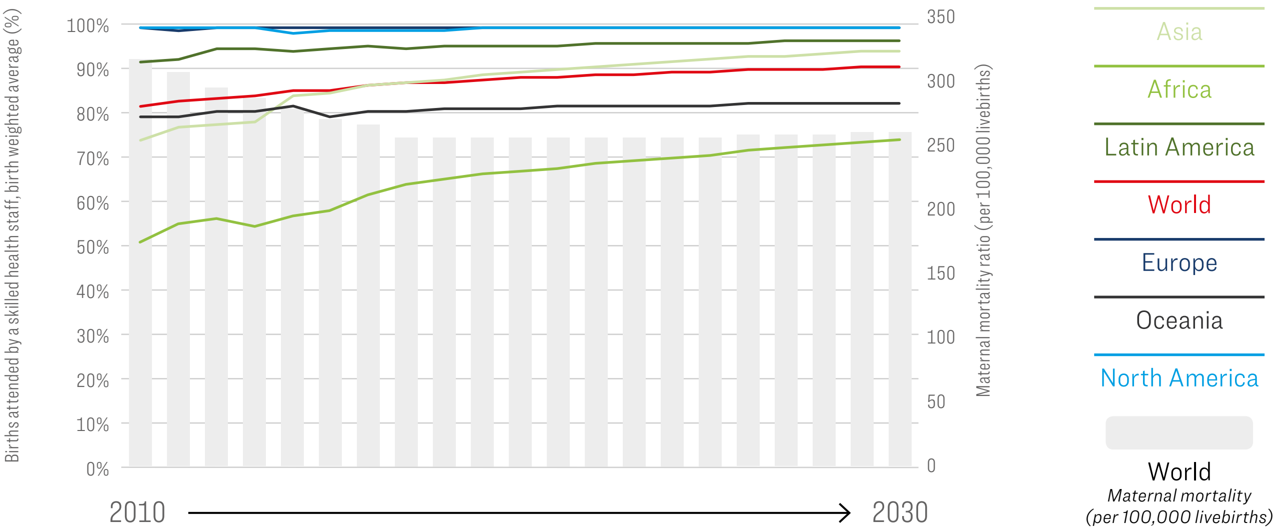
Impact projections to 2030

3.1 Reduce maternal mortality

Births attended by a skilled health assistant, who provides obstetric care, advice during pregnancy, and cares for newborns,[6] is a key driver of the maternal mortality ratio, and there is an inverse relationship between the two.

Historically, there is a steadily increasing trend in the proportion of births attended by a skilled health professional. Currently, 15% of countries (28) for which data is available achieve 100%, and 41% countries (75) achieve at least 99%. The majority (around two-thirds) of these countries achieving high rates (>99% attendance) are in developed countries. By 2030, trends estimated by the Global Burden of Disease Study suggest that the global birth weighted average of the proportion of births attended by a skilled health professional could reach 89%, from around 84% today.

Birth attended vs. maternal mortality



Innovative approaches to healthcare are needed to reach the most vulnerable women to improve health outcomes and reduce health inequalities. Digital technology-enabled interventions have been shown to positively increase the proportion of births attended by a skilled health professional. A particular intervention included in this impact analysis is point-of-care mobile phone applications, used in Tanzania, to provide increased facility delivery awareness, access, and uptake in order to ensure safe motherhood.[7] Another intervention included is an automated SMS system used in Zanzibar, providing mothers with SMS mobile vouchers allowing for two-way communication between mothers and health care providers.[8] Targeted adoption of these technologies could increase the proportion of births attended by a skilled health professional globally in 2030 to 92%, an increase of 3% against the business-as-usual scenario. Most of this increase will come from developing countries. Under digital technology adoption, 60% of countries would achieve rates of 100% and 65% of countries could achieve at least 99%.

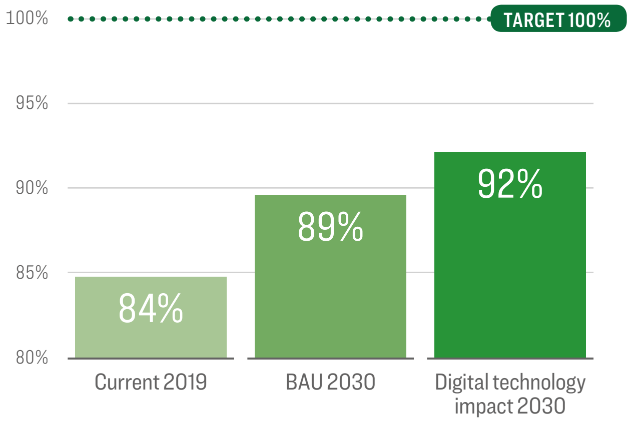
The low performance is driven by countries in Middle, Western and Eastern Africa (e.g. the current rates in Somalia and South Sudan are estimated at around 14% and 21% respectively). Targeting interventions in these areas could result in an even greater increase from ICT than that estimated in the proportion of births attended, given the relative size of the potential gains.

There are multiple studies showing the link between births attended by skilled health professionals and maternal mortality ratio. For example, in Cambodia, a reduction in the maternal mortality ratio from 472 to 170 per 100,000 livebirths between 2005 and 2014 is largely attributed to increased access to skilled birth attendants (increase of 44% to 89% over the same period) and facility based births (increase of 22% to 83%).[9] In Bangladesh, birth attendance resulted in a significant decline in the maternal mortality rate, measuring 1.4 per 1,000 livebirths in the intervention areas compared to 3.8 per 1,000 livebirths in control areas.[10]

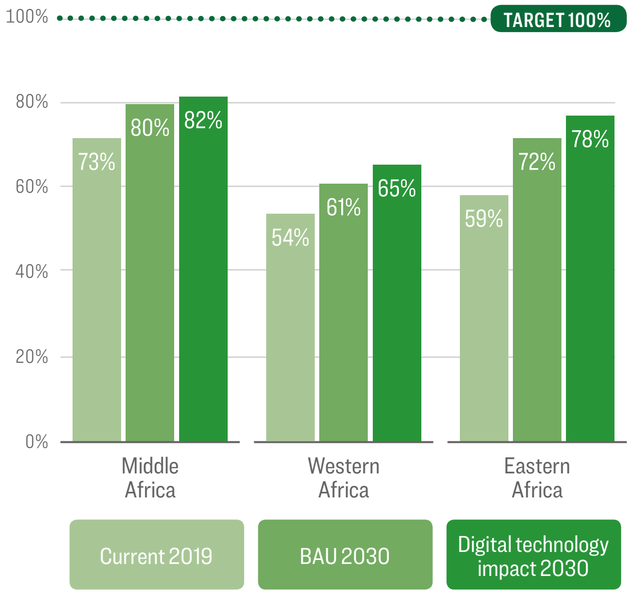
3.4 Reduce non-communicable disease mortality

Tobacco use has been identified as a key risk factor in acquiring non-communicable diseases.[11] Services enabled by digital technologies have proven useful in supporting tobacco use cessation in a range of countries, predominantly through mobile-based services and applications.[12] Based on available estimates, smoking of any tobacco product is around 19% of the population in countries with data, which is expected to fall to 18% by 2030. However, with effective assistance in quitting from mobile services and applications, smoking prevalence may potentially fall to 17%.

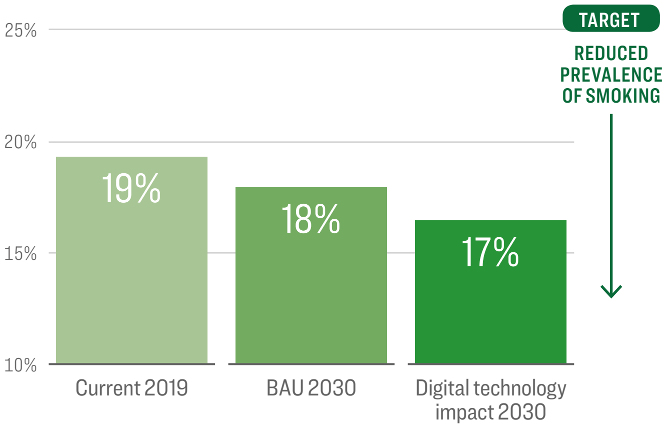
Proportion of countries with 100% of births attended by skilled health professionals



Proportion of countries with 100% of births attended by skilled health professionals



Smoking prevalence globally (% population)



Importance of digital technologies to target attainment

	TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1	**Improve health outcomes**		
🟩	**3.1** Reduce maternal mortality	The application of digital technologies is key for the attainment of this goal. Digital technologies help to achieve improvements in skilled delivery care and increase accessibility to this form of care which will reduce the common killers associated with maternal mortality.	↘
🟩	**3.2** Reduce neonatal and under-five mortality	Reducing preventable deaths of newborns and children under the age of five can be augmented by digital technologies which provide advice and guidance to support new mothers and help to monitor progress against key indicators like weight gain.	↘
🟩	**3.3** End epidemics of communicable diseases	Ending the epidemics of communicable diseases can be significantly helped by using digital technologies to monitor and track the spread of these diseases and to communicate advice and information on outbreaks.	↘
🟩	**3.4** Reduce non-communicable disease mortality and promote mental health	Reducing premature mortality from non-communicable diseases and promoting mental health and well-being primarily relies on digital technologies which help to share understanding of causes and effects, develop new drugs, and design new methods of health care delivery.	→
🟩	**3.6** Halve deaths and injuries from road traffic accidents	Digital technologies are highly relevant for this target, however they are covered in Target 11.2, within chapter 11, which aims “to provide access to safe, affordable accessible and sustainable transport systems for all, improving road safety.”	→
🟧	**3.9** Reduce deaths and illnesses from hazardous chemicals and pollution	Digital technologies help to reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination by improving access to and distribution of information and warnings. Other key drivers include raising awareness, developing training methods and programmes for health workers and encouraging specific research on these risks.	↘
2	**Better, more accessible health care**		
🟧	**3.5** Strengthen prevention and treatment of substance abuse	Whilst strengthening prevention and treatment of substance abuse is mainly driven by improving education and more targeted health policies, digital technologies are being used to share information to raise awareness and to develop digital therapies which reduce substance abuse.	N/A
🟧	**3.7** Ensure universal access to sexual and reproductive health care services	Achieving this target primarily requires integrating sexual and reproductive health into national strategies and programmes. Digital technologies can help by connecting populations in remote areas to health care services and supplies.	↗
🟧	**3.8** Achieve universal health coverage	Access to good-quality, essential health care for all is supported by digital technologies but primarily relies on national health policies and improved insurance coverage.	↗
🟧	**3.B** Support R&D of and affordable access to medicines and vaccines	The attainment of this target will be primarily driven by increased research and development and national health policies. However, digital technologies make a contribution by improving methods of health care delivery and supporting research and development through improved digital access.	↗

3	**Ensure enabling policies**		
⬜	**3.A** strengthen implementation of WHO Framework Convention on Tobacco Control	Digital technologies have limited direct impact on strengthening the implementation of the WHO Framework Convention on Tobacco Control. This target is primarily driven by policy and international cooperation.	N/A
🟩	**3.D** Strengthen early warning risk reduction and management of health risks	Improving the capacity for management of national and global health risks will require digital technologies to improve surveillance, response and preparedness.	🟢↗
4	**Increase health financing and training**		
🟧	**3.C** Increase health financing, recruitment and training of health workforce	Increasing health financing and the recruitment, development, training and retention of the health workforce will mainly be driven by policy and institutions. However, digital technologies can help by enabling online access to training courses and providing virtual reality training.	🟢↗

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

🟩 High impact
🟧 Moderate impact
⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

🟢 Positive progress
🟠 Limited progress
🔴 Negative progress

Cluster 1

Improve health outcomes

Significant progress has been made towards improving health outcomes in recent years. Maternal mortality has fallen by 37%, and the under-five mortality rate has fallen by 49%, since 2000. [13] However, pressing issues still persist. Each year, more than five million children die before their fifth birthday.[14] Epidemics like HIV/AIDs are able to thrive in areas where fear and discrimination act as a barrier to people receiving the services they need to be healthy and productive. The prevalence of non-communicable diseases such as heart disease, cancer, chronic respiratory diseases and diabetes is expected to rise and will generate a $7 trillion cost to low- and middle-income countries in the next 15 years.[15] Better prevention and treatment measures are required to address these problems.

Digital technologies can be leveraged to address these challenges by enabling discovery of better medicines, improving methods of health care delivery, enabling data-enabled interventions and enhancing patient-provider connectivity. The specific technologies that allow these issues to be confronted include digital access, IoT, cloud computing and AI. However, to achieve sustained, improved health outcomes governments will also need more efficient funding of health systems, improvements in sanitation, increased physician presence and accessibility and more ways to reduce air pollution.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Providing information, educational content and treatment reminders through mobile phones Improved digital access enables patients to receive information, educational content and treatment reminders through their mobile phones which enhances patient-provider connectivity leading to better health care delivery and therefore better health outcomes.	**Example:** Telstra Health's MyCareManager Client App helps to improve the lives of those with chronic conditions. MyCareManager allows patients to view their progress against a personalised care plan and communicate with their virtual care team from home. Patients also receive targeted reminders to their mobile phones that prompt them to take their medication, do exercise or complete self-assessments. This technology improves patient-provider connectivity as it notifies a patient's care team if patients have failed to take their medication.[16]	Digital Access	Importance to SDG Role of digital technologies Scalability
Improved access to tests for diseases Increased digital access improves the ability for patients and providers to test for certain diseases in order to help prevent the spread and deterioration of diseases.	**Example:** The Public Health Service of Amsterdam launched a campaign using an internet-based risk assessment to target people infected with hepatitis C who were difficult to identify and reach. The campaign was centred on the idea of using social media and web platforms to draw in people who could be at risk to perform a self-assessment in up to seven languages.[17]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Self-monitoring apps and connected devices providing patients with access to their own health information Self-monitoring, using IoT and digital access, is a form of data-enabled health care intervention. By gathering data from patients' connected devices and reporting it back to them in an informative manner patients are able to take greater ownership in the management of their health, helping to achieve better health outcomes for individuals.	**Example:** Taiwan Mobile have recently launched myAir, a portable PM2.5 detector using IoT technology. It alerts citizens when they are in areas with high particulate concentration, and ultimately aims to help track the hidden killer of air pollution. Users can read the history of their PM2.5 concentration at multiple time levels, and Taiwan mobile is cooperating with research institutions to safe-guard the population through analysing the data.[18]	IoT Digital Access	Importance to SDG Role of digital technologies Scalability
Cloud-based electronic medical record systems Remote data collection and cloud computing technology improves the completeness of data which can be used by clinical and public health services to make more informed decisions relating to diagnosis and treatment options. This form of data-enabled health care intervention also promotes collaborative research and development and the sharing of information to achieve better health outcomes.	**Example:** Dell's KIDS Cloud project is a distributed, cloud-based solution that facilitates collaborative review of information and treatment plans by medical professionals from all Beat Childhood Cancer clinical trial sites in the US and Canada. Another component is the patient portal which allows patients access to view select information.	Cloud	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Analysis of patient data, diagnosis and treatment decisions which can be used to build models to predict individual patients' diagnosis and appropriate treatment and optimise care pathways High-speed data analysis and predictive modelling of patient and disease data can improve clinician knowledge leading to more informed decision making which in turn can help to optimise health outcomes.	**Example:** Fujitsu's foetal heart screening system uses AI to automatically detect abnormalities in foetal hearts in real time from ultrasound images. This reduces the chance that examiners miss severe and complex congenital heart abnormalities that require prompt treatment and in turn leads to early diagnosis and better-planned treatment plans. This technology can help to improve perinatal and neonatal health outcomes.[19]	Cognitive	Importance to SDG Role of digital technologies Scalability
Analysis of data mapping the spread of disease so that regions/populations at risk of disease can be identified The analysis of disease data from a wide variety of sources can map the outbreak and spread of diseases so that citizens can more quickly identify the latest disease spread and providers can respond more quickly and effectively.	**Example:** HealthMap, a real-time epidemic information app, combines data from news sources, social media and public health reports to produce a unified and thorough insight into the current global state of infectious diseases. This information is presented to a wide audience through the use of algorithm-based visualisation tools which allow users to identify the spread and outbreak of diseases around the world and take appropriate action. It also presents information about emerging diseases, aiming to minimise the timing gap between the notification and occurrence of disease. [20]	Cognitive	Importance to SDG Role of digital technologies Scalability
Enable development of new drugs and vaccines through analysis of genetic, bio-chemical, disease and patient data Fighting disease requires understanding biology: what the cells, genes and proteins are doing in a disease/treatment environment, and what they communicate with, and when, how and what the result is. Machine learning can expedite this process, and enable the discovery of new drugs and vaccines which in turn can help to eradicate diseases and lead to improved health outcomes.	**Example:** CytoReason turns human clinical data (genomic, proteomic, microbiomic etc.) into biology, by rebuilding missing data, integrating directionality into the model and identifying disease modulating signals to uncover novel targets, indications, combinations and biomarkers - critical components in bringing new drugs and vaccines to patients faster. This technology identified which patients are likely to respond to therapy, before starting treatment, through discovery of novel, pretreatment biomarkers of response to anti-TNFa therapy in Inflammatory Bowel Disease.[21]	Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 2

Better, more accessible health care

Better and more accessible health care requires improvements in both coverage and delivery. Universal coverage implies providing everyone with access to the health care they need, whilst improved delivery ensures that healthcare providers and facilities have the means with which to provide an adequate service. However, at least half of the global population still does not have access to essential health services and nearly 40% of all countries have less than ten medical doctors per 10,000 people.[22] Availability and quality of health care also varies greatly across even the wealthiest economies.

Digital technology can be deployed to improve the education and training of health care professionals and help ensure that populations in poor or rural communities can obtain access to high standards of health care and can be diagnosed and provided with appropriate treatment. Technologies like blockchain, IoT, AI, 5G and cloud storage have the capacity to create new health care delivery models, offer virtual providers, improve the management of vaccine supplies and increase access to health insurance in order to deliver this outcome. Other drivers through which technology helps to achieve these targets are research and development, developing national health policies and strategies, and improving insurance coverage.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Virtual providers and connectivity providing health care access in remote areas Virtual providers, enabled by mobile platforms, help to provide access to health care in more remote areas and also increase the choice, control and flexibility for patients choosing providers. This helps to improve communication and connectivity between patients and providers which in turn establishes better coverage and delivery of health care.	**Example:** Babyl is a mobile service which connects individuals to primary care providers so that they can receive consultations from health care professionals without having to travel to a facility. The app is also capable of connecting people to facilities, pharmacies and labs if needed. Babyl has already registered more than 2 million users in Rwanda.[23]	Digital Access	Importance to SDG Role of digital technologies Scalability
Virtual provision of training for health care workers Virtual access to basic training for health care workers improves knowledge about the prevention and treatment of common diseases, and confers knowledge gains particularly in developing countries.[24] This is key given there will be an estimated shortfall of 12.9 million skilled health professionals in Africa by 2035.[25]	**Example:** Accenture and Amref have worked to train community health workers via a mobile training platform called "LEAP" designed for basic mobile phone ubiquitous in Sub-Saharan Africa. This encourages continued training, access to supervisors, and allows them to receive campaign messages. To date 3,000 community health workers in Kenya have been trained, and over 300,000 households have benefited.[26]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ■■■■■ Higher

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Management of vaccine inventory, especially in remote areas Real-time information helps to monitor vaccine inventory more closely especially in remote areas where monitoring has proved more difficult. This makes the overall supply chain more secure and enables more accurate forecasting and planning.	**Example:** Nexleaf Analytics, a non-profit technology company, has built Cold Trace which consists of wirelessly connected sensor devices and data analytics tools used for health purposes. Sensors wirelessly transmit temperature data collected from refrigerated units storing vaccines. The system can then generate SMS and email alerts when vaccine storage equipment registers dangerous temperatures. Currently, this technology is deployed in seven countries.[27]	IoT Digital Access	Importance to SDG Role of digital technologies Scalability
New technology, specifically decentralised ledger technology, enables more flexible and innovative provision of health insurance Decentralised ledger technology, such as blockchain, creates a unified platform to share and store patient data in real time, overcoming the inconsistency of different electronic medical records systems, without compromising on security and privacy. This system improves availability of health records, ensures patient data security, removes third-party dependencies and offers fraud prevention capabilities creating a more secure, transparent and streamlined insurance service which can improve coverage. [28]	**Example:** IBM has created a blockchain-based health utility network that brings together a wide range of health care organisations to drive health care transformation. Many health insurance companies including Aetna have joined this network as it improves how sensitive data is shared and stored, making claims more effective. It also includes a system for processing insurance claims and payments which improve efficiency.[29]	Blockchain	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Cognitive artificial health workers used to triage patients Rapid data analysis and predictive modelling using AI can be used to direct targeted individual interventions and deliver personalised medicine at scale. This contributes to improving the delivery of health care by reducing costs of care and improving access to health care services.	**Example:** GNS health care Intervention Optimisation offering, powered by their REFS™ causal AI platform, transforms diverse streams of biomedical and health care data into vast numbers of simulations which analyse outcomes and costs associated with millions of intervention possibilities. This generates greater transparency for health care providers, enabling them to identify the types and timing of interventions that will lead to optimal outcomes.[30]	Cognitive	Importance to SDG Role of digital technologies Scalability
Remote surgery increases access to healthcare for rural patients 5G and AI enables doctors to perform surgery on patients without being present at their physical location. Performing specialised procedures using robot-assisted surgical tools helps patients in more remote areas access the health care they need.	**Example:** A surgeon at St Joseph's Hospital in Hamilton, Canada is able to control a robot surgeon in another part of the country to treat patients. This technology has performed a variety of operations so far including colon operations and hernia repairs.[31]	Blockchain Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Cluster 3

Ensure enabling policies

Whilst there has been substantial progress in improving global health, better management is needed to address persistent health risks such as HIV/AIDS as well as emerging health issues such as the Zika virus which struck originally in 2016. The International Health Regulations (IHR) core capacity index defines 13 attributes needed to improve a country's capacity to manage these health risks.[32] It includes large-scale coordination, surveillance, preparedness, risk communication, national legislation, policy and financing.

Strengthening the capacity for early warning, risk reduction and management of national and global health risks requires improved surveillance, preparedness and response, which are enabled by digital technologies. For example, IoT allows surveillance to be synchronised across affected areas, helping to build early warning systems to help with the prevention and management of health risks. Digital access enables epidemics to be monitored and reported in a more accurate and timely manner which can help to reduce the effects of national or global health challenges. In addition to digital technology, international cooperation, improved policy and increased financing are required to strengthen this form of management.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Providing information and reports on epidemics through web platforms Big data, IoT and digital access help with the discovery, surveillance and reporting of existing or new infectious diseases which can help to prevent the spread of these diseases. These digital technologies allow this information to be communicated to affected regions as well as health authorities in a timely manner.	**Example:** The ProMED epidemic notification mailing service is the biggest private, open system of unofficial disease surveillance and reporting in international health.[33] It acts as a communication channel between scientists, physicians, public health professionals and others interested in infectious diseases with the aim of reporting potential outbreaks of diseases and exposure to harmful toxins, communicated by email and social media channels.	Digital Access IoT Cognitive	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Connected devices to monitor national and global health risks Devices, using IoT connectivity, enable more accurate monitoring of diseases which can help to improve the management of health risks by reducing emergency response times in critical areas and enabling earlier detection of diseases.	**Example:** The US Agency for International Development has funded a US scientific institute that aims to monitor and protect Ebola patients using connected wearable technologies. In areas experiencing the Ebola epidemic Stamp2 sensors, using IoT connectivity, have been integrated into "smart Band-Aids" which can collect a wide range of patient data. This data is then transmitted to a centralised platform that monitors the data and triggers alerts to physicians if there is abnormal behaviour in a patient's behaviour or health.[34]	IoT	Importance to SDG Role of digital technologies Scalability

Lower Higher

Interaction with other SDGs

The targets for SDG 3 are heavily interlinked with the other society-focused SDGs. Improved health outcomes enables effective poverty reduction (SDG 1) by helping citizens be more productive, and better identify and take advantage of opportunities to increase their income and resources and lift themselves out of poverty. In a similar way, ill health can diminish the ability of households or individuals to farm and produce food or work and be able to afford food and so impacts the achievement of zero hunger (SDG 2). Better health outcomes is also a strong enabler for quality education (SDG 4) as poor health limits school attendance and educational achievement.

Better health can also promote healthier economies as it leads to increased productivity of the labour force and reduced unemployment spells which can boost economic growth (SDG 8).

Better and more accessible health care will ensure that women and children especially in poorer or rural communities will be able to receive the care they need to a high standard. This will help to improve the health of women and children which will mean they will have more time to dedicate to participating in decision making and economic activities, which will help to combat gender equality (SDG 5).

Negative Externalities

Whilst digital technologies make powerful contributions to the SDGs, if these technologies are used in the wrong way they may generate some negative unintended consequences for SDG 3.

Impact of widespread use of digital technologies on achievement of SDG 3

E-waste: The generation of e-waste, associated with increased use of digital technologies, can be particularly damaging to health.[35] Various health risks can result from direct contact with harmful materials often found in technological components. Findings from various studies show increases in spontaneous abortions, stillbirths and premature births, and reduced birthweights and birth lengths for those exposed to e-waste.[36] In particular, children are more at risk of hazardous chemical absorption, given that their intake of air, water and food in proportion to their weight is significantly increased compared to adults. This may hamper the development of their bodies' functional systems and cause irreversible damage. Recycling e-waste activities also expose both adult and child workers as well as their families to a range of health risks. In Southeast China, boys aged 8 and 9 living in e-waste recycling towns had a lower forced vital capacity, an important pulmonary function, than those living in a control town.[37]

Spread of false information: As technology spreads and people become increasingly connected, the ability to limit the sharing of fake and misleading information regarding health becomes more challenging. Fake, misleading and over-interpreted health news in social media has the potential to seriously threaten public health. Top links on the internet related to common diseases contain misinformation in 40% cases but were shared over 450,000 times in the period from 2012 to 2017. [38] A continuing example of the dangers of misinformation and the consequences for public health is the ongoing battle against anti-vaccination campaigns, which is likely behind the rise of outbreaks in recent times, in developing and developed countries alike.[39]

Emissions: The increasing deployment of digital technology means that the ICT sector will become responsible for a greater share of energy consumption and therefore greater pollution emissions which are harmful to health. One third of deaths from stroke, lung cancer and heart disease are due to air pollution and it is estimated that air pollution kills 7 million people every year.[40]

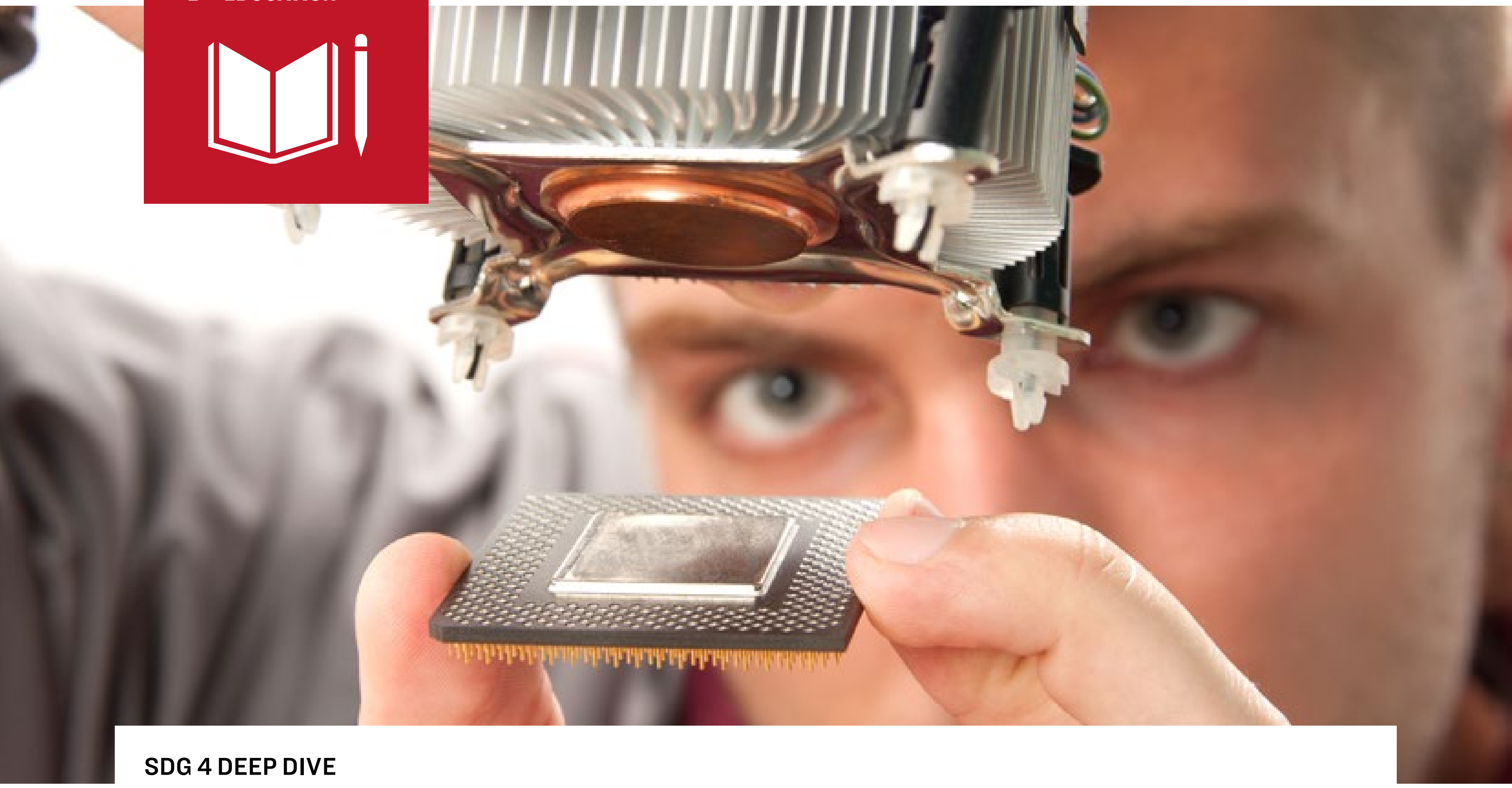
Road safety: Digital technologies such as the smart phone are a major source of distraction for drivers and can cause road accidents, resulting in injuries and deaths. The US National Safety Council estimates that globally, mobile phone usage contributes to 1.6 million crashes per year[41] and that 25% of accidents are caused by texting and driving[42], with texting being more than 6 times more likely to cause an accident than drunk driving.[43]

Impact of using digital technologies to achieve SDG 3

Technology malfunctions: The increased use of digital technology in the health care industry creates a greater dependence which may have negative consequences on health. This implies that if the technology fails, patients' health will be severely jeopardised. This could be due to errors resulting from failure of machines or the loss of vital patient data from system breakdowns.

Sharing biometric data: The use of connected devices to monitor patients' health involves sharing patients' biometric data which raises questions concerning privacy.[44] With this type of technology playing a bigger role in health care there is greater possibility that this sensitive data could be shared without patients' consent which could be seen as a threat to peace and justice (SDG 16). This could have further negative implications if this data then ends up in the wrong hands. For example, it increases the potential damage from security hacks of health systems and databases; hackers can use patient data to fake insurance claims or blackmail victims.

4 QUALITY EDUCATION



SDG 4 DEEP DIVE

Quality Education

Education is a driving force that powers economies and societies. Individuals apply the knowledge and skills they develop in making their contribution to the wider world – particularly as part of the global workforce. SDG 4 aims for all children to gain access to free and high-quality schooling, regardless of gender, socioeconomic status or disability.

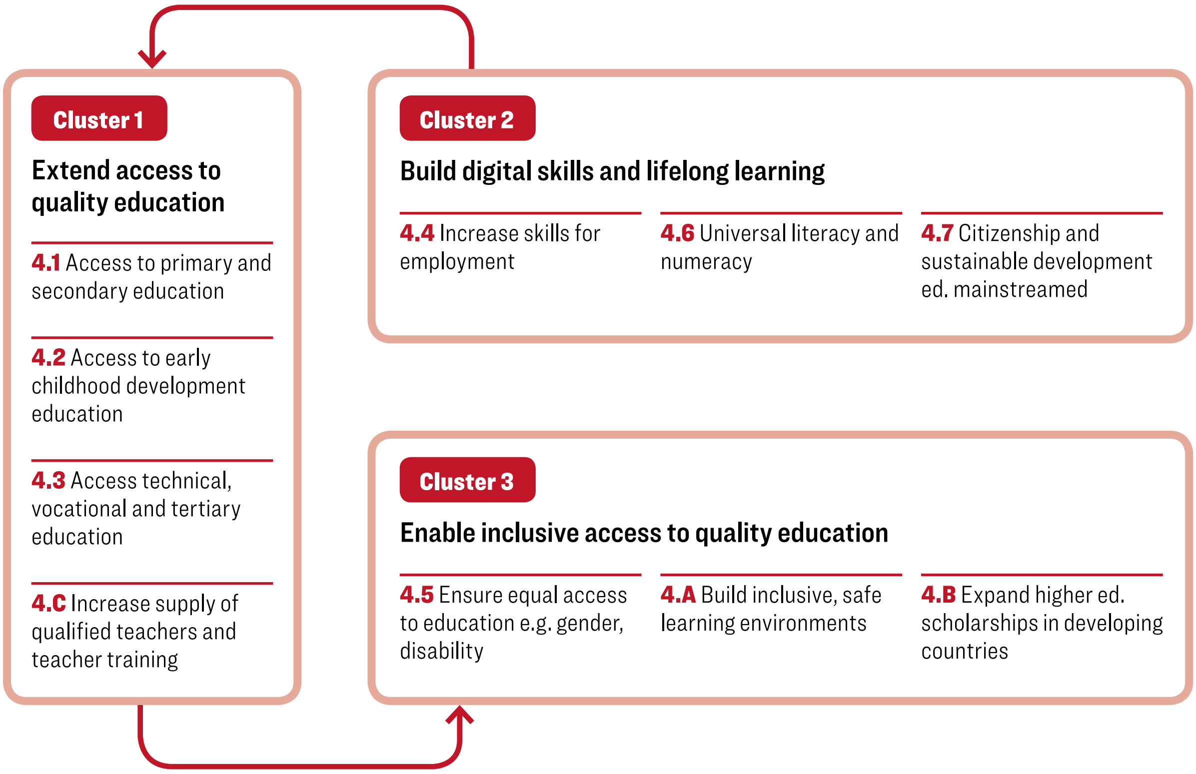
The UN describes education as at the epicentre of the SDGs, reflecting the need to maximise human potential in order to solve the world's most urgent problems.[1] Nelson Mandela identified education as "the most powerful weapon which you can use to change the world".[2]

But despite significant strides made in access to education, over 250 million children still do not regularly take their seats in a classroom.[3] Many of these children are part of vulnerable groups and ensuring they receive a quality education lies at the heart of SDG 4. However, this challenge is likely to deepen as the global population grows and the world approaches a learning crisis. The learning crisis is exacerbated by the global refugee crisis: half the world's 25.4 million refugees are children, with most lacking access to education.[4] To achieve universal access to education by 2030 nearly 70 million new teachers will need to be trained, recruited and deployed.[5]

Alongside access, the quality of education will continue to be an important focus for enabling all people to realise their potential. As it stands, 125 million children attend school and yet are unable to read or write. Digital technologies need to enable the right solutions to address these problems, at scale and quickly.

The need for quality education is no less important in relatively developed countries. As global income inequality continues to rise[6], education will be a key driver of reducing inequalities within and across countries. Greater quality education is also needed to sustain long-term economic growth everywhere. Potentially half of all jobs are at risk of automation in the next 15 years[7], and so, the need for a quality education to train the workforce of the future has never been greater.

SDG 4 System



Cluster 1

Extend access to quality education

4.1 Access to primary and secondary education

4.2 Access to early childhood development education

4.3 Access technical, vocational and tertiary education

4.C Increase supply of qualified teachers and teacher training

Cluster 2

Build digital skills and lifelong learning

4.4 Increase skills for employment

4.6 Universal literacy and numeracy

4.7 Citizenship and sustainable development ed. mainstreamed

Cluster 3

Enable inclusive access to quality education

4.5 Ensure equal access to education e.g. gender, disability

4.A Build inclusive, safe learning environments

4.B Expand higher ed. scholarships in developing countries

Increasing access to education is the core of SDG 4 (Cluster 1). This includes broadening access to primary, secondary, early childhood, and further education. In order to achieve this, new teachers need to be mobilised and trained.

Cluster 2 aims to deliver the basic competencies needed to effectively receive, and benefit from, a quality education. This involves possessing a basic level of literacy and numeracy, as well as digital skills needed for the workforce while understanding the responsibilities of a global citizen conscious of the need to contribute to sustainable development.

Finally, increasing access to education must be paired with an ambition to ensure that education is inclusive (Cluster 3). Inclusivity means ensuring equal access for persons with disabilities, indigenous peoples, and children in vulnerable situations, with the infrastructure to allow this, and allowing youths to pursue education irrespective of their financial status.

The role of digital technologies in delivering SDG 4

Digital technologies can help to deliver SDG 4 in multiple ways. First, digital technologies facilitate wider access to online educational content, especially at secondary and tertiary levels. Digital access can also broaden the availability of training materials, helping to improve the number and quality of teachers. More emerging technologies like facial recognition and predictive analytics may in future be deployed to enable greater access to education – monitoring student attendance and identifying those at risk.

Second, digital technologies can be deployed to improve the quality of educational content – enabling the most effective material to be adapted to a child's learning ability and shared at scale to improve literacy, numeracy and digital skills.[8]

Third, digital technology can enable more inclusive access to quality education. Digital access to free online educational platforms benefits vulnerable groups most. Personalised digital learning using AI can cater to individual learning styles and disabilities. Virtual reality enables children to access quality educational content using interactive, hands-on experiences, which would, if available, be especially beneficial for refugees and disadvantaged and rural communities.

While digital technology acts as a core enabler, there is a need for the broader system to contribute focus, energy and investment. The importance of using research and evidence to inform the decisions around which technologies should be used, and in which instances, should not be understated. There was a lack of success in deploying in the past owing to a lack of evidence-based Ed Tech interventions.[9] The UK's Department for International Development has already recognised this issue and responded by launching the Ed Tech Research and Innovation hub,[10] but governments need to enable further research in evidence-based decision making to improve learning outcomes. Governments, along with multilateral partners, also need to invest in educational provision, pass anti-discriminatory laws, promote the inclusion of sustainable development in curriculums, fund scholarships, and build safe learning environments for all children. Civil society organisations can supplement these efforts by focusing on education awareness and sustainable development. The private sector must also contribute by creating quality educational content, and investing in advanced technologies (such as VR and AI) to widen their accessibility for education purposes purposes, as well as providing microloans for prospective students. Finally, these implementing partners need to take a more cross-sectoral approach to improving education outcomes. Community leaders are viewing education as a lifelong experience that begins well before a child first enters the classroom, and which is influenced by a number of factors outside the classroom. As a result, more communities are developing cross-sector partnerships that support student success from cradle to career by coordinating and implementing a shared community vision, e.g. integrating health and WASH interventions. This approach, known as collective impact, is a framework for taking bold, systemic, collaborative approaches that cut across organisations and sectors to achieve significant and lasting social change.[11]

Projecting the impact to 2030

Today, the global youth literacy rate – defined as the proportion of the population aged 15-24 who can both read and write a short simple statement about their everyday life – is around 92%. By 2030, historic trends imply that the literacy rate could increase to 94%. The measure is important as it gives an indication not just of the quality of education, but also of the quality of the future labour force. There is a known positive relationship between the GDP growth of a country and improved education,[12] while at the personal level there is evidence to show that higher literacy levels can attract a wage premium of 8-10%.[13]

In addition, literacy is linked to life expectancy through health. People with low literacy skills are often unable to understand everyday health information, known as 'health literacy'. A study in England estimated low health literacy to be associated with a 75% increased risk of dying earlier compared to people with high health literacy levels.[14]

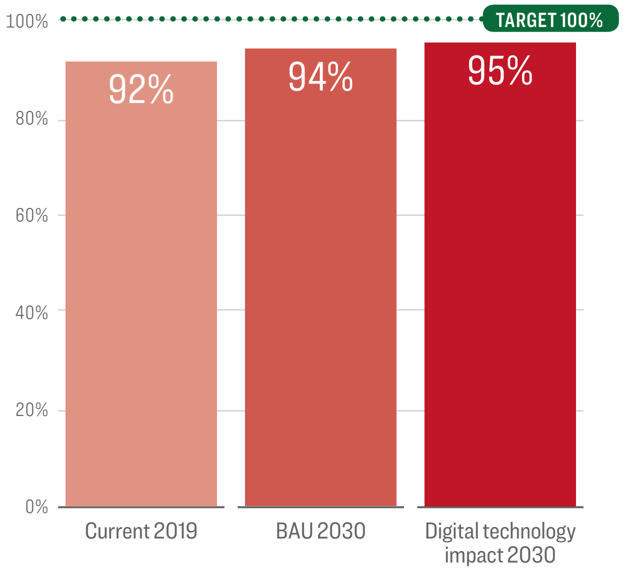
Digital technology could improve on future youth literacy levels. For instance, the introduction of e-readers for students and tablets for teachers or supervisors, or educational games as part of a computer assisted learning programme have been shown in controlled trials to increase literacy outcomes. Applying the results of such trials implies that, with the full targeted adoption of such ICTs globally, the youth literacy rate in 2030 could be 95%, equivalent to an additional 17 million additional young people attaining basic literacy skills.

The relative impact is estimated to be greatest for low-income countries, where there is more to gain, with a 2% increase in literacy rates with full adoption of ICT in 2030 compared to the business-as-usual scenario. Much of the absolute global gain will come from middle-income countries, with the potential for almost 14 million additional young people in middle-income countries gaining basic literacy skills.

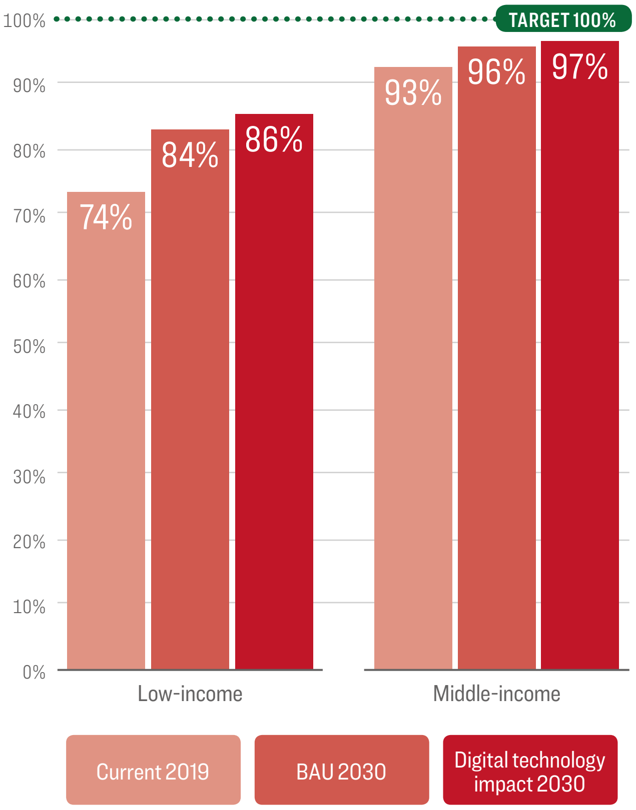
SDG Target 4.6 calls for all youth and a substantial proportion of young adults, both men and women, to achieve literacy (and numeracy). Ensuring that the final 5% of young people are able to achieve basic literacy will be reliant on the achievement of the other targets, improving access to education and the availability of trained teachers.

More than just ICT will be required in countries where the youth literacy rate is currently particularly low (less than 50%, e.g. Chad, South Sudan). In these countries in 2017, only 11% and 25% of the respective populations had access to electricity. Investment in basic infrastructure, i.e. electricity, internet access, is required before ICT can have an impact on basic literacy levels in these areas.

Literacy rate, youth total (% of people ages 15-24)



Literacy rate, youth total (% of people ages 15-24)



Importance of digital technologies to target attainment

		TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1		**Extend access to quality education**		
	🟩	**4.1** Access to primary and secondary education	Most of the 262 million children out of school belong to vulnerable groups living in rural areas, are disabled or are girls. Accessing educational content online will be crucial for these groups who would otherwise be unable to receive an education.	🟢 ↗ [15]
	⬜	**4.2** Access to early childhood development education	Digital technologies have a limited direct impact in ensuring governments reach this target, for example through collaboration to develop effective early childhood learning programmes[16].	🟢 ↗ [17]
	🟩	**4.3** Access technical, vocational and tertiary education	Digital technologies are and will remain an integral part of further education access. Online providers may open opportunities for populations who would or could not otherwise pursue education.[18]	🟢 ↗
	🟧	**4.C** Increase the supply of qualified teachers and teacher training	Digital technologies increase access to resources for teachers, allow for remote teaching which increases the supply of teachers, and create a wider platform for teacher recruitment. Public investment in teacher training is also required to achieve this target.	🟠 →
2		**Build digital skills and lifelong learning**		
	🟧	**4.4** Increasing skills for employment	Digital technologies will be an important factor in lowering the cost and increasing the spread of vocational and technical training in an increasingly technology-dominated world, but requires government regulation and quality content from providers.	🟢 ↗
	🟧	**4.6** Universal literacy and numeracy	Digital technologies will be necessary in increasing access and affordability to educational materials. However, this target will only be achieved if public policy and investment ensures that content is available and delivered effectively through the education system.	🟠 →
	🟧	**4.7** Citizenship and sustainable development	Digital technologies enable the mainstreaming of sustainable development and global citizenship in education. For example, digital technologies are integral to much of the research involved in the science behind sustainable development, and will be integral in delivering the content to schools. Policymakers will need to ensure that this content is included in curricula.	N/A
3		**Enable inclusive access to quality education**		
	🟩	**4.5** Ensuring equal access to education e.g. gender, disability	Increasing access to education for vulnerable groups, including girls and children in rural areas, and providing effective education for children with disabilities, will be heavily reliant on digital technologies.	🟠 →
	🟧	**4.A** Building safe, inclusive learning environments	Aside from security systems in schools, and ensuring the security of online educational environments for children, digital technologies have an indirect impact in ensuring a safe learning environment – reliant on effective regulation and investment.	N/A
	⬜	**4.B** Expanding higher ed. scholarships in developing countries	Besides creating awareness of scholarships and improving the efficiency of financing, digital technologies have a minimal direct role in expansion of higher education scholarships.	N/A

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET
🟩 High impact
🟧 Moderate impact
⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

🟢 Positive progress
🟠 Limited progress
🔴 Negative progress

Cluster 1

Extend access to quality education

The global participation rate in early childhood and primary education was 70% in 2016, up from 63% in 2010. Whilst global access to education increased, there remains an acute challenge to universal access of primary and secondary education in Sub-Saharan Africa, where the net enrolment rate stood at 79% in 2015.[19] This is partially driven by the effects of conflict, poor health which results in 200 million school years lost each year[20] and a lack of quality teachers with 90% of secondary schools in Sub-Saharan Africa understaffed.[21]

Digital technologies will be important in extending access to education. Digital technologies can provide access to educational content in rural communities, leapfrogging poor attendance issues caused by the distance of physical schools. Girls often encounter greater obstacles to obtaining an education, including sexual harassment on the way to and in school, a lack of willingness to fund their education, and a lack of female toilets. Online platforms reduce the cost and ease the spread of further education, particularly benefitting girls in developing countries who are currently underserved.

Meanwhile, 74 countries are facing an acute shortage of teachers.[22] Online training platforms can be deployed to scale training and recruitment efforts. Big data analytics combined with predictive analytics software can aid in effectively deploying teachers to where they are most needed.

While digital technologies will be beneficial to those who receive an education, these solutions should be complemented with effective government policies to make education compulsory and available. As well as subsidising the cost, for governments to enable universal access to education they must ensure a stable conflict-free environment and sufficient standards of basic infrastructure and human services, including food and health provision.[23] Education content providers also face a responsibility to make their online platforms more widely accessible.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital access to streaming services reduces physical constraints in the classroom Effective teaching is not possible in overcrowded classrooms.[24] Livestream services mean that students do not have to be in the same physical space as a qualified teacher.	**Example:** Echo360 is a video platform that supports teaching and learning, via livestreaming lectures, sharing educational resources, tracking and using analytics to monitor student engagement.[25]	Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability
Cloud computing increases teachers' ability to download educational content in communities with low data coverage Cloud computing will allow students to download educational content in areas with low or no data coverage.	**Example:** Eduze is an offline platform for classrooms in Africa that does not require any data to use. CLOX, Eduze's cloud product, offers a safe, secure autonomous network that requires little to no other infrastructure. 30 minute video lessons can be downloaded by 30 devices simultaneously within two minutes without using any data.[26]	Cloud Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Digital access to online courses supplements curriculums enables e-reading, improving student literacy and numerical proficiency Access to online educational content increases the quality of curriculum in many developing countries, allowing students to learn based on proficiency.	**Example:** Microsoft's Skype in the Classroom provides access to a wide range of global content and resources, helping students to discover new cultures, languages and concepts remotely. The programme offers shared and innovative learning experiences through online collaboration, games, guest speakers and interactive and digital teaching tools. It is a free global community which connects students, guest speakers and more than 100,000 teachers from 235 different countries in 66 different languages.[27] **Example:** Onebillion develops educational software for reading and numeracy in the child's own language and supports global partners to get their software into the hands of children around the world. Onecourse, their flagship software, has reached over 100,000 children around the world.[28]	Digital Access	Importance to SDG Role of digital technologies Scalability
Digital access to online courses increases access to further technical or vocational education such as distance learning Many rural communities are situated in terrain that makes it too difficult to travel to institutions of further education.[29] Online further education programmes also reduce the cost of education, increasing access.	**Example:** Eduncle is a learning platform for students in India seeking to pursue further education, including the local Engineering Entrance exam (JEE). Eduncle has over 32 million site visitors, and provides many free courses.[30]		Importance to SDG Role of digital technologies Scalability
Digital access to teacher training platforms encourages collaborative learning, enables the use of tablets for teachers and allows greater access to training materials 70 million new teachers are needed by 2030 to fulfil SDG 4. Access to training platforms will improve the quality of teaching.	**Example:** BetterLesson offers one-on-one virtual coaching for teachers, instructional coaches, and school leaders tailored to individual goals and focused on data-driven strategies, reflection and growth. 92% of teachers report that they are able to leverage technology in more thoughtful and strategic ways as a result of working with their coach.[31]		Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Using big data helps to optimise the deployment of teachers within schools and between schools 33 countries will not have enough teachers to provide every child with a primary education,[32] while teachers in better-funded schools are not efficiently managed.[33] An efficient allocation of teachers and support staff within communities using big data helps improve cost-effectiveness and improves teaching quality.	**Example:** Tatvasoft is a custom Software Development Services company that uses big data and predictive analytics to track teachers' competencies in order to enhance teacher performance. This increases teaching quality by up to 7%.[34]	Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Virtual reality simulates real life scenarios to improve the quality of vocational training VR allows for large savings in vocational training costs by allowing scenarios, many costly or unsafe, to be retried, providing real-time feedback.	**Example:** Avantis Systems Ltd. delivers VR immersive end-to-end experiences for vocational training and classroom education. Avantis' support teams manage over 200,000 active devices daily.[35]	Digital Reality	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 2

Build digital skills and lifelong learning

With jobs increasingly requiring not just basic skills, but more advanced digital skills, digital literacy will continue to be a critical focus for the global education system. The OECD estimates that up to 47% of jobs will be automated by 2034,[36] indicating the scale of the transformation ahead. However, digital skills are lacking – for example, of eighth grade students only 9% in Turkey and 13% in Thailand have functional working knowledge of computers.[37]

Even in basic literacy and numeracy, the world has not made significant gains in the last five years. Rates have stagnated since 2015 at about 85% and 90% respectively.[38] A significant barrier to improving this figure is teacher absenteeism, which is 44% in India, for example.[39]

To train the workforce of the future, there is a need to unleash the potential digital technologies provide. Access to online educational content will improve both digital and traditional literacy. It will also be a major channel in delivering global citizenship and sustainable development curricula to schools. Cloud technologies aid in monitoring teacher attendance. Artificial intelligence will personalise training courses, while virtual reality will lower the cost of vocational training and eliminate safety hazards.

The push for universal literacy, numeracy and digital skills is highly dependent on public investment in effective programmes. Cooperation between governments, companies and providers to invest in training programmes is crucial. Improving the quality of work (SDG 8), especially the market for skilled labour, is needed to provide students with incentives to complete their education and to encourage upskilling.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital access increases the reach of educational resources for skills and employment Access to online training courses and social networks, many of which are free, enables a wider pool of youths and adults to build the technical and vocational skills needed to gain decent employment.	**Example:** Skillshare is an online learning community with thousands of classes in design, business, tech, and more. Skillshare has over four million students and 22,000 classes.[40]	Digital Access	Importance to SDG Role of digital technologies Scalability
Digital access increases youths' and adults' ability to improve their digital literacy Access to the internet is a precondition for gaining digital literacy, which can be spread through online courses or offline platforms.	**Example:** Dell is equipping 400 schools in Ethiopia with computers to deliver ICT training to teachers and school leaders. This programme brings digital literacy to 400,000 students through 16 million hours of ICT education training.[41]	Digital Access	Importance to SDG Role of digital technologies Scalability
Computer assisted learning programmes increase students' and adults ability to reach educational resources to improve their literacy and numeracy Access to online educational content improves the quality of learning and improves educational outcomes.	**Example:** Ubongo, based in East Africa, gives "edutainment" lessons via mobile phone, radio, print, Internet, and TV. Kids who watch Akili and Me outperform their peers by 24% in counting and 12% in higher school readiness scores than control groups watching other cartoons, accounting for relevant variables including age.[42] **Example:** Matific sets homework allowing pupils to continue to learn in a 'hands-on' way through immersive maths learning modules and interactive mini-games which apply maths skills to real-life scenarios and problems. Matific schools had on average, a 17% higher pass rate than other schools.[43]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Digital access increases the reach of global citizenship and sustainable development resources Access to relevant content on global citizenship and sustainable development can be utilised by policymakers, teachers and individual pupils to deepen understanding and commitment to sustainable development.	**Example:** The Climate Pioneers Initiative offers schoolchildren from pre-school to secondary school the opportunity to realise their own climate protection projects. In 2011, 1,500 climate pioneers implemented a total of 100 climate projects.[44]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Facial recognition and cloud access in classrooms increases teacher accountability, lowering the rate of teacher absenteeism One reason why there are 125 million illiterate school-going children is due to teacher absenteeism.[45] Tracking teacher attendance and linking attendance with financial incentives improves learning outcomes.	**Example:** Duflo and Hannah ran a pilot study using cameras to monitor teacher attendance in schools in India. The teacher absence rate decreased from 42% to 22%, and students in the experiment were 40% more likely to be admitted to regular schools.[46]	Cloud Cognitive	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Big data and artificial intelligence can help to provide personalised training programmes for employees Personalising the level of difficulty for different individuals during training increases the effectiveness of learning.	**Example:** Docebo is a cloud-based Learning Management System solution to provide training programmes for employees. AI-powered technology augments the learner experience by delivering the highest level of personalisation.[47]	Cognitive	Importance to SDG Role of digital technologies Scalability
Big data and artificial intelligence personalises literacy and numeracy content and assessments to suit various levels of ability Personalised learning using big data adapts to learning styles and base proficiencies to improve learning outcomes.	**Example:** Literator, based in San Francisco tracks students' literary skills and predicts progress over time. As teachers and students use the program, Literator collects and translates data into insights and integrates this with attendance data.[48]	Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 3

Enable inclusive access to quality education

Most of the 262 million children that lack access to education today, belong to vulnerable groups. Children, especially in poor, rural, indigenous and conflict-prone communities, and refugees, face many obstacles to attending school from gender discrimination to a lack of safe access, poor transport links and limited public investment. 90% of children with disabilities do not go to school.[49] Many of these disabilities are minor, such as poor vision[50], yet teachers lack the training, and schools lack the resources, to create an inclusive learning environment. School dropouts, which reach up to 65% of primary school enrolees, tend to be from minority and vulnerable groups.[51]

Digital technologies play a significant role in enabling greater access to education for vulnerable groups. Fast internet allows students who may otherwise be disenfranchised, virtual access to the classroom. Immersive virtual reality helps children with physical and learning disabilities integrate into classrooms from which they would be otherwise excluded. Predictive analytics allows teachers to track students at risk and take action before they drop out of formal education.

Government investment, including funding schools' physical and digital infrastructure, especially electricity and broadband, is required to enable the power of digital technologies. Funding restrooms for girls and physical infrastructure such as ramps for children with disabilities are also crucial for inclusivity. Policy positions are needed to support vulnerable groups, for example, the issue of child marriage (Target 5.3) and lack of education are deeply intertwined, and need to be dealt with in tandem. Girls with no education are three times more likely to marry before age 18 than those with a secondary or higher education, reinforcing their lack of autonomy.[52] The 152 million children subject to child labour have little to no chance of receiving an education unless these practices are eliminated (Target 8.7.)[53]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital access to online courses decreases barriers to education, increasing access to education for vulnerable groups in poor and/or rural and/or conflict-prone areas Digital access lowers the cost of education and removes the need to travel, increasing accessibility of education for girls, children with disabilities, indigenous populations and children in vulnerable situations.	**Example:** Pearson possesses a portfolio of digital and blended learning solutions, including workforce training for prison inmates in the US, language learning for refugees in Germany, and math skills development for low-income students in South Africa.[54]	Digital Access	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Predictive analytics, with the help of big data, allows teachers to spot students at risk and take action to prevent them from dropping out of school Students at risk of dropping out tend to belong to vulnerable groups. Using predictive analytics to track students reduces the school dropout rate.	**Example:** Civitas Learning's platform uses predictive modelling to identify students at risk. It focuses on student engagement, persistence and completion to improve college attendance, retention, and graduation rates. Del Mar College reported a 34% increase in graduation after using Civitas.[55]	Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Virtual reality personalises learning and increases engagement for children with disabilities Virtual reality allows physically disabled children to experience what they may not be able to physically access, and allows children with autism to improve their social skills such as by simulating public speaking.[56]	**Example:** VOISS developed a Technology Innovation Adoption Model that will be specific to the needs of the schools involved and that will be applicable to helping school staff across the country successfully implement evidence-based technologies into the lives of students with disabilities. VOISS will be used in 17 schools in the USA.[57]	Digital Reality	Importance to SDG Role of digital technologies Scalability

Lower ■■■■■ Higher

Interactions with other SDGs

A range of SDGs are integral to increasing access to education. On an individual level, a significant barrier to education is a lack of nutrition (SDG 2) and poor health (SDG 3). Increasing immunisation and supplying micronutrients are critical steps to allowing more children to attend school. On a country level, conflict-prone areas tend to be unsafe for children to travel to school, while child labour accounts for the majority of uneducated children. Addressing systemic violence against children and their communities (SDG 16) will foster a safer environment for learning.

The effect of a more inclusive education ecosystem is to reduce inequality. Empowering girls through a quality education is central to the fight for gender equality, and is a first step in reducing the incidence of child marriages (SDG 5). Empowering women in this way will alter the relationship between gender inequality and economic growth (SDG 8), and indeed enable more representative public institutions (SDG 16), as more women enter the workforce and increase their representation in economic and political decision making processes. As more girls, indigenous peoples and disabled children gain access to the education needed to join the skilled labour force, inequality among and within countries will fall (SDG 10).

A quality education for all children is needed to escape the poverty cycle and ensure equal rights to economic resources (SDG 1), and equip people with the skills needed for decent work (SDG 8). Increasing the number of people in higher education will be important in increasing the level of research and development, which is needed to foster innovation (SDG 9).

Negative externalities

Impact of widespread use of digital technologies on achievement of SDG 4

Worse health outcomes: The extraction of nickel and lithium needed for digital devices tend to be mined in developing communities. This thriving new market could increase the exploitation of child labour, detracting from the goal of universal education. Further, extraction causes sulphur dioxide emissions, worsening health outcomes,[58] and could prevent children from attending school.

Greater digital divide: The uptake of digital technologies worldwide creates an increasing need for individuals to upgrade their skills. As a greater proportion of educational content is put online, vulnerable groups could be the last communities to receive this access. The digital divide could also manifest in wider educational inequalities.

Impact of using digital technologies to achieve SDG 4

Power in curricula framing: Wider uptake of online education increases the power of online private education providers. This could result in these providers yielding significant influence over the way they wish to cover content, potentially shaping biases and omissions in curricula.

Lower productivity: Gaining access to the internet comes with, alongside useful educational content, social media, which could lower learning and productivity by up to 13%.[59]

Loss of privacy: Companies that use big data, cloud and facial recognition technologies for education could also jeopardise the privacy of personal information.

SDG 5 DEEP DIVE

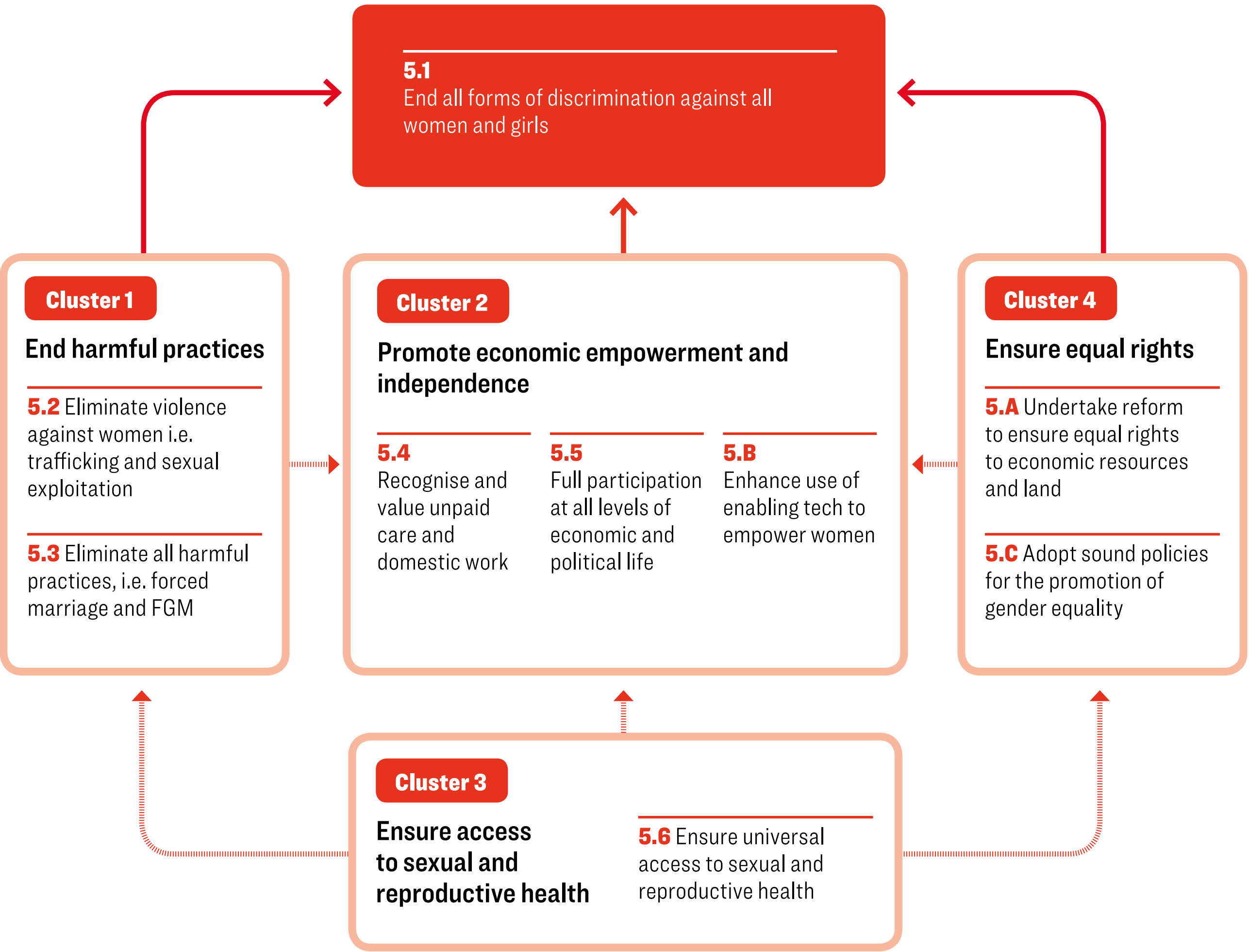
Gender Equality

SDG 5 focuses on achieving gender equality and empowering all women and girls. Providing women and girls with equal access to education, health care, decent work, and representation in political and economic decision making processes is critical to the attainment of global gender equality.[1] SDG 5 also promotes the implementation of new legal frameworks to improve female equality in the workplace and to eradicate harmful practices targeted at women in order to end gender-based discrimination.

Gender equality is a fundamental human right which provides a necessary foundation to build a peaceful, prosperous and sustainable world. The UN Economic and Social Council emphasises it is impossible for the world to achieve the 17 SDGs without also achieving gender equality and the empowerment of women and girls,[2] given that women and girls represent half of humanity.[3]

However, the 2019 SDG Gender Index finds that of all the SDGs, the world is furthest behind on SDG 5.[4] According to the Index, nearly 40% of the world's girls and women, approximately 1.4 billon, live in countries failing on gender equality. Rapid progress and concerted effort is needed to attain global gender equality, which in turn will help to create sustainable economies and benefit society more broadly.[5]

SDG 5 System



5.1
End all forms of discrimination against all women and girls

Cluster 1

End harmful practices

5.2 Eliminate violence against women i.e. trafficking and sexual exploitation

5.3 Eliminate all harmful practices, i.e. forced marriage and FGM

Cluster 2

Promote economic empowerment and independence

5.4 Recognise and value unpaid care and domestic work

5.5 Full participation at all levels of economic and political life

5.B Enhance use of enabling tech to empower women

Cluster 4

Ensure equal rights

5.A Undertake reform to ensure equal rights to economic resources and land

5.C Adopt sound policies for the promotion of gender equality

Cluster 3

Ensure access to sexual and reproductive health

5.6 Ensure universal access to sexual and reproductive health

Ending all forms of discrimination against all women and girls (5.1) is at the core of SDG 5. This can be enabled by four interacting groups of targets. Ending harmful practices (Cluster 1) is a key enabler of the eradication of gender discrimination by eliminating violent activities towards women such as trafficking, sexual exploitation, forced marriage and FGM. The core Target, 5.1, is also directly enabled by promoting economic empowerment and independence (Cluster 2) and ensuring equal rights (Cluster 4). The overall achievement of this goal also requires ensuring universal access to sexual and reproductive health (Cluster 3) which helps to end harmful practices against women and promote their independence.

The role of digital technologies to deliver SDG 5

The use of mobile technology greatly improves the communication and dissemination of knowledge on women's rights, fair treatment and sexual health. Mobile phone ownership also contributes to the economic empowerment of women by giving them more independence and control of their lives. Together, IoT connectivity and cognitive technologies improve the global capacity to identify trafficking networks and victims of violence and their locations. Digital technologies can also be deployed to improve the reporting of violent and harmful practices against women, for example by digitising the reporting process of perpetrators or encrypting reports of violence until multiple reports of the same perpetrator are identified. Big data and AI, with appropriate safeguards, allow for the safe sharing of data across agencies, enabling health care providers to better shape interventions that tackle discrimination.

Whilst digital technologies are necessary to achieve SDG 5, they are not sufficient. Many problems related to gender equality arise from attitudes and values regarding women that are deeply embedded in social and cultural norms, which in turn guide peoples' actions. Therefore, delivering SDG 5 requires changes in norms and cultural beliefs via social reform and legislative policy, encouraging civil societies to participate, and increasing outreach programmes for those affected by discrimination. Effective governance of policies and international cooperation are also needed to address this global issue.

Impact projections to 2030

Target 5.6: Ensure universal access to sexual and reproductive health and reproductive rights

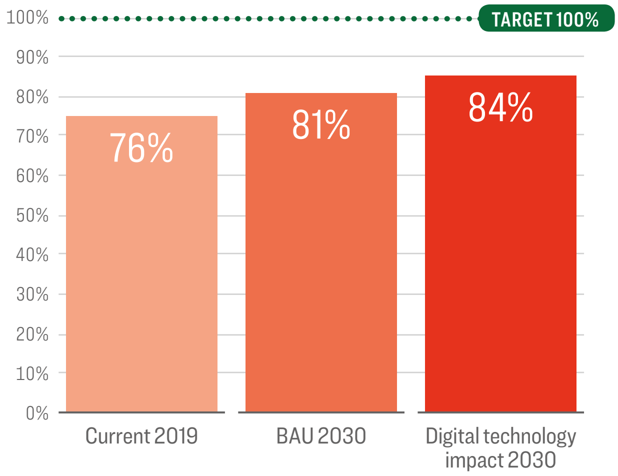
Note: The analysis for this target has been carried out on Indicator 3.7.1 which measures the proportion of women of reproductive age (15-49 years) who have their need for family planning satisfied with modern methods. This is because the indicator is closely linked to the indicators assigned to Target 5.6 (primarily 5.6.1 which measures the proportion of women aged 15–49 years who make their own informed decisions regarding sexual relations, contraceptive use and reproductive health care) and therefore is a reasonable proxy for the target. Another reason why Indicator 3.7.1 is used for the analysis is that it has better data availability; the Global Burden of Disease Study 2017 has provided forecasts to 2030, meaning a third-party reliable BAU on this indicator is available.

Globally, the proportion of women of reproductive age who have their family planning needs satisfied with modern methods is around 76%. Whilst this target focuses on the rights of women, there are economic and social impacts that overspill from the achievement of the goal. For instance, a study in developing countries showed that over the long term, a women's earnings, assets and body-mass indexes all improve in the regions with improved access to family planning services.[6] In addition, the WEF estimates that for every dollar invested in reproductive health services, $2.20 is saved in pregnancy-related healthcare costs.[7]

By 2030, some progress is projected to have been made by the Global Burden of Disease Study 2017 and the global average is projected to reach 81%. However, this figure could be improved upon with the targeted adoption of digital technology-enabled interventions. For instance, multiple studies demonstrate how such interventions can result in an improvement in family planning. In Kenya, a two-way SMS with a nurse to improve knowledge about contraception post-partum resulted in 12.5% more women using contraceptives relative to the control group.[8] In Cambodia, an mHealth service increased the effective use of contraception by 18% for women using the service.[9]

Adoption of these use cases in the communities where the largest gains are to be made could result in a higher proportion of females who have their needs for family planning met: up to 84%. This is an increase of 4% on the business-as-usual scenario and translates to an additional 70 million women having their family planning needs satisfied. However, there will still be more to do to reach the target of 100%, including dissemination of knowledge through other means and broader access to health centres.

Proportion of women of reproductive age (15-49 years) who have their need for family planning satisfied with modern methods



Importance of digital technologies to target attainment

	TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
⬜	**5.1** End all forms of discrimination against all women and girls	Ending all forms of discrimination primarily requires changing social norms, increasing international cooperation and maintaining effective governance. Digital technologies will indirectly help to achieve this target via their contribution to the groups of targets below.	N/A
1	**End harmful practices**		
🟧	**5.2** Eliminate violence against women	Digital technologies contribute to ending violence against women through victim identification, better communication of women's rights and improved reporting processes. Other key drivers include educating communities and changing cultural beliefs.	🟠 →
🟧	**5.3** Eliminate harmful practices	Achieving this target primarily requires changing social norms. However, digital technologies help by verifying victims' identities and enhancing education and knowledge dissemination of women's rights.	🟢 ↘
2	**Promote economic empowerment and independence**		
🟧	**5.4** Recognise and value unpaid care and domestic work	Whilst the recognition and valuing of unpaid care and domestic work is primarily a social and policy-focused issue, the gig economy, enabled by digital technologies, helps to address this challenge by recognising and rewarding jobs typically occupied by women.	N/A
🟧	**5.5** Full participation at all levels of economic and political life	Digital technologies improve the ownership and usage of mobile phones to enhance effective participation of women in economic and political life. Other key enablers of this target include changing social norms and improving education.	🟠 →
🟧	**5.B** Enhance use of enabling technology to empower women	Achieving this target relies on policy change and education of women in order to increase the adoption of technology. However, digital technologies help to empower women through mobile phone ownership and the ability to connect victims of violence.	N/A
3	**Ensure access to sexual and reproductive health**		
🟧	**5.6** Ensure universal access to sexual and reproductive health	The attainment of this target will be primarily driven by increasing awareness and changing cultural beliefs, but digital technologies do help by disseminating knowledge about sexual health and monitoring the supply of health items such as contraceptives	N/A
4	**Ensure equal rights**		
⬜	**5.A** Undertake reform to ensure equal rights to economic resources& land	Digital technologies have limited direct impact on establishing reform to achieve equal rights to economic resources. This target is primarily driven by policy and legislation.	N/A
⬜	**5.C** Adopt sound policies for the promotion of gender equality	Digital technologies have little direct impact on this target which primarily requires political willpower to legislate and enforce policies.	N/A

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET
🟩 High impact
🟧 Moderate impact
⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

🟢 Positive progress
🟠 Limited progress
🔴 Negative progress

Cluster 1

End harmful practices

Whilst progress is being made towards gender equality, women still suffer from discrimination and violence all over the world. One in five women and girls, including 19% of women and girls aged 15 to 49, have experienced physical and/or sexual violence by an intimate partner within the last 12 months.[10] Despite this, 49 countries have no laws that specifically protect women from this violence. [11] Sexual trafficking and exploitation is also of serious concern; women and girls represent more than 70% of detected trafficking victims[12] and 83% of trafficked women are subject to sexual exploitation.[13] Although child marriage is declining,[14] it continues to affect girls far more than boys; globally nearly 15 million girls under the age of 18 are married every year, equivalent to 37,000 child marriages each day.[15] Female genital mutilation declined by 25% between 2000 and 2018,[16] but more than 200 million women and girls have been cut.[17]

Cultural and social problems, such as violence against women, are complex and need to be addressed through educating communities, changing cultural norms and supporting social reforms. However, digital technologies do play an important role in helping to prevent violence, identifying victims of violence and enabling better reporting and prosecution of the perpetrators of violence.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Education and knowledge dissemination helps change cultural norms Mobile phone technology, such as social media platforms and SMS messaging, enables greater communication and dissemination of knowledge relating to women's rights, helping to change the perception of how women should be treated.	**Example:** UNICEF Uganda launched an SMS service, U-report, to act as a forum for children and youth. In 2012, a message was sent out to all 85,000 participants to alert them of the illegality of FGM and over 32,000 responded in 12 hours, sparking debate on culture vs the law.[18]	Digital Access	Importance to SDG Role of digital technologies Scalability
Mobile phone ownership increases the sense of safety felt by women Women with mobile phones tend to feel safer as they have better connections with each other and support services. The use of mobile phones also increases access to communication channels which can be used to report violence or seek help.	**Example:** In surveys conducted by GSMA between 68% and 94% of women in every country said that owning a mobile phone helps them, or would help them if they could afford one, to feel safer. [19]	Digital Access	Importance to SDG Role of digital technologies Scalability
Digital access connects victims to each other to increase the likelihood of reporting Digital access, through mobile phones or web platforms, enables victims to connect with each other and identify repeat offenders which encourages and empowers them to report cases of violence.	**Example:** Callisto aims to detect serial perpetrators of sexual assault and professional sexual coercion. This project uses sophisticated encryption to enable survivors to securely store information about their perpetrator. If the same perpetrator is named more than once, the system will connect survivors to a Callisto Legal Options Counsellor who can help survivors take co-ordinated action. Survivors that visited their school's Callisto Campus website are six times more likely to report their assault and three times more likely to connect with medical or emotional resources.[20]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ■■■■■ Higher

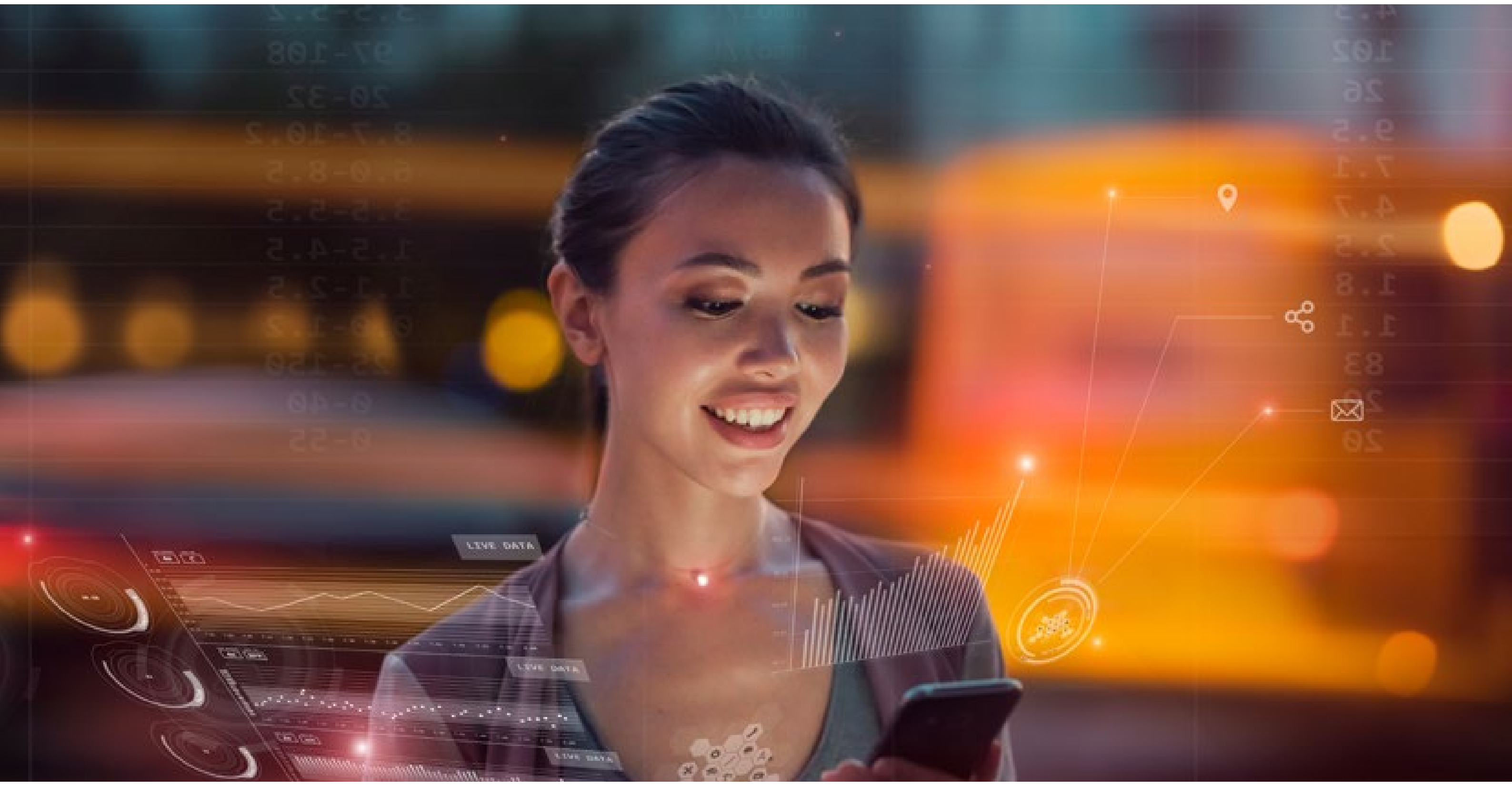
Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital identity verification prevents under-age border-crossing The use of blockchain has the potential to enable digital verification of identities in order to prevent underage border-crossing as part of trafficking networks.	**Example:** Moldova, with the help of ConsenSys, a software company, has been working on the development of a blockchain solution to catch traffickers and help child victims. The aim is to create secure, digital identities on blockchain which will help Moldovan children by linking their personal identities with other family members. When children attempt to cross the Moldovan border their eyes and fingerprints would be scanned, which would alert their legal guardians, requiring at least two to approve the crossing.[21]	Blockchain	Importance to SDG Role of digital technologies Scalability
Wearable technologies monitor and alert of imminent threat of danger Connected devices, using IoT, are capable of monitoring and tracking a vulnerable person's location in order to enable the interception of harmful practices and the provision of help.	**Example:** ROAR for Good is a woman-led technology-enabled company aiming to create safer space for women through the use of a wearable technology. Users create a list of contacts in the app who can monitor their safety. When the panic button is triggered, it sounds an alarm and alerts the people on the list who can then contact the victim or call emergency services with the victim's precise location. The company is currently focusing on the 58% of housekeepers that face sexual harassment at work.[22]	IoT Digital Access	Importance to SDG Role of digital technologies Scalability
Digitally-enabled identification of trafficking networks through monitoring victims of violence Rapid scanning of data such as ads and chat rooms helps to identify trafficking networks and individuals which helps to locate victims and connect them with resources.	**Example:** Thorn, a non-profit organisation, launched Spotlight, a product that uses AWS to protect children from child abuse. It is able to process and analyse data from 150,000 ads each day based on risk profiles supplied by law enforcement to identify trafficking networks and victims. Spotlight is used by more than 5,300 law enforcement officers in 50 states and Canada and over the last two years it has saved more than 21,000 victims including 6,000 children. [23]	Cloud Cognitive	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Image scanning of prostitution adverts identifies location of trafficking victims AI technology scans prostitution adverts to identify where trafficked people may be housed. This technology enables quicker identification of a victim's location when shown an online advert or picture.	**Example:** Adobe Research and its university partners are collaborating on a trial to locate human trafficking victims around the world. This trial involves applying AI and computer vision technology to potential trafficking images, for example to recognise a hotel from an image of a hotel room to help identify where victims have been trafficked. [24]	Cognitive	Importance to SDG Role of digital technologies Scalability
Analysis of data on violence against women finds trends and enables authority to act quickly Big data and AI have the potential to integrate data sources to provide a more accurate insight on violence against women and women's rights. This enables governments or organisations to have a more proactive approach in protecting women.	**Example:** Fujitsu and the Indonesian Ministry of Women's Empowerment and Child Protection have worked together to offer a solution to help end harmful practices against women. Data is collected from reported incidents, social media, and a news and social media tracker which uses AI. Data analytics is then used to cross-reference data to find trends and produce key insights which enable the government to improve and alter their services to focus on the protection of women's rights. [25]	Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher



Cluster 2

Promote economic empowerment and independence

Promoting economic empowerment and independence of women, closely linked to SDG 8, is essential to boosting economic growth and promoting social development. Currently, women in many countries do not have equal access to education, health care, decent work, representation in political and economic decision making and system leadership.[26] In 18 countries, husbands can legally stop their wives from working. This unequal access occurs even at a young age; around one third of developing countries have not achieved gender parity in access to primary education.[27] This translates to reduced access to skills and limited opportunities in the labour market for girls. Gender inequality in opportunities is also apparent globally in political and economic representation. For example, women represent less than 7% of CEOs of Fortune 500 companies[28] and only 24.3% of all national parliamentarians are women.[29]

Digital technologies can greatly help to support women's economic empowerment and independence. For example, increasing mobile ownership enables women to access more information and enhance their learning, manage their finances, and set up and run their own businesses. These opportunities improve women's sense of autonomy and independence enabling them to make equally important contributions to economy and society. Closing the gender gap in mobile internet use across low- and middle-income countries could add $700 billion in GDP growth in these countries over the next five years.[30] Other key enablers for increased empowerment and independence include implementing new legal frameworks regarding female equality in the workplace as well as changing attitudes towards women.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile money services improve financial independence of women Using digital technologies to offer mobile money services to women enables them to improve their financial situation and stability to help lift themselves out of poverty. This increases their sense of empowerment and independence. The long-term positive effects of mobile money services on poverty reduction are especially pronounced amongst women.[31]	**Example:** 24% of married women in Tanzania are using M-Pawa, a mobile savings and loan service, without their husbands' knowledge, giving them the power to make financial decisions without having to ask their husbands for consent. [32]	Digital Access	Importance to SDG Role of digital technologies Scalability
Mobile phone ownership improves female empowerment Approximately 200 million women are still deprived of the benefits of mobile ownership. [33] By increasing female mobile ownership, women have increased autonomy and independence as they can connect and communicate with more people allowing them to play a more active role in their economy and society.	**Example:** A GSMA survey found that 58% of women feel more autonomous and independence with a mobile phone. [34]	Digital Access	Importance to SDG Role of digital technologies Scalability
Mobile platforms improve learning and entrepreneurship Mobile technology and social media create new platforms for women to learn and acquire skills that can help them find jobs or set up their own businesses. This helps to improve women's empowerment and economic representation.	**Example:** In 2018, The Cherie Blair Foundation for Women launched HerVenture, a micro learning app. HerVenture delivers information and educational content to women owners of micro and small businesses in the start-up and growth stages of their business, providing them with practical guidance to manage and grow their business. Since its launch, HerVenture has supported more than 15,000 women in Indonesia, Nigeria and Vietnam.[35]	Digital Access	Importance to SDG Role of digital technologies Scalability
Digital technologies promote economic inclusion and valuation of women Digital access and mobile technology give women greater economic opportunities, helping to improve their participation in economy and society. For example, these digital technologies open up new platforms through which women can find work, allowing them to find access to more flexible employment.	**Example:** A survey of 2,000 women working in the US gig economy found 43% were professional freelancers, offering services on platforms such as Upwork.[36] 33% of women searched for more flexible employment, and 28% looked for work that would fit around their caring responsibilities.[37]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Cluster 3

Ensure universal access to sexual and reproductive health

Achieving universal access to sexual and reproductive health is essential to improving gender equality. Universal access to these services helps to end discrimination against women through the associated sense of empowerment and its contribution to ending harmful practices. Around the world, only 52% of women married or in a union freely make their own decisions about sexual relations, contraceptive use and healthcare.[38]

Digital technologies such as digital access and mobile phone technology can be utilised to spread knowledge and awareness on women's sexual and reproductive health and to monitor and maintain a constant supply of health items relating to these specific services. This will help to attain universal access, which can be further enabled by changing social and cultural norms as well as increasing financing of typically under-funded sexual and reproductive health services.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
mHealth helps disseminate knowledge on women's sexual health Voice messages and text messages sent using mobile phones can educate women on the use of the contraceptive pill and offer counsellor support and targeted interventions relating to family planning.	**Example:** A controlled study found that full access to m4RH, an mHealth service in Kenya providing family planning information via text message, increased customers' scores on a contraceptive knowledge test by 14%.[39]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital technologies help effectively monitor the supply of health items Digital technologies can be deployed to monitor supply chains to ensure health providers maintain a constant supply of contraceptives and other sexual health items. This reduces stock outs which helps to maximise access to these services.	**Example:** The Performance Monitoring and Accountability 2020 programme collected data on the supply of contraceptives in 11 countries. The programme was based on a unique annual data collection model capable of tracking trend data on family planning, such as contraceptive use, in order to improve the provision of sexual healthcare.[40]	Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Around the world, only 52% of women married or in a union freely make their own decisions about sexual relations, contraceptive use and healthcare.

Interaction with other SDGs

SDG 5 is closely linked to the achievement of many other SDGs, with gender equality being reflected in 36 targets and 54 indicators across the other goals. [41]

Ending harmful practices against women has positive impacts on the rest of society. It helps to eliminate inequality (SDG 10) by promoting appropriate action to reduce discriminatory activities such as trafficking and sexual exploitation. It also helps to promote peaceful societies (SDG 16) which are threatened by these type of actions.

Achieving female empowerment and independence facilitates the social, economic and political inclusion of all which promotes overall equality (SDG 10). Economic growth (SDG 8) is also positively impacted by economic empowerment and the independence of women which promotes growth that is inclusive and sustainable. Within SDG 8 there is also a specific target on the inclusion of women which can only be achieved through "full and productive employment and decent work for all women and men and equal pay for work of equal value". [42] Furthermore as demonstrated in the modelling, ensuring universal access to sexual and reproductive health, such as family planning services, is a key enabler of better health and well-being for all (SDG 3).

Digital technologies can greatly help to support women's economic empowerment and independence. For example, increasing mobile ownership enables women to access more information and enhance their learning, manage their finances and run their own businesses.

Negative externalities

Digital technologies have a particularly important role to play in the attainment of the SDGs, however they could create negative impacts on gender equality if they are not used appropriately.

Impact of widespread use of digital technologies on achievement of SDG 5

Online abuse: As mobile internet and social media become more widely adopted, security and harassment issues will become increasingly important for women around the world. Amnesty reports that one in five women in the UK have suffered from online abuse or harassment.[43] In particular, digital technologies act as an enabler for domestic abuse; individuals can monitor their partners' social media profiles, send out abuse using social media, share intimate photos or videos without their consent and even use GPS locators or spyware. Women's Aid carried out research on online domestic abuse and found that 29% of respondents experienced the use of spyware or GPS locators on their phones or computers by a partner or ex-partner. [44] Online forums also increase the ability of strangers to abuse women. [45] This can be in the form of misogynistic responses to women expressing opinions about politics or current events, which can affect their future political or economic participation.

Economic opportunities: The increasing use of digital technologies could harm women's economic opportunities. For example, it has led to the emergence of a digital gender divide across the world.[46] Robotics and deep learning are capable of playing an important role for companies but at the expense of elements of the labour force, particularly women, who are more vulnerable than men to losing their jobs to automation. [47] This is primarily because women occupy jobs more susceptible to automation such as administrative and support roles. Experts have also raised concerns that artificial intelligence could be creating male-coded gender biases throughout the systems where it is used, which would impact decision making later on.[48] Furthermore, women working in STEM careers, often heavily related to digital technologies, represent only a small percentage of the labour force in this sector. For example, they make up only 14% of the UK STEM occupations.[49]

Whilst the gig economy improves flexibility and access to opportunities for women it can also limit their economic progress. Gig-work is often short-term and project based which limits the inclusion of women in leadership roles; currently only 14% of top executives are women.[50] This reduces female empowerment and the capacity of women to play an active role in the work environment.

Enables trafficking operations: With the growth of digital technologies, one small device can facilitate many interactions central to trafficking networks such as communication, tracking, payment, and exploitation collaboration.[51] For example, using smartphone features like instant messaging apps, traffickers are able to communicate more easily with interested buyers to discuss payment or establish a meeting point. GPS capabilities and location apps enable traffickers to monitor and track in real time the location and movement of their victims making it more difficult for the victim to find help, contact law enforcement, or leave their trafficker. Electronic payments, enabled by digital technologies, allow traffickers to operate more discretely; for example, electronic funds such as Bitcoin are used as a quick and untraceable payment method. Increased technology also enables traffickers to exploit their victims to a larger audience through the use of the dark web and social media apps. Enabling traffickers to grow their operations increases discrimination against women but also threatens peaceful societies (SDG 16).

Impact of using digital technologies to achieve SDG 5

Safety concerns: Mobile phone ownership amongst women increases the channels through which strangers can harass women. This is an issue facing women across the world; a survey of 11 countries found that between 19% and 76% of women feared being contacted by strangers on a mobile. [52] This safety concern also acts as a barrier to women owning mobile phones and so constrains the potential for female empowerment.

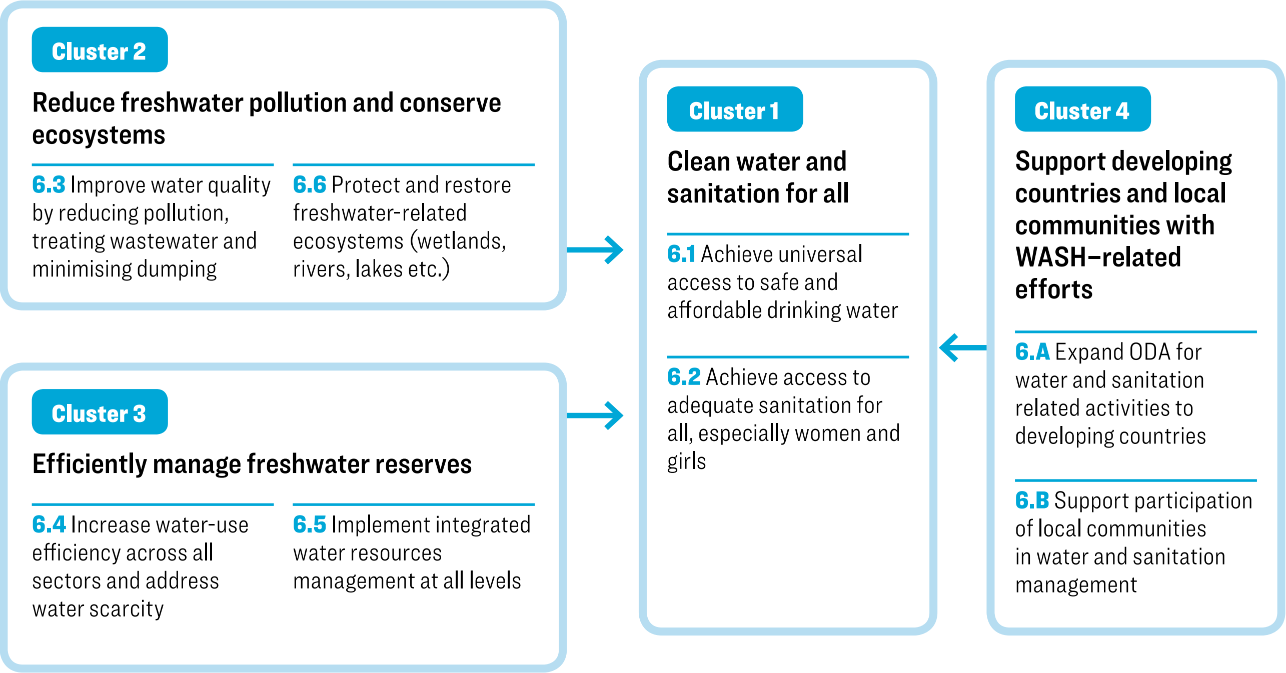
6 CLEAN WATER AND SANITATION

SDG 6 DEEP DIVE

Clean Water and Sanitation

SDG 6 focuses on the attainment of clean and safe WASH (water, sanitation and hygiene) services for all, reducing freshwater pollution and conserving ecosystems and efficiently managing freshwater reserves. Whilst access to clean water and sanitation is a basic human right, it is fundamentally lacking; 55% of the global population do not have access to safely managed sanitation services and 785 million people still lack any basic drinking service.[1] This has trapped millions of people “in poverty [through] poor water supply and sanitation, which contributes to childhood stunting and debilitating diseases such as diarrhoea”.[2] Furthermore, as temperatures rise due to climate change, the planet’s already-limited freshwater reserves will be at increased risk of water scarcity.[3]

SDG 6 System



Cluster 2

Reduce freshwater pollution and conserve ecosystems

6.3 Improve water quality by reducing pollution, treating wastewater and minimising dumping

6.6 Protect and restore freshwater-related ecosystems (wetlands, rivers, lakes etc.)

Cluster 3

Efficiently manage freshwater reserves

6.4 Increase water-use efficiency across all sectors and address water scarcity

6.5 Implement integrated water resources management at all levels

Cluster 1

Clean water and sanitation for all

6.1 Achieve universal access to safe and affordable drinking water

6.2 Achieve access to adequate sanitation for all, especially women and girls

Cluster 4

Support developing countries and local communities with WASH–related efforts

6.A Expand ODA for water and sanitation related activities to developing countries

6.B Support participation of local communities in water and sanitation management

Clean water and sanitation for all (Cluster 1) is at the crux of SDG 6 and is central to its achievement. Reducing freshwater pollution and conserving ecosystems (Cluster 2) and efficiently managing freshwater reserves (Cluster 3) directly enable Cluster 1. They focus on preserving the health of freshwater supplies, by both protecting water quality and promoting sustainable usage (and reusage, in the case of wastewater). Supporting developing countries and local communities with WASH-related efforts (Cluster 4) will help ensure that no country or community is left without access to sustainable WASH services.

The role of digital technologies in delivering SDG 6

The use of digital technologies is central to the improvement of all services, whether improving the quality of an existing supply or extending the reach of services. At a basic level, digital technologies help to connect the unconnected to WASH services. Mobile phones allow best practice messages on improved hygiene to be promulgated and e-water payment methods provide consistent and regular payments for water suppliers. Through mobile payment, traditional issues with supplying water to poor or remote regions can be leapfrogged, e.g. non-payments that result in chronic under-funding for maintaining clean drinking-water supplies.[4]

With IoT technology, there is ever-greater capability for monitoring water closely and accurately. Connected sensors can return real-time information on water distribution and quality to utilities supplying drinking water, organisations processing wastewater, and even those tasked with maintaining freshwater bodies. Meanwhile, the installation of home smart meters can encourage households to reduce their water consumption.

As digital technologies become more prevalent in water and wastewater networks, water-use efficiency is materially enhanced and decision making is better informed. Smart water networks can detect leaks and predict failures before they occur, leading to reduced water loss. Machine learning can be used to predict water scarcity, directing action before it is too late. Advanced technology, crucially, can maximise water-use efficiency in industries where consumption is high, such as smart irrigation, which could have a very significant impact on water use in agriculture and landscaping.

In addition to the application of digital technologies, achievement of SDG 6 will require significant financial investment. Public sector funding is unlikely to be sufficient to establish safe water and sanitation services globally, so finance may need to be leveraged from the private sector and crowdfunding programmes.[5] Addressing the growing threat of drought will require regulated conservation of the world's freshwater bodies, too, in addition to continued development of innovative solutions to ease water stress, e.g. desalination technology.[6]

Impact projections to 2030

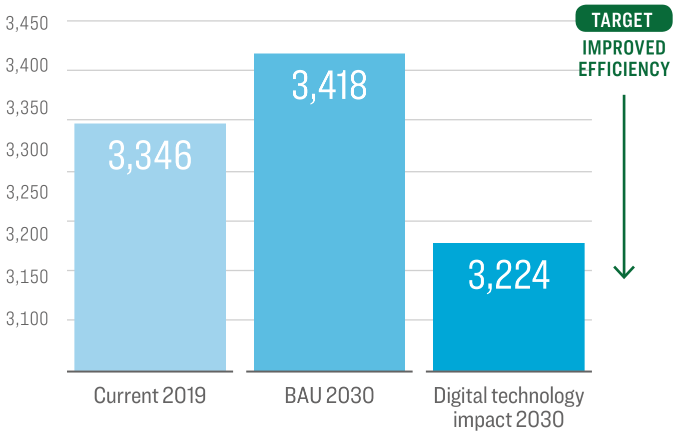
Target 6.4: Increase water-use efficiency across all sectors and address water scarcity

Growing populations are increasing the future demand for clean water, both on an everyday basis and through its use in manufacturing and the production of food.

Water withdrawal is the removal of water from the ground. It can include water from primary renewable and secondary freshwater resources, as well as direct use of treated wastewater and desalinated water.[7] Agriculture and municipal water withdrawals make up around 80% of total water withdrawals: agriculture withdrawals include irrigation, livestock and aquaculture, whilst municipal withdrawals cover domestic use. Excess water withdrawals can lead to water stress or scarcity, where water supply does not meet demand. The issue is typically localised, given difficulties in transporting water. The issue is also dynamic, such that the situation can change with the number of users and quality of the resource.[8] Climate change further compounds water scarcity, as weather events and higher temperatures lead to quicker evaporation rates, resulting in water loss.[9]

Based on predicted trends in demand, agriculture and municipal water withdrawals are expected to increase by 2.1% between now and 2030, from 3,346 billion m3 per year to 3,418 billion m3 per year. With the adoption of smart water networks and precision agriculture improving the efficiency of water use, this increase could be reversed so that even with the same levels of demand per person and as an agricultural input, municipal and agriculture water withdrawals fall 3.6% to 3,224 billion m3 by 2030. This is equivalent to a reduction of 5.7% in 2030 on the business-as-usual scenario.

Agriculture and municipal water withdrawals (10^9 m3 per year)



Target 6.1: Achieve universal access to safe and affordable drinking water

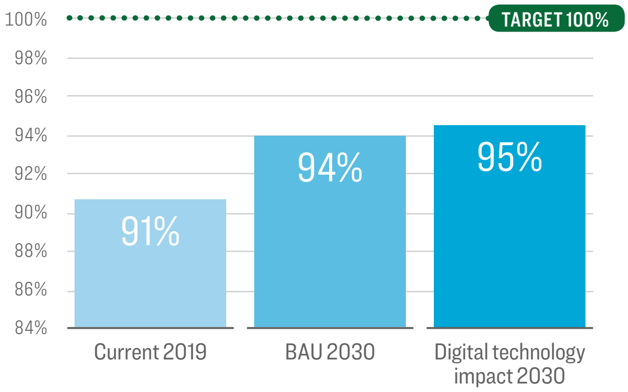
Currently, 91% of the global population have access to at least basic drinking-water services (for which the collection time is not more than a 30 minute round trip). In developing countries, the overall figure is lower at 89%, meaning that 11% of the population do not have access to basic drinking water. Based on historic trends, 94% of the global population and 93% of the population in developed countries are expected to have access to at least basic drinking-water services by 2030, though clearly this still leaves a gap.

In terms of coverage, only around a quarter of countries[10] currently have full coverage, that is, 100% of the population with access to at least basic drinking-water services. Of these countries, 31 are developed (63% of all developed countries for which data is available) and 22 are developing (15% of all developing countries for which data is available). By 2030, based on historic trends it is estimated that the number of countries with full coverage will be almost half.[11]

Safe drinking water is vital for maintaining global health. A lack of access to such services can contribute to death and illness, in particular through drinking of water that is contaminated with diseases such as cholera and typhoid.[12] The WHO estimates that annually, safe water could prevent 1.4 million child deaths from diarrhoea and the serious incapacitation of 5 million people from lymphatic filariasis, which can case painful enlargement of body parts and debilitating inflammation.[13]

Digital technologies such as smart water infrastructure to monitor water quality and automated leakage control and detection, e.g. smart meters, could open access to clean drinking water to more people. For example, rapid detection of leaks improves water-use efficiency and reduces the down time of water supplies. Based on a literature review and a survey of experts, further adoption of smart infrastructure[14] could increase the proportion of the population with access to clean drinking water to 95% (more than half of countries with full coverage) by 2030,[15] compared to the business-as-usual scenario of 94%. This increase under the digital technologies scenario would improve the lives of an additional 93 million people globally.

Proportion of the population using at least basic drinking-water services



Importance of digital technologies to target attainment

		TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1		**Clean water and sanitation for all**		
	🟧	**6.1** Achieve universal access to safe and affordable drinking water	Universal provision of clean drinking water will primarily require physical infrastructure and public investment. However, digital technologies play an important role in accelerating progress against this target by enabling WASH facilities to be effectively monitored and accessed.	🟠→
	🟧	**6.2** Achieve access to adequate sanitation for all, especially women and girls	A certain degree of physical infrastructure will be crucial to achieve this target (i.e. building and providing toilets to rural communities). However, digital technologies can be deployed to connect communities to vital knowledge and WASH initiatives. Additionally, digital technologies help to monitor the efficacy of sanitation systems.	🟢↗
2		**Reduce freshwater pollution and conserve ecosystems**		
	🟩	**6.3** Improve water quality by reducing pollution, treating wastewater and minimising dumping	Digital technologies play an integral role in monitoring the water quality of water bodies, enabling humans to intervene in polluted areas. In particular, communications networks and IoT sensors and devices enable organisations to monitor and react to changes in water quality in real time.	🟠→
	🟧	**6.6** Protect and restore freshwater-related ecosystems (wetlands, rivers, lakes etc.)	Enforced regulation that protects freshwater bodies is essential for driving progress against this target. Additionally, digital technologies (using AI and machine learning), can help predict areas most at risk of water scarcity to inform conservation efforts.	N/A
3		**Efficiently manage freshwater reserves**		
	🟩	**6.4** Increase water-use efficiency across all sectors and address water scarcity	Digital technologies provide many opportunities to improve water-use efficiency, at both the organisational and individual level. IoT sensors and AI can be used to monitor water usage and quickly detect leaks or failures in distribution systems. At a consumer level, digital technologies improve transparency on water consumption and available resources, encouraging reduced water use.	🟠→
	⬜	**6.5** Implement integrated water resources management at all levels	Expanding integrated water resources management is driven largely by policy and cross-stakeholder cooperation; digital technologies can contribute but have a secondary impact.	N/A
4		**Support developing countries and local communities with WASH-related efforts**		
	⬜	**6.A** Expand ODA for water and sanitation related activities to developing countries	Policy decision making and international cooperation are central to supporting developing countries and local communities with WASH-related efforts. While digital technologies play an indirect, enabling role for these activities, the technology itself does not contribute directly towards the achievement of these targets.	🟠→
	⬜	**6.B** Support participation of local communities in water and sanitation management		N/A

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

🟩 High impact
🟧 Moderate impact
⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

🟢 Positive progress
🟠 Limited progress
🔴 Negative progress

Cluster 1

Clean water and sanitation for all

Access to safe drinking water and sanitation services is still lacking for a large portion of the global population. The proportion of the global population using at least basic drinking water increased from 81% in 2000 to 89% in 2015,[16] but this leaves 785 million people without access to local clean drinking water, and in 2015, 12% of the global population still practised open defecation.[17] This is a major issue as contaminated water and poor hygiene practice causes the death of millions of people each year, particularly via water-borne diseases such as diarrhoea and cholera.[18] Areas in developed countries still struggle with clean water access, too. In Flint, a city in Michigan, USA, poorly treated drinking water spread lead poisoning and caused a state of emergency in 2016.[19] Amongst other side effects, this had a 'horrifyingly large' impact on the number of foetal deaths in the city.[20]

Digital technologies can connect organisations to communities where WASH services are lacking. This allows access to WASH services to be monitored in real time and key messages on hygiene and sanitation to be spread quickly. Connecting and monitoring clean water supplies is particularly important – in Nigeria 30% of water points stopped working within two years of installation. Digital technologies can ensure that these points are monitored and maintained.[21]

In addition, achieving universal WASH access will require an increase in global investment, particularly into traditional water infrastructure but also into institutions for maintaining consistent water supplies.[22] Furthermore, to provide access to safe sanitation services requires adequate faecal matter treatment and disposal. This necessitates more extensive planning than just providing access to toilets.[23] Typically, access to WASH services is disproportionately provided to the wealthy and those in urban areas; as such, investment should be directed to help those most marginalised in society.[24]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital marketing techniques can stimulate donations There is a large financing gap in the WASH sector.[25] NGOs can help to bridge this gap by providing basic services to the most vulnerable and populations where there is inadequate government support. Virtual reality films can bring the issues highlighted by SDG 6 to life and encourage greater donation to charities driving progress against the SDG.	**Example:** A VR film shown at UNICEF's annual fundraising conference influenced one in every six viewers to donate to UNICEF.[26] **Example:** WaterAid has produced a VR documentary – 'Aftershock' – that illustrates the struggles of a community to regain access to clean water after an earthquake.[27]	Digital Reality	Importance to SDG Role of digital technologies Scalability
Spread basic hygiene knowledge and training to remote areas Mobile access can be used to disseminate essential WASH information to remote communities.	**Example:** Oxfam and UNICEF developed a mobile platform, hosted on the cloud, that allowed access to surveys, interactive learning modules and e-vouchers to receive free items to facilitate better hygiene behaviour. The project, rolled out in Somalia, gave the NGOs informative data in respect to WASH coverage and practice in the region and educated the local populace to improve sanitary habits. At the beginning of the project only 75% of households evaluated knew the causes of polio, but by the end of the project nearly 100% of households knew the causes of polio and how to prevent it.[28]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Maintain consistent water supplies through e-payment systems Mobile payment can replace traditional cash payment for water. This allows a traceable payment collection and accountability throughout the supply chain. Tracking revenue (through cloud-hosted analytics) allows maintenance of the water supply to be continued, ensuring that water is constantly available. It has also lead to increased revenues in comparison to cash collection. This implementation has further benefits in areas where people traditionally had to walk long distances to collect water, and could only collect water when water vendors were available.[29]	**Example:** eWaterPay has allowed constant access to water through its e-payment model. Users place pre-paid NFC tags on an eWATER tap (equipped with IoT sensors) that will automatically dispense water.[30] The tags can be topped up through mobile money or via the eWaterPay app, removing the need for communities to travel to pay water vendors. Additionally, this increases the visibility and accountability over payments.	IoT Cloud Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT sensors reduce the downtime of water pumps due to breaks and empty wells Sensors (primarily accelerometers) can be installed in hand pumps to i) estimate the water usage; ii) measure shallow-aquifer depths; and iii) predict failure events.[31]	**Example:** Researchers from Oxford University have developed machine learning algorithms that can determine the level of water from the pump handle vibrations. The data that is collected and analysed is then shared over a mobile network to cloud storage to provide real-time information on groundwater levels and the condition of rural pumps.[32] This can reduce pump downtime due to failures (by sharing this real-time data with pump maintenance teams) and through accurate demand data, can provide more consistent supplies of fresh water.[33] The use of sensors within the pumps integrates digital technologies within a typical process for communities, without requiring digital literacy to use. As such, it could be scaled to other areas with similar effect.	IoT	Importance to SDG Role of digital technologies Scalability
Blockchain enables traceable water usage to conserve groundwater reserves In arid regions, both in developed and less developed countries, groundwater reserves must be managed and maintained to ensure clean water can be consistently offered to all. A combination of IoT sensors in aquifers, Blockchain technology, and cloud-hosted dashboards can produce a clear picture on how groundwater resources are being used, and by whom.[34]	**Example:** IBM is piloting this solution in California to try to reduce the impact of drought in the Sacramento San Joaquin River Delta. Farmers in the region will be able to trade their 'shares' of nearby groundwater with each other over the Blockchain platform to allow those who require more water to purchase it from other farmers.[35]	Blockchain	Importance to SDG Role of digital technologies Scalability
Monitoring local access to WASH services can guide investment and focus A clear picture of the distribution and access to WASH services in a region can be established through mobile connectivity and cloud platforms. This allows utilities and government organisations to identify and target the areas that are most in need.	**Example:** SeeSaw equips local communities with a water-monitoring tool that can be used to report on water quality and availability. The reporting system is simple, requiring very basic digital literacy, and carries no cost for the users (requiring users to make 'missed calls' to a central system).[36] **Example:** The Ministry of Health in Kenya, to drive its campaign to end open defecation, developed a cloud-hosted dashboard to monitor progress across the country.[37] Based on data submitted by local communities, the Ministry of Health can build an up-to-date view of access to sanitation and direct public workers more effectively.	Cloud Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 2

Reduce freshwater pollution and conserve ecosystems

As water scarcity becomes a more pressing issue, it is increasingly important to conserve existing freshwater sources and ecosystems. Currently over 80% of wastewater is discharged into water bodies without pollution treatment, hindering progress in ensuring universal access to clean water.[38] Close management of freshwater bodies is essential to maintain water quality and to anticipate and prevent the loss of freshwater reserves.

Digital technologies can play a large role in monitoring the quality and quantity of freshwater bodies. AI analysis of satellite imagery is able to both demonstrate the historical patterns of water bodies but also predict where future drought may occur. Additionally, as IoT becomes more widespread, it will offer the opportunity to providing real-time information to monitor freshwater sources and to improve the efficiency of wastewater processing.

Effective regulation and sufficient resource allocation are also central to conserving freshwater ecosystems. In addition, establishing water stewardship frameworks within organisations will encourage more sustainable treatment of water bodies.[39]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile connectivity and online platforms generate awareness about, and collective pressure for, conservation Mobile platforms allow organisations to spread essential information on freshwater bodies that are under threat or require better management. Additionally, they offer an opportunity for national and even global communities to put pressure on regulators and companies to treat freshwater and its sources responsibly.	**Example:** WWF raises awareness and support for the conservation of freshwater ecosystems through its online Action Center. Individuals can sign their name in support of advocacy campaigns, e.g. Cooperate on Fresh Water[40] and Freshwater Force,[41] to draw attention to the degradation of freshwater ecosystems.	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT allows real-time monitoring of water bodies to quickly identify polluted areas IoT-enabled drones can be employed to provide real-time and constant monitoring of the water quality in groundwater reserves. UAVs, equipped with AI image recognition, could inspect water quality in real time and be deployed in remote or hard-to-access areas, which would have previously required a human inspection.[42]	**Example:** ZTE combined the latest NB-IoT technology, cloud computing, and advanced integrated multimedia command-dispatch technology, to launch their smart water management solution. The solution can detect water pollution, and trigger a visual command-dispatch program in the event of a sudden pollution incident.[43] **Example:** Static IoT sensors can also be used to monitor freshwater sources. AT&T and Ericsson installed low-cost sensors in the Chattahoochee river, connected by low-power wide-area mobile networks, to monitor the water quality along the river. This allowed local organisations to monitor the river water quality remotely, rather than relying on infrequent manual checks, to improve responses to water pollution.[44]	IoT Fast Internet / 5G Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

IoT and AI solutions monitor waterways to prevent dumping Live video monitoring, enabled by IoT cameras, can be used to detect illegal activity around waterways. The video streams are collected into one cloud-based repository that allows oversight of activity along a waterway – this increases the chance of illegal dumping being identified and stopped.[45] Furthermore, the application of image recognition algorithms can enable AI to monitor the video streams and automatically detect signs of illegal activity.[46]	**Example:** IBM built a cloud-based IoT platform to assist Chinese government agencies to monitor freshwater bodies. It developed AI tools to recognise abnormal activities based on live video feeds from IoT cameras based at various water bodies. This can improve protection of key water bodies without a need for additional personnel, through a centralised monitoring system. Once illegal or damaging activity is detected by the system, the local agency is alerted and can react immediately to minimise potential water pollution.[47]	Cloud IoT Cognitive	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Smart water management technology can improve wastewater processing Smart sensors can be installed at wastewater facilities to collect and instantly feed back data on water quality to a cloud platform.[48] Cloud-connected web apps can display the IoT sensor data in real time and offer insights into the water quality, which helps users to adjust water treatment methods according to the levels of chemicals in the water. In addition, in conjunction with predictive modelling, the data gathered from smart sensors can be used to forecast the demand on resources and plan accordingly (reducing waste and energy use).[49]	**Example:** IBM worked with Aqualia Spain to implement digital technologies to improve their wastewater management at a plant in Spain. IoT sensors collected data, which fed into advanced algorithms to determine the necessary quantities of energy, oxygen and chemicals required to treat the water. The system updated this feedback every two hours, which improved the treatment efficiency. There was a 17% reduction in sludge production and the plant required 14% less chemicals to remove phosphorus from the wastewater.[50]	Cloud IoT Cognitive	Importance to SDG Role of digital technologies Scalability
Computer image recognition can predict future water scarcity The analysis of satellite imagery using AI can map the rate of depletion of water sources and determine whether they are at particular risk (i.e. if they are being depleted at a faster rate than can be replenished). This can improve visibility of water availability and concentrate focus on water sources most at risk.[51]	**Example:** Descartes Labs, in conjunction with Google Cloud, have developed a platform to analyse historical satellite imagery to model and illustrate changes to water bodies over time. With these models and the historical datasets, machine learning can then be used to predict future changes and indicate where water scarcity may emerge. This can be used to identify which water ecosystems are at risk to inform conservation and encourage sustainable use of water bodies.[52]	Cognitive Cloud	Importance to SDG Role of digital technologies Scalability
Analysis of water level data and weather forecasts can predict risks of flooding Cognitive technologies can analyse key data from freshwater bodies and weather forecasts to produce accurate flood warnings. This allows early warnings to be provided to households at risk and utilities companies to adjust water management to reduce the severity of flooding.	**Example:** WSP, the University of Surrey and Pyterra developed a machine learning solution that can predict flooding and optimise water storage catchments. This allows utilities companies to better manage water flows in extreme conditions and reduce the impact of flooding.[53]	Cognitive IoT	Importance to SDG Role of digital technologies Scalability

Lower 🟦🟦🟦🟦🟦 Higher

Cluster 3

Efficiently manage freshwater reserves

Depleting freshwater reserves affects developed and developing countries alike. Approximately one third of countries have medium or high levels of water stress,[54] with more than two billion people living in countries experiencing high-level water stress.[55] However, the current deployment of freshwater resources can be greatly improved with an estimated 30% of global water withdrawals currently lost through leakage.[56] As such, moving towards efficient management and use of freshwater reserves can play a major role in minimising the impact of water scarcity on society.

Digital technologies can provide a number of opportunities to aid and encourage water-use efficiency. Smart water meters help reduce individuals' water consumption and smart technology can be used to improve water-use efficiency, both in the water distribution network as well as for irrigation and manufacturing. This technology will be central to improving water-use efficiency in cities, where seasonal water shortages are forecast to affect 1.9 billion people in 2050.[57]

National and global cooperation to manage freshwater resources (Target 6.5: Implement integrated water resources management at all levels) will help ensure use does not exceed recharge of freshwater bodies, to protect against depleting water reserves. Agriculture (SDG 2) and water usage are inextricably linked – globally agriculture irrigation accounts for 70% of global water use.[58] Increasing water-use efficiency in agriculture would have a material impact on global water use, though this might be offset if there were also a marked increase in agricultural production.[59]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Apps gamifying water consumption can encourage reduced water use Apps that monitor and collect real-time water usage information can encourage users to lower water consumption.	**Example:** TapOff was developed during the Day Zero water crisis in Cape Town, South Africa, to encourage reduced water consumption. It shared important information regarding the water shortage but also featured a water usage leaderboard (collecting data from the City of Cape Town website). This gamified water saving amongst the local population.[60]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ■■■■■ Higher

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Connected water meters allow consumers to quickly identify leaks and adjust their water usage Smart water meters, using IoT sensors and a mobile broadband connection, can provide real-time feedback to consumers, and utilities providers, on consumption. This allows consumers to track their daily use of water, rather than relying on estimates. By giving consumers accurate oversight of their water consumption, smart water meters can encourage more conservative behaviour and efficient use of water; smart meters can reduce water demand by up to 17%. Additionally, smart meters can help identify leaks in home water systems in real time, which can drastically reduce water loss – a major source of inefficiency in domestic water consumption.	**Example:** Suez has developed a smart water meter that both tracks household water consumption, and aims to assist consumers in managing their water consumption. Smart water meters provide real-time information to an application – "ON'connect coach" – that displays a breakdown of different water usages and compares this to consumption rates of similar households. Additionally, the application provides suggestions for adjusting water consumption, indicating the potential savings if the household changed its activities or used water-saving technology. The application aims to promote sustainable water consumption habits, particularly by allowing users to see how much money they are able to save by using water more efficiently.[61]	IoT Digital Access	Importance to SDG Role of digital technologies Scalability
Digitally-enabled water recirculation can improve water efficiency in homes Closed loop shower systems can provide on-site water recycling.	**Example:** The Oas shower filters use water with micro-filters and then sterilise it to allow reuse. IoT technology tracks water and energy consumption, and monitors the water quality and filters. This data is then fed back to the user via a mobile app, e.g. to alert the user when the filter needs to be replaced.[62] Consumption data is then stored in the cloud, allowing users, e.g. hotels, to analyse water- and energy savings. The shower can generate up to 90% water savings and 80% energy savings.[63]	IoT Cloud	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Smart water networks predict water demand and anomaly events to improve efficiency of water uses AI can be integrated within a water management system to predict demand and recognise anomalous events (indicative of equipment failure). This allows water pressure and distribution to be optimised (lowering the energy used by water facilities) and can prevent system failures or leaks, reducing water loss.[64]	**Example:** EMAGIN deploys AI to optimise water transmission and to prevent system failures or leaks. The 'HARVI' (Hybrid Adaptive Real-Time Virtual Intelligence) solution can anticipate disruptive events, e.g. high demand, and manage pump pressure accordingly.[65]	Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Smart and reactive systems improve water efficiency of urban irrigation AI can be used to analyse weather data (collected from satellites, weather stations and increasingly IoT sensors) to improve weather forecasting and prediction. More accurate and real-time weather predictions can reduce water usage for irrigation.[66]	**Example:** AT&T and HydroPoint partnered to connect HydroPoint's highly advanced weather data analytics to smart controllers (connected devices that control urban landscape irrigation). This allows real-time weather data (including insights on temperature, humidity and rainfall) to be taken into account to improve water conservation.[67] This automated process can reduce water use between 16% and 59%.[68]	IoT Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Interaction with other SDGs

Achieving access to clean water and sanitation for all will have particularly positive effects on no poverty (SDG 1) and good health and well-being (SDG 3).[69] Clean water access lowers the proliferation of waterborne diseases, improving the health of communities.[70] Additionally, local and consistent supplies of clean water can minimise the time rural families need to spend collecting water, allowing children to stay in education.[71] In Panama, schools with better WASH services had reduced dropout rates (particularly among girls).[72]

Reducing freshwater pollution and conserving ecosystems go hand in hand with the aims of life below water (SDG 14) and life on land (SDG 15). Maintaining clean freshwater bodies will preserve terrestrial ecosystems and help limit pollution entering the world's oceans.[73]

Efficiently managing freshwater reserves will be critical in order to end hunger (SDG 2) – agriculture is the largest consumer of freshwater and will not be able to keep up with global food demands without sustainable water supplies.[74] Furthermore, if the effects of water scarcity can be minimised globally and universal freshwater access maintained, this should help prevent human conflict (SDG 17) over water bodies.

Negative externalities

Impact of widespread use of digital technologies on achievement of SDG 6

E-waste: Improper disposal of e-waste, i.e. when e-waste is dumped or sent to landfill, causes leakage of toxic metals into the soil and, eventually, groundwater sources.[75] This contaminates freshwater sources, reducing the safety and availability of water. As only 20% of e-waste is formally recycled, the growing proliferation of digital technologies will continue to exacerbate this issue.[76]

Rapid urbanisation: Rapid urbanisation, stimulated by the economic growth of the technology industry, places more strain on freshwater resources. Bangalore, the technology hub of Southern India, experiences water shortages and can only provide water for 60% of the city's population through its current infrastructure. Its population doubled from 2001 to 2019, owing to the growth of the technology industry in the city.

Impact of using digital technologies to achieve SDG 6

Use of sensors: Many of the solutions that digital technologies provide for promoting progress against SDG 6 involve the use of IoT sensors. They are valuable for monitoring water quality and flow and can provide this information in real time to the users. However, the propagation of IoT sensors will contribute to the e-waste problem (SDG 12), particularly as the sensors used in these solutions must be waterproof, and therefore will be less easy to disassemble or recycle.[77]

Wastewater treatment is energy intensive: Solutions for treating wastewater are energy intensive. As the use of smart water management systems becomes more common, efforts to reduce wastewater pollution may increase energy usage (SDG 7) and, therefore, increase emissions, contributing to Climate Change (SDG 13).[78]

Approximately one third of countries have medium or high levels of water stress, with more than 2 billion people living in countries experiencing high-level water stress.

7 AFFORDABLE AND CLEAN ENERGY

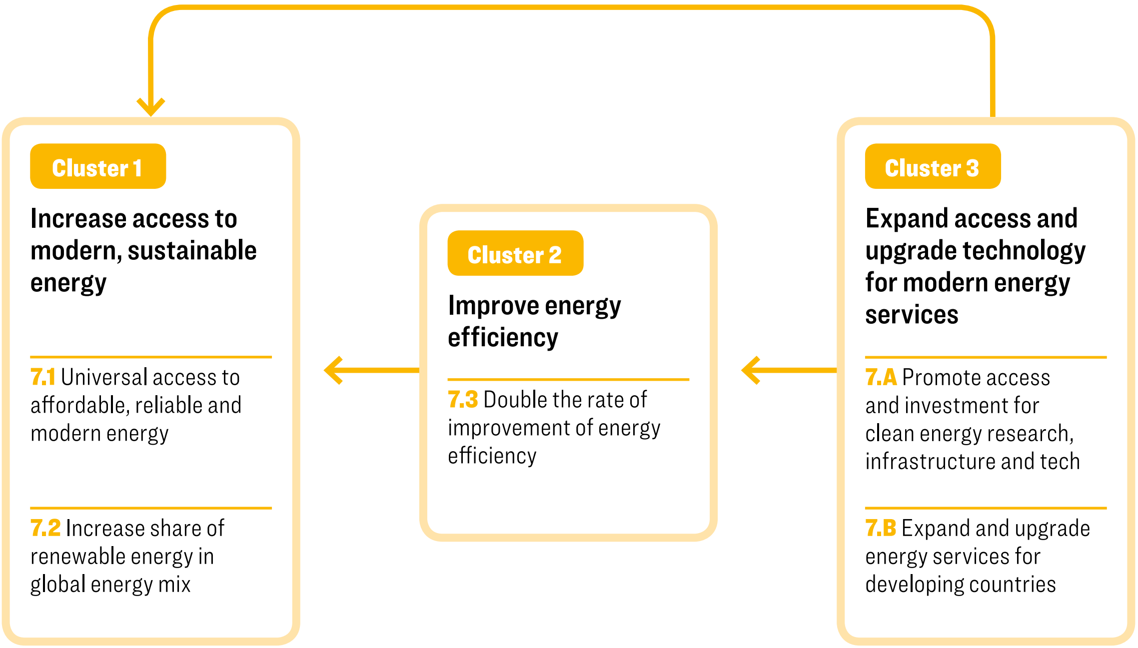
SDG 7 DEEP DIVE

Affordable and Clean Energy

SDG 7 focuses on the universal provision of affordable and clean energy, including improving access to energy sources, increasingly making these sources renewable, improving energy efficiency and upgrading the technology that is currently deployed.

This Goal addresses a critical challenge for both society and the biosphere, against which global efforts are off track. 840 million people do not have access to electricity,[1] 2.9 billion people live without access to clean cooking equipment,[2] and only 17.5% of total final energy consumption is from renewables.[3] For developing countries, access to energy is the key priority, as it is critical to alleviate poverty. Globally, without dramatically increasing the proportion of clean energy used, it is inconceivable that the world will be able to tackle the global climate crisis. The most developed, and by extension typically polluting, economies will need to lead the way to address this.

SDG 7 System



Cluster 1

Increase access to modern, sustainable energy

7.1 Universal access to affordable, reliable and modern energy

7.2 Increase share of renewable energy in global energy mix

Cluster 2

Improve energy efficiency

7.3 Double the rate of improvement of energy efficiency

Cluster 3

Expand access and upgrade technology for modern energy services

7.A Promote access and investment for clean energy research, infrastructure and tech

7.B Expand and upgrade energy services for developing countries

Achieving universal provision of modern, sustainable energy is driven by the three clusters of SDG 7 targets. At the core of SDG 7 is improving access to sustainable energy (Cluster 1), which involves extending grid access, and reducing reliance on ‘dirty’ fuels e.g. wood for power and household use, as well as increasing the share of renewables and decreasing reliance on fossil fuels. Improving energy efficiency (Cluster 2), or reducing energy intensity, helps negate rising energy demand by reducing the amount of energy required to achieve the same economic ouput. Energy efficiency is defined by the UN in terms of energy intensity, i.e. the amount of energy required to produce one unit of economic output.[4] Finally, SDG 7 relies on expanding infrastructure, research and technology (Cluster 3) through increased investment and international cooperation.

The role of digital technologies in delivering SDG 7

Digital technologies impact the provision of modern, sustainable energy primarily through enabling new business models, helping connect those in rural under-provisioned communities to new ways of financing their electricity access through pay-as-you-go (PAYG) mobile schemes. Digital technologies also contribute to increasing the use of renewable energy through improving the forecasting of renewable supply and also through enabling the smart grid, which primarily relies on digital technology to transmit information. The smart grid will allow greater analysis of data, to smooth demand curves and better balance supply and demand, by incentivising customers to alter their consumption patterns to periods of renewable production.[5] The smart grid is also likely to improve energy intensity, as it allows better pinpointing of grid losses.[6]

Digital technology will not, however, be sufficient to meet the aims of SDG 7. Governments and the private sector must continue to invest in the physical supply side infrastructure including distributive infrastructure. Furthermore, increased storage capacity is necessary to continue effectively balancing the supply and demand of electricity as more renewables are integrated into the grid. Improving the renewable energy-generation infrastructure will also be necessary to ensure that the sustainable aspects of SDG 7 are fulfilled. Carbon pricing and carbon taxes are increasingly seen as key policies for combatting climate change by reducing CO2 emissions.[7] Carbon offsetting to finance clean-energy products will also be one means of acquiring the required investment for the transition to sustainable energy production.

Impact projections to 2030

7.1: Access to electricity

Reliable electricity supplies are integral as enablers for economic growth and community prosperity. Considering the use cases discussed in this report, electricity access will continue to be important as it provides access to digital technologies, e.g. technology in education (SDG 4); mHealth to improve health access (SDG 3); and precision agriculture (SDG 2).

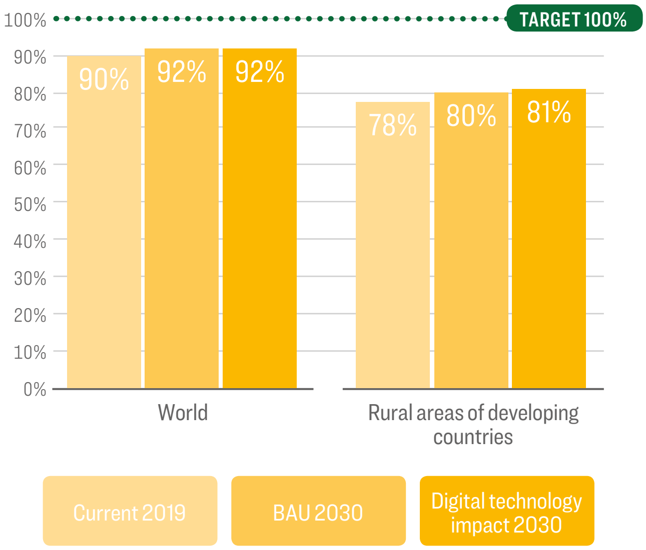
Currently, around 89% of the global population have access to electricity. Given the nature of electricity networks and geography, the figure varies between urban and rural areas; 97% of urban populations have access, compared to 79% of rural populations. The proportion further varies by geographic region. In sub-Saharan Africa for instance, only around 44% of the population has access to electricity. According to the IEA, 90% of the people without access to electricity in 2030 will live in sub-Saharan Africa.

Micro grids have been shown to be affordable tools to connect the unconnected, given the complexity and expense of connecting potential users in inaccessible rural locations to national networks. Solar powered microgrids could be used as part of the solution to address the lack of national grid access in parts of Sub-Saharan Africa, for example, as they are able to provide an autonomous source of electricity. Digital technology can enable the spread of micro grids in two ways. Firstly, for one-household micro (sometimes called 'pico' or 'nano') grids, PAYG models enabled by digital access can allow users to gradually pay off the capital cost of the purchase of individual-household solar panels. Secondly, blockchain is emerging as an option to enable the trading of locally produced renewable energy between households.

Focusing on rural populations in developing countries where the largest gains are to be made, the situation is projected to improve somewhat to 2030. Currently, 78% of populations in the rural areas of developing countries have access to electricity. Based on projections made by the IEA,[8] 80% could have access to electricity by 2030 under a business-as-usual scenario (equivalent to 44 million more people).

Targeted adoption of micro grids has the potential to connect the unconnected to a renewable energy source. Under this digital technology adoption scenario, the proportion of rural populations in developing countries across the world with access to electricity could increase to 81% (equivalent to an additional 31 million people).

Proportion of the population with access to electricity



7.2: Renewable energy share in the total final energy consumption

Currently, 18% of all energy consumed globally is estimated to be from renewable sources. In developed economies, where there has been a built up reliance on electricity production from oil, gas and coal sources over the years, the figure is around 12%, whereas in developing countries the figure is around 23%.

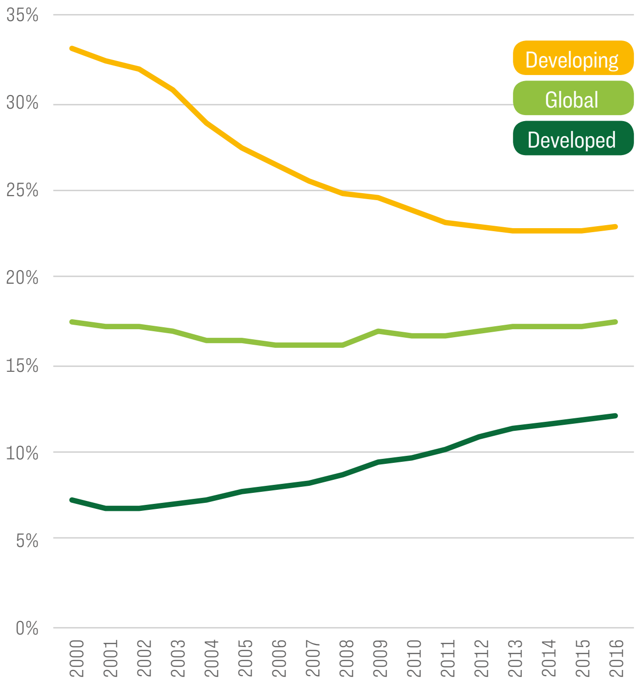
In recent years, the share of renewable energy in final consumption has shown slow signs of increasing globally (around 7% increase between 2006 and 2016). This trend is the result of a combination of factors. In developed countries, policymakers and populations have become increasingly aware of climate change and the cost of renewable energy is declining, resulting in an increase in renewable consumption. In developing countries, there has been a decline in renewable consumption as a result of rapid electrification using fossil fuel electricity production.

Digital technologies have a role to play in improving the share of renewable energy consumption. Smart electricity grids use digital communications and other advanced technologies to detect local changes in usage, enabling improved management of electricity supply and demand. Smart electricity grids allow for real-time recording of electricity consumption and off-grid production using renewable sources via smart meters (i.e. behind the meter production); the optimisation of distribution networks using real-time monitoring and automation; and at the transmission level allow networks to operate at higher capacities, closer to their physical limits. Smart grids also improve the management of energy by allowing consumers to become 'prosumers' (i.e. consumers are able to supply the grid with surplus energy produced by their own renewable sources). Two ways by which digital technology enables this is through IoT, which can be used to remotely monitor consumption and production, and AI, to automatically control devices.

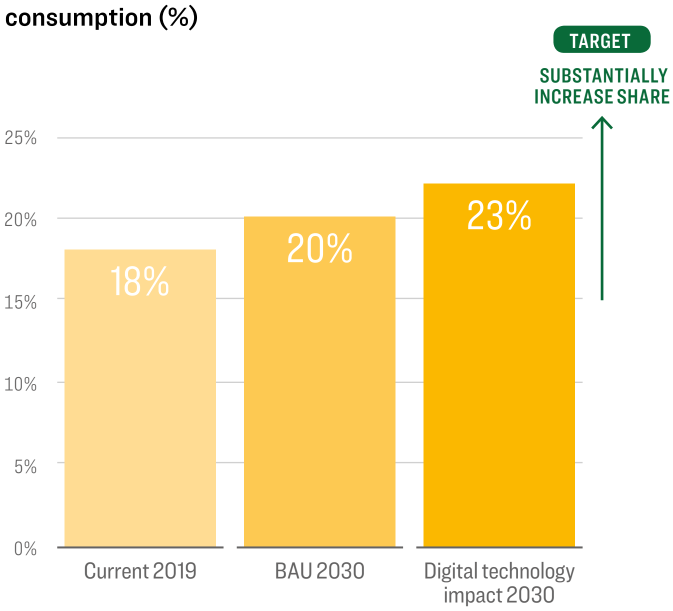
By enabling more efficient management of the electricity grid and consumers to become 'prosumers', the share of renewable energy consumption could increase to 23% globally by 2030 compared to a business-as-usual scenario of 22%. Though a small percentage increase, this could mean avoiding 71 Mt (0.071 Gt) of CO2e emissions.

Achieving progress beyond this level will require more than digital technology. A survey of experts unanimously agreed that improved storage options, e.g. batteries or thermal storage, an increased number of renewable energy sources, and reliable interconnections of these with the main grid would be required to achieve a higher share of renewables in final energy consumption.

Renewable energy share in the total final energy consumption (%)



Renewable energy share in the total final energy consumption (%)



Importance of digital technology to target attainment

		TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1		**Increase access to modern, sustainable energy**		
	🟧	**7.1** Universal access to affordable, reliable and modern energy	Digital technologies will directly improve basic electricity access through facilitating new business models. However, they will have a more limited impact on the adoption of clean fuels and energy for household use.	● ↗
	🟩	**7.2** Increase share of renewable energy in global energy mix	Digital technologies will have a substantial impact on improving renewable share, through facilitating new business models and improving the function of the grid.	● ↗
2		**Improve energy efficiency**		
	🟩	**7.3** Double the improvement in energy efficiency	Digital technologies will have a major impact on improving energy efficiency, primarily by enabling the smart grid.	● ↘
3		**Expand access and upgrade technology for modern energy services**		
	⬜	**7.A** Promote access and investment for clean energy research, infrastructure and tech	Digital technologies will have limited direct impact on the provisioning of access to research and technology, but may help to track the financial flows to support this.	N/A
	⬜	**7.B** Expand and upgrade energy services for developing countries	Digital technologies will have limited direct impact on the expansion of infrastructure and upgrading of technology. This is primarily driven by policy and financing.	N/A

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

- 🟩 High impact
- 🟧 Moderate impact
- ⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

- 🟢 Positive progress
- 🟠 Limited progress
- 🔴 Negative progress

Cluster 1

Increase access to modern, sustainable energy

Increasing access to energy is critical to the improvement of a range of other development indicators,[9] yet current progress suggests that the 2030 aim of providing universal access to electricity (Target 7.1) is unlikely to be met. Whilst the current global electrification rate is 89%[10] and access from 2010-2017 grew by 920 million, the UN projects that access to electricity in 2030 will only be 92%.[11] This is because the vast majority (87%)[12] of the remaining unconnected settlements are located in rural areas, where it is hard to achieve the economies of scale required for grid electrification.[13] Meanwhile, three billion people are still reliant on polluting fuels and technology for cooking,[14] and by 2030, the UN estimates just 74% of the global population will have access to clean cooking solutions.[15]

The energy sector is making some progress in increasing the share of renewables, but this is not currently sufficient to meet the goal, given the need to reach a zero-carbon energy system by the second half of the century.[16] The share of renewables of total final consumption is growing only marginally and in 2015 reached 17.5%, up from 16.6% in 2010.[17] Global renewable energy consumption needs to accelerate substantially to meet the 2030 Agenda.[18]

Digital technologies will aid efforts to expand access to sustainable energy. Solving the rural electrification issue will require decentralised off-grid options, which are likely to be the least-costly option for 60% of those still lacking access to electricity.[19] Decentralised networks are frequently renewable based, e.g. PAYG solar,[20] and may require digital technologies to create the business models that uphold the networks. The smart grid can also enable increased renewable share through demand response programmes, and via predictive modelling of renewables. [21] However, digital technologies are likely to have a more limited role in the adoption of clean fuels and technology for household use.

Future improvements in the grid will require substantial government and private sector investment, and it should be noted that the uptake of the smart grid will be affected by factors including geography, market need, and the existing infrastructure and generation mix. Governments will also need to create sufficient policy support to enable operators to invest in off-grid access. Carbon offsets created through carbon trading schemes could be used to finance these clean energy solutions. To meet challenges around clean cooking, current solutions must be scaled, with governments investing in transitional cooking solutions, and encouraging a multi-sectoral collaboration between health, climate and energy sectors to improve the uptake of clean cooking.[22]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT and digital access create new business models which encourage the use of clean cooking stoves Clean cooking stoves with attached IoT temperature sensors measure a household's cooking activity when switching to clean fuel, and allow them to earn usage-based payments, generating income for families in less economically developed countries.	**Example:** Nexleaf StoveTrace produces next-generation sensors and analytics tools that can evaluate the adoptability of clean stoves (including liquid and solid fuels). The tools track usage of clean stoves as well as old, dirty stoves whilst providing users with usage-based payments to afford the cleaner stoves.[23]	IoT Digital Access	Importance to SDG Role of digital technologies Scalability
Digital access enables PAYG financing with digital payments PAYG-based plug-and-play solar solutions, where consumers pay tailored instalments towards the ownership of systems spread at an average annual growth rate of 140% between 2013 and 2016.[24]	**Example:** SolarAid provides not-for-profit access to renewable solar energy to the poorest customers in sub-Saharan Africa. A pilot of PAYG in Kenya found purchase rates for entry-level micro solar grids increased from 10-15% of targeted customers to 20-50%.[25]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ■ ■ ■ ■ ■ Higher

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AI and IoT are used for predictive maintenance of renewables to keep supply functioning effectively Predictive maintenance helps ensure the renewable supply is functioning at its optimal level with maximum supply into the grid.[26]	**Example:** Boldare, a project team from a wind-based hackathon sponsored by leading European energy-providers, is piloting an application for the predictive maintenance of wind turbines using machine learning algorithms.[27] The application was able to detect the failure of wind turbine components up to 60 days in advance.[28]	Cognitive IoT	Importance to SDG Role of digital technologies Scalability
Grid integration of renewable energy is enabled by greater digitisation of system operating procedures Implementing renewable energy in the grid requires a number of practices, e.g. producing the facilities for generation and investing in transmission lines. However, digital technologies can also be effective in increasing renewable share in the grid. In particular, the sharing of real-time information between wind and solar operators and the grid allows it to accommodate fluctuations in renewable supplies.[29]	**Example:** The Electric Reliability Council of Texas (ERCOT) transitioned to a nodal market, with a higher percentage of renewable power thanks to real-time, data-driven grid insight and assessment tools.[30] The percentage of wind-powered electricity in ERCOT has increased from 2% in 2006 to about 18% in 2017, while total electricity use has increased in parallel.[31] This has allowed a number of local companies, including Dell, to increase their renewable share substantially.	Digital Access	Importance to SDG Role of digital technologies Scalability
AI improves quality of renewable prediction AI can help improve the quality of solar or wind forecasting, which is inherently difficult to predict. Improved forecasting makes it easier and more lucrative for renewable-power generators to participate in electricity markets.[32]	**Example:** Researchers compared models that were fed using US government weather data and found that AI could be 27% more accurate at predicting solar forecasts than standard models.[33]	Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Blockchain automates grid-level electricity trading between prosumers, consumers and suppliers Using the smart contracts enabled by blockchain, small electricity producers can sell excess renewable energy to other network participants.[34] This could range from decentralised grids where small-scale renewable producers trade, to selling energy back into the national grid. These processes are executed autonomously through smart contracts.	**Example:** LO3 Energy, the developer of the Brooklyn Microgrid, is developing a series of projects in partnership with utility providers and retailers that allow participants to buy and sell locally generated renewable energy over a peer-to-peer network, via smart contracts.[35]	Blockchain	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 2

Improve energy efficiency

As the world's energy demand continues to increase, improving energy efficiency is key to reducing the pressure on energy supply. The rate of improvement in primary energy intensity fell by more than 10% globally between 2010 and 2016,[36] as energy use became more efficient. However, the recent rate of improvement in energy efficiency is still considerably below the 2.7% needed to meet the global target in 2030,[37] with the estimated rate of improvement in 2018 just 1.3%.[38]

Digital technologies will help improve energy efficiency, as the smart grid and smart meters give consumers a clearer picture of energy consumption and potentially help them move towards dynamic tariffs.[39] Digital technologies also reduce grid losses on the supply side.[40] The smart grid has a multi-faceted role across clusters 1 and 2, as it can both help to integrate more renewable sources and improve energy efficiency.[41]

Alongside the introduction of new digital technologies, governments need to build policy and regulatory frameworks to mandate efficiency standards in electrical goods design. Continual efficiency gains in end-use devices, e.g. refrigerators and computers, will be necessary to improve energy intensity. Modernisation of supply infrastructure will also be required to reduce electricity transmission and distribution losses,[42] and improvements in electricity generation from fossil fuels will also be essential.[43] However, the sustained presence of energy-intensive sectors, e.g. manufacturing, will prevent substantial energy intensity reduction, particularly in developing economies.[44]

Cluster attainment by technology table

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Smart meters allow people and organisations to monitor and track energy usage, prompting behavioural change Businesses and individuals can use smart meters to measure and understand their energy usage better, allowing them to take steps to reduce consumption.[45] In the UK, research shows that 86% of people take energy-saving actions once their device is installed,[46] for example 40% of people install energy-efficient lightbulbs immediately after acquiring a smart meter.[47]	**Example:** Taiwan Mobile uses remote detecting devices to monitor base station energy consumption, gathering real-time information. This reduces reliance on human meter-reading (minimising travel emissions) and allows anticipation and prediction of energy consumption. This has reduced CO2 emissions by 25 tonnes per year.	IoT	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
The smart grid can be used to deliver more precise demand side management Current grid infrastructure typically relies on the ramping up of carbon-intensive 'peaking' power stations when demand outstrips supply. However, the smart grid provides suppliers with real-time information on electricity consumption, allowing them to make demand side management strategies to encourage consumers to shift demand to off-peak periods.[48]	**Example:** UK government research suggests that the rollout of 53 million smart meters in the UK could save up to £8 billion a year, and allow settlement of pricing on a half-hourly basis.[49]	IoT	Importance to SDG Role of digital technologies Scalability

Lower ■■■■■ Higher

Interaction with other SDGs

Increasing access to energy has traditionally improved a range of other development indicators, such as economic growth (SDG 8), poverty (SDG 1), and equality (SDG 10).[50] Access to energy is necessary to help generate income and to satisfy basic needs, such as lighting and heating.[51] Energy access can also increase gender equality (SDG 5). For example, in South Africa electrification has raised female employment in newly electrified communities by almost 10%, because it has improved the efficiency of household tasks.[52] Access to clean energy will also have huge impact on SDG 3 as the dirty fuels used within homes for cooking and cleaning are currently estimated to cause 3.5 million premature deaths each year.[53]

Increasing access to renewable energy has a host of other benefits, most notably on SDG 13, the achievement of which is dependent on the world moving towards net zero-carbon emissions. Poor outside air quality will also be improved by a reduction in incomplete combustion from fossil fuels, which is currently linked to a further three million premature deaths a year (SDG 3).[54]

Improvements in energy efficiency will have further positive interactions with SDG 13, as improved energy efficiency will temper the increasing energy demand from economic growth.[55]

Negative externalities

Impact of widespread use of digital technologies on achievement of SDG 7

Increased energy demands: The widespread adoption of digital technologies is unlikely to be a significant barrier to the attainment of SDG 7. However, the increased energy demands of digital technologies deployed to achieve sustainable development may hinder improvements in the percentage of energy from renewable sources.

Impact of using digital technologies to achieve SDG 7

Exacerbating inequalities: More broadly, deployment of digital technologies within SDG 7 are unlikely to have significant negative impacts on other SDGs unless they exacerbate inequalities in access. In developed economies, the elderly and underprivileged may be ill-equipped to fully participate, given the high upfront costs of new equipment and the extensive reliance of online services.[56] In developing economies, the introduction of PAYG solar has the potential to exacerbate inequalities, as some customers may not be able to repay loans (particularly those in or close to poverty with other pressing financial matters).[57]

Energy savings: An increased deployment of digital technologies to achieve SDG 7 will also contribute to the energy footprint. However, this may be offset in energy efficiency savings.

Hacking: The introduction of the smart grid, and proliferation of IoT devices, could leave businesses and citizens open to hacking.[58] Given the criticality of energy supply for the economy, there may also be increased geopolitical incentive to hack smart grids.

SDG 8 DEEP DIVE

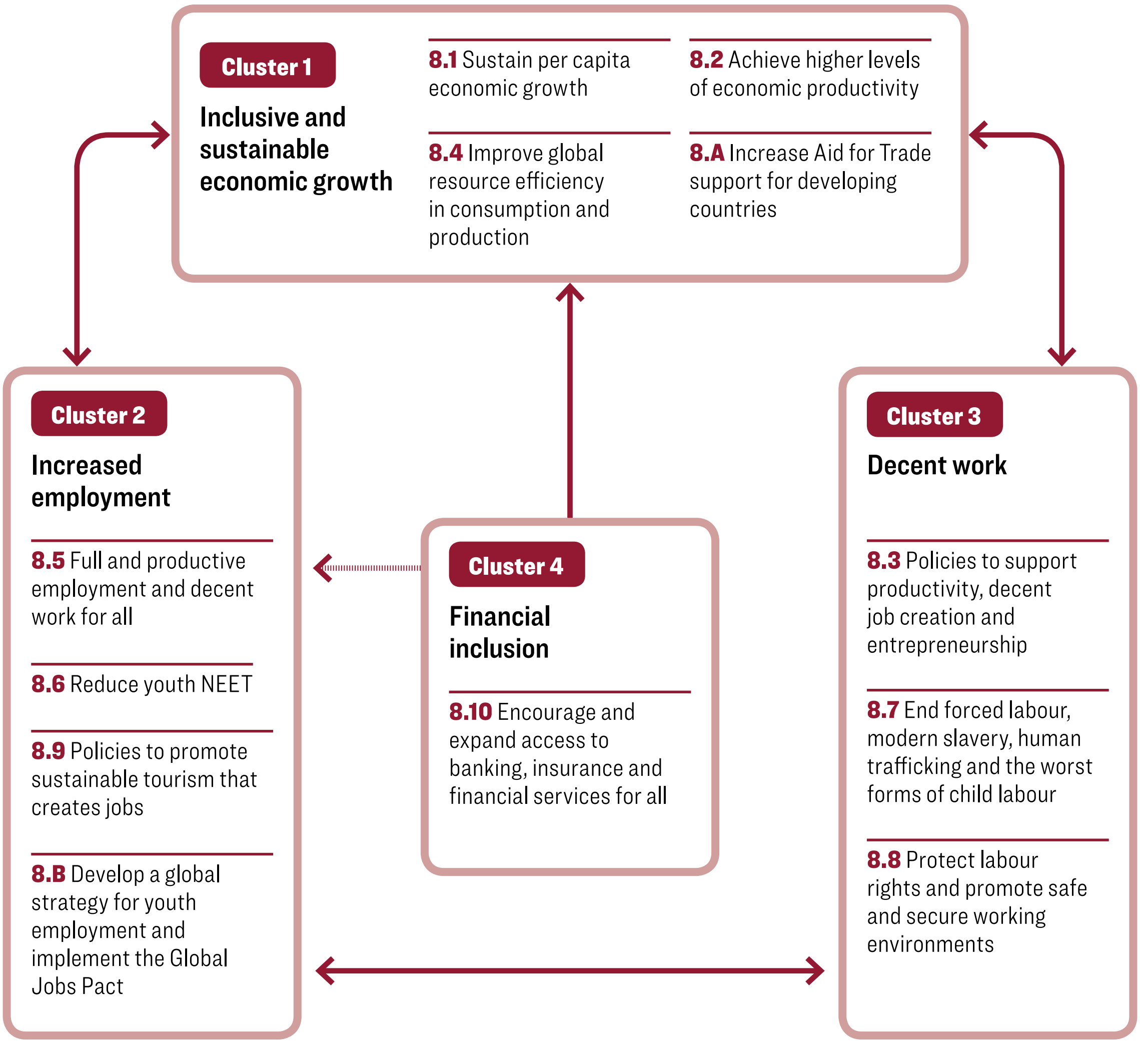
Decent Work and Economic Growth

Sustained and inclusive economic growth and decent work opportunities are necessary for achieving sustainable development.[1] With around half of the world living on the equivalent of $2 per day or less, raising incomes and providing jobs is an important step to raising living standards and quality of life. A lack of decent work opportunities risks eroding the basic social contract underlying democratic societies: that all must share in progress.[2]

SDG 8's targets focus on sustained economic growth, increased employment and provision of decent work, supported by greater financial inclusion. Achieving these targets enables people to better their own circumstances, helping to address many of the other SDGs such as poverty, hunger, education, health and inequality.

Since the financial crisis in 2008, progress has been mixed. Global labour productivity has increased, albeit more slowly than previously, and unemployment is back to pre-crisis levels. However, the global economy is growing at a slower rate than previously and a large proportion of adults in developing countries remain unbanked. Youth unemployment and informal employment persist as concerns and many workers, particularly in developing countries, experience poor and unsafe working conditions. The world must act to ensure that these concerns are addressed as part of a wider effort to promote sustainable growth and decent work for all by 2030.

SDG 8 System



Cluster 1

Inclusive and sustainable economic growth

8.1 Sustain per capita economic growth

8.2 Achieve higher levels of economic productivity

8.4 Improve global resource efficiency in consumption and production

8.A Increase Aid for Trade support for developing countries

Cluster 2

Increased employment

8.5 Full and productive employment and decent work for all

8.6 Reduce youth NEET

8.9 Policies to promote sustainable tourism that creates jobs

8.B Develop a global strategy for youth employment and implement the Global Jobs Pact

Cluster 4

Financial inclusion

8.10 Encourage and expand access to banking, insurance and financial services for all

Cluster 3

Decent work

8.3 Policies to support productivity, decent job creation and entrepreneurship

8.7 End forced labour, modern slavery, human trafficking and the worst forms of child labour

8.8 Protect labour rights and promote safe and secure working environments

The targets of SDG 8 can be grouped into three main clusters, which feed into and support each other. Inclusive and sustainable economic growth (Cluster 1) targets sustained per capita economic growth across all countries; in particular, it targets 7% growth in output for least-developed countries. This is directly supported by increased productivity, resource efficiency and Aid for Trade. Increased employment (Cluster 2) targets full and productive employment for all, with specific reference to youth employment and training. Decent work (Cluster 3) targets working conditions and issues such as modern slavery, child- and forced labour. Inclusive and sustainable economic growth is also supported by financial inclusion (Cluster 4), which is driven specifically through Target 8.10.

The role of digital technologies in delivering SDG 8

Digital technologies have become a foundation for the economies of many, if not all, countries, driving the transformation of industries, businesses and government. This is reflected in the array of new, digital business models and value streams that are disrupting traditional products and services globally.

In this context, digital technologies are driving growth in multiple directions. Digital technologies enable market access, innovation and new business models. Consumers and businesses are now able to engage in new ways, increasing economic participation, and the digitally-enabled sharing economy has given rise to new products and services. In addition, connectivity improves the functioning of the labour market through job matching platforms and flexible working, allowing workers to look for jobs in new ways or find new sources of income that fit with their particular circumstances.

Digital technologies also affect productivity. While productivity in a whole economy is complex, with improvements in productivity difficult to muster, there is good evidence that digital technologies have significant impacts on business and sector-level productivity. For example, Deloitte analysis of cloud computing found that business users enjoy a net return of $2.5 for $1 invested in cloud services,[3] and the OECD found that a 10% increase in high-speed broadband and cloud computing penetration at the industry level raised average productivity by 1.4% and 0.9% respectively after one year.[4] According to the World Economic Forum, digital technologies contribute to total factor productivity growth and create positive employment effects when used to complement the workforce.[5] These productivity impacts are driven by improved collaboration, automation and augmentation.

Digital technologies are deployed to improve prospects for decent and safe work by enabling flexible working, and monitoring poor practices such as modern slavery, child-and forced labour. Digital technology can also improve safety in workplaces by improving fault prediction, maintenance, and repair of industrial machinery.

Finally, digital technologies, and in particular mobile money, have fundamentally transformed access to financial services for many, particularly in developing countries. In many parts of the world, mobile money has become the primary driver of greater financial inclusion, especially where physical banking infrastructure is lacking.

However, it is important to note that while digital technologies have the capacity to assist in delivering inclusive economic growth and decent work, there are concerns over the extent of the ‘digital divide’, which leads to unequal adoption of digital technologies, as well as the impact on employment. While technological progress in general drives job creation,[6] there are fears that greater automation of work will lead to an increase in unemployment, disproportionately affecting the poor and low skilled.

Whilst digital technologies do play a role in driving towards economic growth and decent work, non-digital drivers are critical. Growth, employment and decent work rely on strong policies and stable institutions, as well as a healthy and educated workforce. Investment, trade, and the international macroeconomic climate, e.g. international monetary policy, all combine to drive growth.

Impact projections to 2030

Beyond the ICT sector's direct contribution to the economy, digital technologies are a key enabler of economic growth and employment. Academic research confirms the positive relationship between digital technologies and GDP growth for particular countries, in particular developing countries. A long-established study in Africa estimated that a 1% increase in penetration of mobile phones and internet usage increases per capita GDP by 0.15-0.39% and 0.21% respectively.[7] A more recent study in Brazil highlights improved regional productivity through increased broadband penetration.[8]

As a use case, mobile money has been shown to support economic growth by improving access to financial services. Based on the historic increase in mobile money accounts associated with an equivalent increase in mobile subscriptions per 100 people, and future estimated mobile subscriptions, an additional 118 million mobile money accounts could be opened by 2030. If accounts are unique to people, then this is equivalent to an additional 1.9% of the population with access to financial services.

By increasing financial inclusion, mobile money services can help people escape the poverty trap: a study showed that M-Pesa, a mobile money system in Kenya, lifted around 194,000 households out of poverty, equivalent to 2% of Kenyan households. With the adoption of mobile money accounts, households were able to increase their consumption levels due to increased financial resilience and savings.[9]

However, the analysis of the Global Findex Survey[10] suggests that mobile money cannot improve the proportion of unbanked global citizens alone. The survey reports the most common reason for individuals not having a bank account is 'insufficient funds' rather than access, reiterating the importance of SDG 1 (no poverty) to improve incomes of the poorest and lift people out of poverty.

As laid out in this report, the ICT sector contributed €3.2 trillion in GDP and 48 million jobs globally in 2015. This is projected to rise to €6 trillion in GDP and 80 million jobs by 2030. Although the ICT sector's economic activity is predominantly concentrated in developed countries and selected developing countries, e.g. China, it also has a large impact on developing countries. For example, according to UN research from 2011, the telecommunications sector offers one of the highest opportunities for employment creation in low-income countries.[11]

As laid out in this report, the ICT sector contributed €3.2 trillion in GDP and 48 million jobs globally in 2015. This is projected to rise to €6 trillion in GDP and 80 million jobs by 2030.

Importance of digital technology to target attainment

	TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1	**Inclusive and sustainable economic growth**		
🟧	**8.1** Sustain per capita economic growth	Digital technologies will be important to growth through enabling market access, competition and innovation. Wider enablers include policy and investment.	↘
🟩	**8.2** Achieve higher levels of economic productivity	Business adoption of digital technologies is a key driver of improving productivity. Improved collaboration, flexibility, automation and augmentation underpin this impact.	↗
🟧	**8.4** Improve global resource efficiency in consumption and production	Digital technologies allow resources to be used more efficiently, either through the digitally-enabled sharing economy or new services for businesses, e.g. cloud, enabling efficient and flexible resource utilisation. Resource efficiency also relies on effective policy, incentives and behaviour.**	N/A
⬜	**8.A** Increase Aid for Trade support for developing countries	This target relies on both domestic and international policy and coordination.	→
2	**Increased employment**		
🟧	**8.5** Full and productive employment and decent work for all	Digital technologies impact these targets by enabling increased efficiency in job markets through flexible working and improved job matching. In addition, policy and provision of education and skills training are key drivers.	↗
🟧	**8.6** Reduce youth NEET		↘
⬜	**8.9** Policies to promote sustainable tourism that creates jobs	These targets are driven primarily by policy and international agendas, rather than digital technology interventions.	N/A
⬜	**8.B** Develop a global strategy for youth employment and implement the Global Jobs Pact		N/A

3		**Decent work**		
	⬜	**8.3** Policies to support productivity, decent job creation and entrepreneurship	This target is driven primarily by the domestic policy agenda.	🟠 →
	🟧	**8.7** End forced labour, modern slavery, human trafficking and the worst forms of child labour	Digital technologies support the detection of practices such as forced- and child labour, modern slavery and human trafficking. Wider enforcement of laws, standards and regulations are also important to achieving this target.	🟢 ↘
	🟧	**8.8** Protect labour rights and promote safe and secure working environments	Digital technologies are being used to secure labour rights and employment contracts, as well as to make working conditions safer. Policies and enforcement of laws and regulations are also critical to achieving this target.	🟢 ↘
4		**Financial inclusion**		
	🟩	**8.10** Encourage and expand access to banking, insurance and financial services for all	Digital technologies, in particular mobile money, are increasingly important in delivering access to the financial services to those unable to access services through traditional means.	🟢 ↗

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

- 🟩 High impact
- 🟧 Moderate impact
- ⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

- 🟢 Positive progress
- 🟠 Limited progress
- 🔴 Negative progress

**This target has an important sustainability aspect, but due to its breadth this is more properly captured in SDG 13.

Cluster 1

Inclusive and sustainable economic growth

Since the financial crisis, global growth has been maintained at lower levels than in the previous growth phase. Since 2011, global GDP per capita has grown at under 2% whereas pre-2007 it was 3%.[12] In addition, growth of economic output in least-developed countries is below the 7% targeted by the SDGs (Target 8.1); real GDP growth in these countries was 4.5% in 2017, although it is expected to increase to 5.7% in 2020. More positively, labour productivity has been increasing since 2001, albeit more slowly in the past decade, with growth in output per worker rising by 2.1% in 2018.[13]

Digital technologies are a key driver of economic growth and productivity; they enable a large amount of economic activity and the ICT sector itself represented €3.2 trillion of direct GDP in 2015. Digital technology is being integrated into almost every sector in the economy and becoming a foundation upon which the economy functions. In particular, increased connectivity and digitalisation are driving growth in innovation, competition, and market access, enabling new forms of consumption and economic participation, and the introduction of new, disruptive digital business models. Increased connectivity and digitalisation is also reducing transaction and coordination costs of doing business.

Integrating digital technologies such as AI, IoT, blockchain and digital reality into current business practices is also improving productivity, whether it be improving communication and monitoring or autonomating and augmenting processes. These technologies also improve efficiency and asset utilisation.

In general, sustainable economic growth is driven by an educated and healthy workforce, investment in infrastructure and skills, and innovation. This in turn needs to be supported by a well-functioning financial system and economic policies. Current constraints to achieving economic growth include increasing levels of debt and inequality, as well as uncertainties around international trade and the international macroeconomic climate.[14]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital technologies enable access to markets and digital marketplaces Mobile and other digital access technology is used for activities such as purchasing, accessing information and engaging with services. This gives consumers and small businesses increased and flexible access to markets, and increases participation in the economy. This also reduces transaction and coordination costs, in turn improving productivity.	**Example:** DNV GL, Sustainia and the UN Global Compact have established a digitally-enabled global opportunity explorer that helps business leaders, entrepreneurs and investors connect with new partners, projects, markets and talents to deliver on the SDGs.[15]	Digital Access Fast Internet / 5G Cloud	Importance to SDG Role of digital technologies Scalability
Mobile connectivity and digital access drives economic growth Mobile-enabled innovation is an important factor for economic growth, especially service innovation and process innovation in knowledge-intensive activities. Digital access also increases the level of competition between firms.	**Example:** Telstra Labs is Telstra's centre for digital technology innovation where the technology powering the future digital access networks is developed. In addition, it includes Telstra's technology start-up accelerator, which provides support to new businesses and entrepreneurs developing new digital technology solutions.[16] **Example:** Samsung organises a Vietnamese Industrial Consultant Training Program, intended to support Vietnam in improving local skills and thereby the share of local components in production. This is structured in a manner intended to support the diffusion of skills from those trained and lead to quality improvements within Vietnamese companies.[17]	Digital Access Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability
Digital technologies enable flexible working and collaboration, improving productivity Digital technologies make new business tools available at scale. For example, the cloud enables remote working and collaboration, which increases flexibility and productivity of workers.	**Example:** AT&T provides a cloud-based solution for businesses, which, like many cloud solutions, enables information to be shared quickly and flexibly between people and teams within businesses, improving teamwork and business productivity through enhanced collaboration and flexible working.[18]	Digital Access Fast Internet / 5G Cloud	Importance to SDG Role of digital technologies Scalability
Digital technologies enable new business models, which are introducing new sources of income and driving economic growth Digital technologies and platforms are enabling disruptive new business models and value streams, which in turn are driving economic growth. New business models include subscription based (e.g. Spotify), pay-per-use (e.g. video rental) and advertising based: free content in exchange for viewing adverts (e.g. Facebook).[19] Digital technologies also enable sharing economies that enable people to share their time, labour, homes or cars etc., which increases resource utilisation within an economy. Not only does this increase productivity but also opens up new sources of income for people.	**Example:** Nebengers is a carpooling network in Indonesia which enables ride-sharing by connecting drivers with empty seats in their cars with passengers looking to go in the same, or similar, direction. The aim of the service is to reduce congestion and pollution in the country's cities, and make transport more efficient.[20]	Digital Access Fast Internet / 5G Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital technologies improve business practices Digital technologies such as blockchain and AI can be used to prevent tax fraud and secure property rights by providing a transparent, secure and immutable account of business and ownership. In this environment, fraud can more easily be detected. This creates a more favourable and secure environment for business.	**Example:** The tax authority of Shenzhen, China, has started a partnership with Tencent to use blockchain platform TrustSQL for electronic tax invoicing. The initiative will support in identifying tax evasion.[21]	Blockchain Cognitive	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital technologies enable more efficient use of resources and assets Using digital technologies such as cloud and AI, companies are able to save costs, utilise ICT resources and physical assets more efficiently, and increase agility and performance.	**Example:** A recent Deloitte report for Google found that 93% of public cloud users experienced operational efficiencies, driven predominantly by time savings enabled by cloud, which on average are two to three hours per employee per week. In addition, 75% of businesses using public cloud experienced a reduction in their capex, primarily through reducing the investment required to maintain IT infrastructure, which on average is estimated to fall 19% with the use of cloud.[22]	Fast Internet / 5G Cloud Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digitally-enabled augmentation of labour improves productivity Through augmentation of human capital and labour driven by data and AR/VR, workers are now able to engage with processes in smarter and more innovative ways.	**Example:** GE is applying augmented reality across its businesses to deliver information to workers at the right moment, in the ideal format, directly in workers' line of sight and hands-free. Examples of where this is being used include wiring of wind turbines and inventory work in warehouses.[23]	Cognitive IoT Digital Reality	Importance to SDG Role of digital technologies Scalability
Autonomation improves productivity Intelligent automation systems – powered by digital technologies such as IoT, fast internet and AI – are transforming services and processes across multiple sectors.	**Example:** According to a Deloitte report, 47% of companies surveyed are focussing on using AI to automate IT processes.[24] IT professionals estimate that almost 20% of daily tasks could be automated by AI and intelligent automation.[25]	IoT Cognitive	Importance to SDG Role of digital technologies Scalability

Lower 🟦🟦🟦🟦🟦 Higher

Cluster 2

Increased employment

Global unemployment has returned to pre-crisis levels of below 5%, having reached 5.6% in 2009.[26] However, there remains a significant global challenge with youth unemployment, which is three times higher than adult unemployment. In 2018, one fifth of the world's youth were not in education, employment or training (NEET), representing a significant loss of experience and skills.

Digital technologies play an important role in improving the functioning of the job market and enabling flexible working, with digital access technologies connecting workers with businesses for either full-time employment or discreet jobs or services. Job platforms provide a new way for people to search for new employment and increase the reach of businesses within the job market and lower cost recruitment. Digital platforms enabling flexible working, sometimes referred to as the 'gig economy', provide people with the opportunity to earn an income more on their own terms without necessarily being employed full time. This is particularly beneficial for those who would otherwise have trouble in finding full-time employment, for example those who have particular responsibilities or dependents, those who are less able to leave their homes, and those who would otherwise be part of the informal economy.

There are, however, some concerns regarding the 'gig economy' and whether workers participating in this are the recipients of a stable income, adequate working conditions, and support.

Employment is driven in a large part by economic activity. The more vibrant and dynamic the economy, the more jobs and vacancies there are likely to be. Other key factors include making sure people have the skills required for jobs (see SDG 4) and policy-driven initiatives such as apprenticeships, which drive attainment of skills and experience.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital platforms facilitate improved job matching Digital access enables employees and employers to match online through job platforms, facilitating improved functioning of the labour market.	**Example:** Applied is a UK jobs platform that uses behavioural and data science to remove bias from hiring decisions and make recruitment fairer and more diverse. Since launching in 2016, 70,000 candidates have applied through the platform and it has expanded to government departments and large corporations both in the UK and abroad.[27]	Digital Access Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability
Digital technologies enable flexible or gig working, improving participation in the workforce Digital technologies are enabling new forms of flexible working, where workers pick up discreet jobs through platforms to suit them and their particular circumstances or schedule. These platforms sometimes come with support and training for the users offering their services, with digital technologies enabling this to be delivered in new ways to maximise impact.	**Example:** Beat is an app, established in Athens but now also operating across cities in South America, which matches private drivers to individuals looking for one-off rides. The platform connects the driver with riders and handles the payment online. Unlike competitors, its Beat Lite service aims to recruit drivers from lower-income demographics, driving older vehicles. This provides one-off, flexible working opportunities for those without the capital to invest in a new car.[28] **Example:** Bilforon is a food delivery platform in Jordan that enables people to sell home-cooked food in order to generate an income. The platform counts among its home cooks refugee women from Syria who have limited mobility and would otherwise find making a living challenging.[29]	Digital Access Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 3

Decent work

Informal employment remains pervasive in many countries, with more than half of all persons employed (in non-agriculture sectors) informally employed in countries with data. This is a concern as informal employment does not necessarily include the stability, adequacy of earnings, occupational health and safety, and working conditions that are important for sustainable development.[30] In addition, linking with SDG 5, a disproportionate number of workers in the informal sector are women[31] and so a disproportionate amount of work that women carry out, such as domestic work and care, is unlikely to be captured in national statistics such as GDP. This leads to an undervaluing of the work carried out by women and, importantly, a lack of transparency concerning the conditions in which this work is being carried out. For example, the value of unpaid work in the UK, India and Australia has been estimated as 56%, 39% and 35% of GDP respectively.[32]

In terms of bad labour practices, it is estimated that 40 million people are victims of modern slavery, with a quarter of these being children.[33] More broadly, many workers globally are subject to conditions which put them at risk of injury or death while at work, with a median of three deaths occurring per 100,000 employees and a median of 889 non-fatal injuries occuring per 100,000 employees across countries.[34]

Digital technologies such as blockchain are increasingly used to monitor and track the rights of workers and poor employment practices. AI can be used to predict where bad practices such as modern slavery and child- and forced labour, are taking place, and to improve industrial safety by predicting faults and improving maintenance work.

Whilst digital technologies do contribute to decent work, the extent to which economic activity and suitable policies, rules, and legislation exist and are enforced will be critical to the achievement of this target.

Increased connectivity and digitalisation are driving growth in innovation, competition, and market access, enabling new forms of consumption and economic participation.

Cluster attainment by technology table

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital platforms enable aggregated, transparent job ratings Digital platforms collect feedback from employees on their workplace to build a picture about working conditions.	**Example:** Glassdoor hosts a database of workplace reviews and aggregates current and ex-employee opinions to rate employers.[35] This enables a 'race to the top' for employee engagement – improving working standards for all.	Digital Access Cloud	Importance to SDG Role of digital technologies Scalability
Blockchain can monitor and detect bad employment practices Blockchain technology is being used to record and preserve information through supply chains on working conditions. This promotes transparency and improvements in business practice.	**Example:** The US State Department and Coca Cola are working on a project to create a secure registry for workers' contracts using blockchain technology. Working with other companies, the aim is to combat forced labour around the world.[36]	Blockchain	Importance to SDG Role of digital technologies Scalability
Blockchain can help secure labour rights Blockchain decentralised ledger technology can be used to upload and verify employment and labour contracts, securing labour rights.	**Example:** Researchers have proposed a blockchain-based system for temporary workers that ensures fair and legal remuneration , financial protection, and respect for the rights of all involved in the arrangements.[37]	Blockchain	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AR/VR and AI are improving safety in the workplace Combining AR/VR with image recognition and AI helps to predict factory faults and improve worker safety by decreasing workplace incidents.	**Example:** Industrial use of augmented reality smart glasses provides machine operators, and maintenance and repair service workers with key information that can improve repair of machines and ultimately safety.[38]	Digital Reality IoT Cognitive	Importance to SDG Role of digital technologies Scalability
AI-enabled image analysis helps detect worker exploitation AI can be used to analyse satellite imagery and big data to identify and track exploitation. Employment practices that can be detected in this way include human trafficking, child labour and forced labour.	**Example:** Researchers have demonstrated the importance of analysing satellite imagery to spotting areas of modern slavery.[39] This can be augmented by AI, such that areas can be detected automatically and more accurately.[40]	Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 4

Financial inclusion

The UN notes that access to finance and financial services is on the rise globally, with access increasingly relying on digital technologies. In terms of physical infrastructure, from 2010 to 2017, the number of ATMs per 100,000 adults grew by nearly 50% both globally and in least-developed countries, but the number of commercial bank branches per 100,000 adults grew by only 2%.

As noted extensively by international institutions[41] and associations,[42] digital technologies, in particular mobile money, have become an essential component of financial inclusion. They connect people around the world, who do not have access to traditional financial services infrastructure, with digital financial services. Since 2011, the increase from 23% to 42% in the proportion of adults with bank accounts in developing Sub-Saharan African countries is almost entirely driven by mobile money.[43] In addition, blockchain technology is enabling financial inclusion through digital identities and secure and transparent peer-to-peer lending.

Beyond digital technologies, increased financial inclusion relies on the proper infrastructure and physical access to financial services that is still required by many, as well as appropriate policy and regulation.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
mMoney and mobile financial services improve financial inclusion Through the prevalence of digital access technology, access to financial services is being expanded. In particular, mobile money and other mobile-enabled services are increasingly used for banking and insurance.	**Example:** Amdocs provides a mobile financial services platform that enables banks, operators and service providers to provide mobile financial services to customers. The solution covers digital payments, digital banking and connected money, which are all important services to provide to users with financial services, especially where other infrastructure is lacking.[44]	Digital Access Fast Internet / 5G Cloud	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Blockchain enables a secure and immutable digital identity, to improve access to and control over finances Financial inclusion is enabled in part by a secure and immutable identification. With digital identification, personal and biometric information can be secured, shared and accessed through the blockchain.	**Example:** uPort is an identity and data platform built on Ethereum blockchain technology, which allows users to register a globally unique identifier and give them control over their identity, private keys, user accounts and private data.[45]	Blockchain	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Blockchain can enhance financial interactions and enable peer-to-peer lending Blockchain decentralised ledger technology is enabling secure and transparent peer-to-peer financial interactions and insurance. This enables individuals' access to new sources of finance and improves flexibility of lending.	**Example:** Lendoit is a decentralised peer-to-peer lending platform, which connects borrowers and lenders from all over the world. The platform uses blockchain technology to ensure trust and speed in transactions.[46]	Blockchain	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

SDG Interlinkages

The interactions between SDG 8 and the other SDGs are complex. Decent work and economic growth are generally associated positively with some SDGs, e.g. SDG 1 – reducing poverty, SDG 3 – increasing access to healthcare. However, increased economic activity has traditionally been detrimental to progress against the biosphere SDGs, e.g. SDG 13 – combatting climate change, SDG 14 – conservation and sustainable use of the oceans.

In particular, reducing poverty (SDG 1) and hunger (SDG 2) can contribute to growth by increasing people's capacity to participate in the economy and start businesses. Similarly, healthier (SDG 3) and better-educated people (SDG 4) can also increase participation in the workforce, and importantly drive productivity and growth. In return, economic growth and employment enable people to escape poverty and hunger and access better healthcare and education.

In addition, increased participation by women in the workforce (SDG 5) is important to achieving positive economic outcomes as this can bolster the workforce and make the economy more inclusive. In addition, sharing the benefits of growth and employment reduces inequality and fosters inclusion (SDG 10).

Industrialisation, infrastructure development and manufacturing productivity (SDG 9) are all key to delivering growth and increased employment. Also, making production and consumption activities sustainable (SDG 12) can drive resource efficiency which improves productivity.

Peace, justice and strong institutions (SDG 16) as well as partnerships (SDG 17) are strongly linked with economic growth. A lack of partnerships, fair trade and strong institutions, with an associated rise in lack of international cooperation and crime, reduces prospects for growth, whereas transparency and accountability foster it. Economic growth also builds a strong foundation on which to develop institutions and partnerships.

Negative externalities

Impact of widespread use of digital technologies on achievement of SDG 8

Job displacement: Digital technologies may drive job displacement. A major concern expressed about the wider application of digital technologies, particularly regarding AI and IoT and the automation they enable, is that it will lead to a loss of jobs as employers substitute workers with digital technologies. It is clear that this change is already occurring, with administrative and customer service roles increasingly becoming automated. However, the lasting impact remains unclear.

Assessments and projections of the potential impact vary in their results. Nevertheless, an over-arching message appears to be that there are many jobs at risk of automation; however, automation will also create many opportunities and new jobs.[47] Beneficiaries of this shift are considered to be high-skilled workers, with low-skilled workers being most at risk and requiring retraining.[48] In addition, there are concerns that many of the jobs at risk are mainly performed by the young and women.[49] This has obvious implications not only for SDG 8 but also on achieving greater equality (SDGs 5 and 10). Therefore, it is of great importance that the transition to wider adoption of digital technologies needs to be well managed with respect to job displacement, and measures to mitigate the negative impacts, such as new skills development, education, and re-training, are rolled out.

Worker protection and rights: Digital technologies may contribute to an erosion of worker protection and rights. Digitally-enabled expansion of the 'gig economy', while reducing friction in the labour market and enabling people to earn income in new ways, may also lead to an erosion of worker rights and protections. Participants in the 'gig economy' can sometimes be indistinguishable from employees, providing the same amount of labour and services for pay. However, they may not enjoy the same benefits and legal protections as employees, such as minimum pay, holiday entitlement, statutory sick pay and protection from wrongful termination of employment.

Systemic risk: The increasing reliance of businesses and sectors across the economy on digital technologies may introduce greater systemic risk. In recent years, the world has experienced large-scale cyber attacks and network interference that have caused major disruption and damage to the provision of essential services and ultimately people's lives.

Impact of using digital technologies to achieve SDG 8

Impact of economic growth: Wider adoption of digital technologies may support economic growth; however, this itself may have negative consequences for achieving other SDGs, particularly those related to the environment, if growth is not decoupled from environmental degradation (as per Target 8.4).

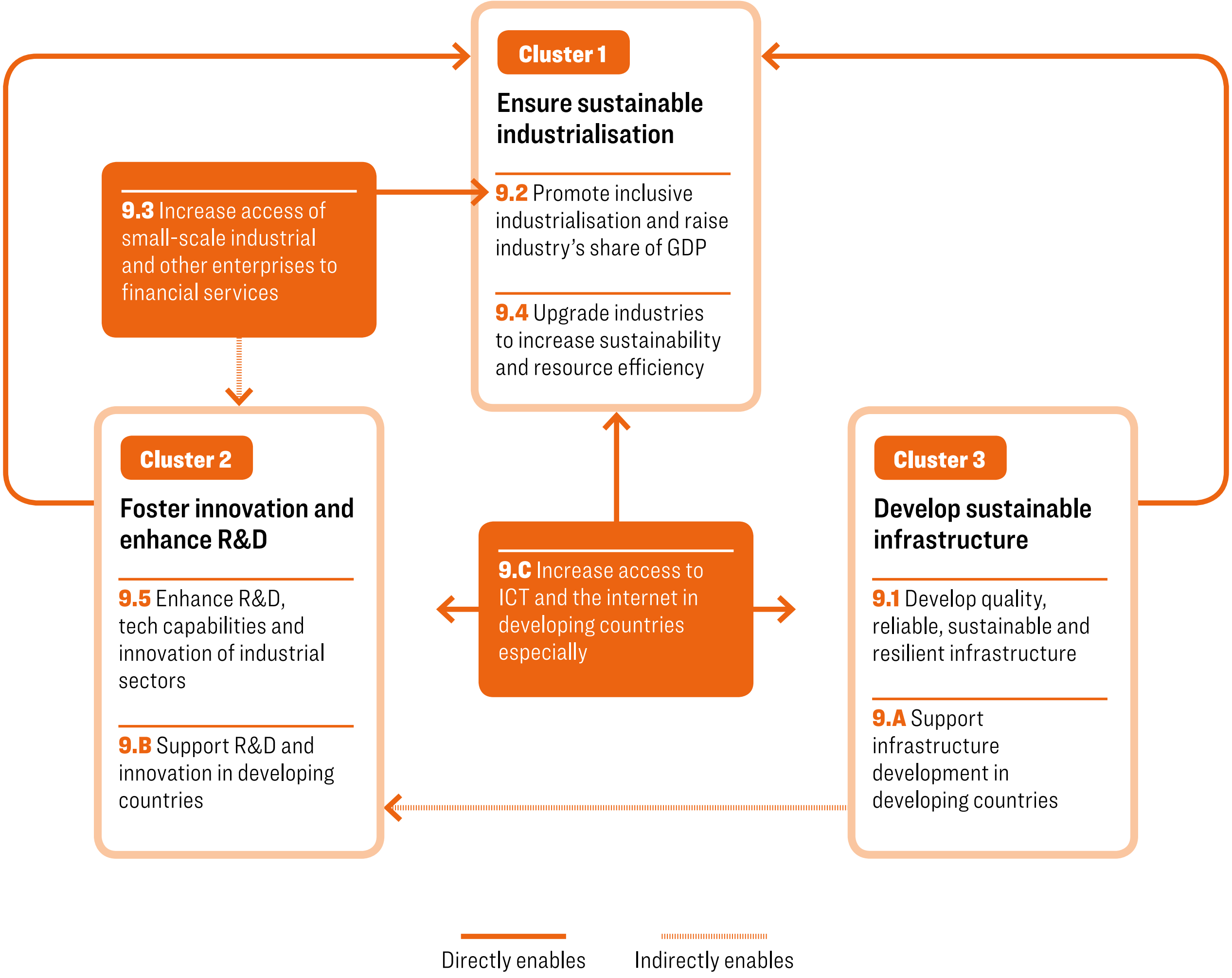
Inequality: Adoption of digital technologies to support economic growth and decent work may disproportionately benefit the already well-off and developed countries, leading to an increase in inequality. As an illustration of this, forecasts predict that the share of jobs and wages for those with high-digital skills will increase by 11% and 10% respectively, while the share of jobs and wages for those with low-digital skills will decrease by 11% and 39%, respectively by 2030.[50]

SDG 9 DEEP DIVE

Industry, Innovation and Infrastructure

SDG 9 addresses three important aspects of sustainable development: to ensure sustainable industrialisation, assisted by the building of both sustainable and resilient infrastructure; the enhancement of innovation; and R&D. UN Deputy Secretary-General Amina Mohammed called SDG 9 a "docking station" for all 17 Goals, as achieving SDG 9 will facilitate the fulfilment of many SDG themes including job creation, sustainable livelihoods, improved health, technology and skills development, gender equality, food security, resilient cities, green technologies and climate change.[1] Digital technologies, especially those delivered through Industry 4.0, have immense potential to drive progress towards SDG 9 at scale and speed.

SDG 9 System



Sustainable industrialisation (Cluster 1), involves boosting industrial productivity whilst concurrently reducing CO2 emissions per unit of productivity. Innovation and enhanced R&D (Cluster 2), is a key enabler of achieving sustainable and productive industrialisation, as well as all of the other SDGs.[2] Sustainable infrastructure (Cluster 3), is a precursor to industrialisation, as well as other basic elements of sustainable development, such as access to healthcare, education and electricity.[3] The two remaining targets, access to finance for small and medium enterprises (SMEs) and small-scale industries (9.3) and access to ICT (9.C), in particular the internet, are critical enablers of all three clusters, as well as of economic growth and sustainable development more broadly.

The role of digital technologies in delivering SDG 9

The ICT sector is driving progress against SDG 9 with a scale, speed, quality, accuracy, and cost once unimaginable,[4] through catalysing a significant industrial transformation, often referred to as “Industry 4.0”. Industry 4.0 enables industry to become more connected, efficient and smart; in turn boosting productivity whilst reducing emissions and material wastage.

Digital technologies are the underlying drivers of Industry 4.0. The adoption of computers and automation that occurred in the third industrial revolution is being enhanced through the introduction of smart, connected and autonomous systems,[5] powered by a range of digital technologies, in particular big data and machine learning, IoT, and high performance cloud computing.[6] Industry 4.0 drives the transformation of the physical components of industrial production into smart, data-driven and connected systems that allow for intelligent manufacturing, predictive maintenance, and optimised production lines and supply chains.[7] Industry 4.0 also enables the creation of “digital twins” (digital, 3D counterparts of products, production lines and supply chains) which allow more efficient design, testing of products and running of processes. Digital technologies also allow for the augmentation of humans, with AR and VR technologies that can improve R&D, accelerate prototyping and help factory workers to complete tasks faster and more safely.[8]

In addition to accelerating sustainable and productive industrialisation and enhancing R&D (Industry 4.0), digital technologies can support the remaining SDG 9 targets that facilitate industrialisation, including sustainable infrastructure, access to internet and access to finance. Digital technologies improve the monitoring of existing infrastructure, and optimise design and planning of new infrastructure. They also connect people, industries and SMEs to the internet and to finance, through the expansion of internet access and digital finance systems (e.g. mMoney, Bitcoin and crowdfunding).

Aside from digital technologies, the investment and building of physical infrastructure is a necessary foundation for sustainable industrialisation. Policies and incentive structures that favour industry and entrepreneurship, and funding or loan schemes that facilitate R&D will also accelerate progress towards SDG 9. Finally, upskilling and education in STEM subjects and e-literacy will be needed to ensure the workforce can adapt to changing job roles and requirements, as more manual roles become automated.

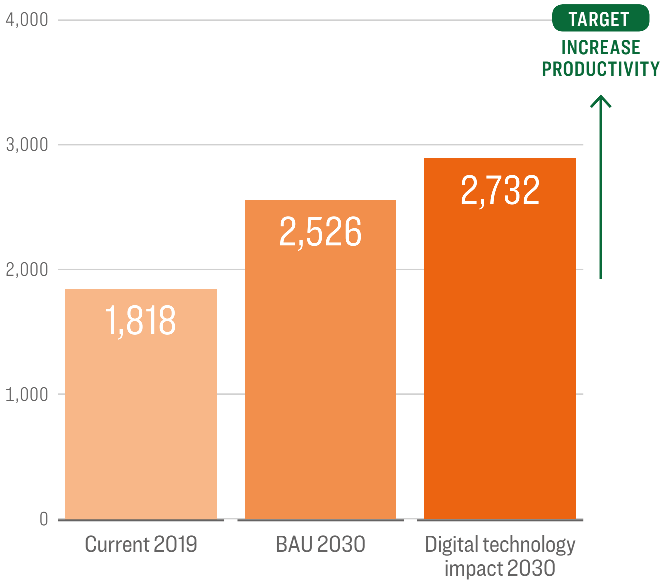
Impact projection to 2030

Wider adoption of Industry 4.0 in manufacturing is expected to produce substantial productivity gains by 2030. It is estimated based on existing trends that the current value of manufacturing activities per person across all countries analysed are expected to rise from $1,800 to $2,500 by 2030 (values represent manufacturing GVA per capita in 2010 prices). However, with adoption of Industry 4.0 this is expected to be $2,700 per capita – an increase of 8% attributable to Industry 4.0 relative to the business-as-usual scenario.

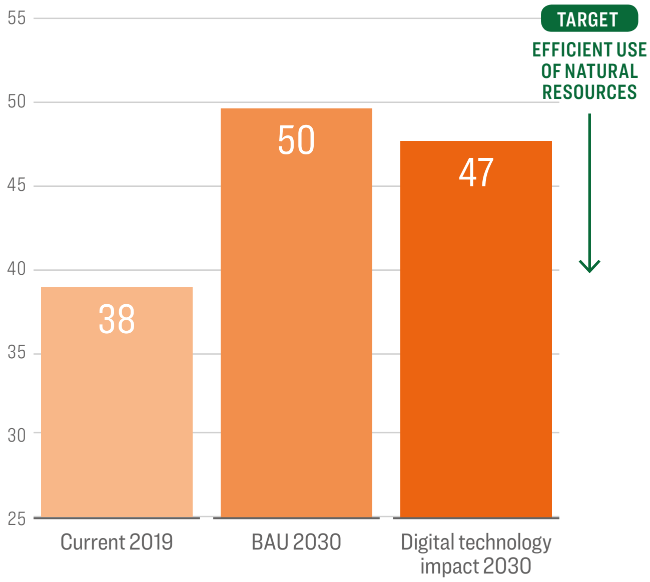
Breaking down the analysis by country, there are significant differences between developed, developing and least-developed countries, driven by the varied impacts Industry 4.0 is expected to have and by Industry 4.0 adoption rates. In developed countries, the impact of Industry 4.0 is expected to lead to an additional 10% of manufacturing GVA per capita ($700), whereas in developing and least-developed countries this is estimated to be 7% ($140) and 3% ($6) respectively. If increase in adoption rates in these countries mirrored developed countries then the increases would be 8% and 5%.

It is also estimated that use of Industry 4.0 will reduce manufacturing domestic material consumption through greater resource efficiency in production processes, which is also relevant to both SDG 8 (Target 8.4) and SDG 12 (Target 12.2). It is estimated that in 2019 manufacturing domestic material consumption was 38 billion tonnes of raw material. Based on current trends, this is expected to rise to 50 billion tonnes of material by 2030. Factoring in adoption of Industry 4.0 and the impacts this may have on domestic material consumption of the manufacturing sector at the country level the rise may be reduced to 47 billion tonnes; a 5% reduction compared to the business-as-usual scenario.

Manufacturing Productivity (Value Add per capita USD 2010)



Domestic material consumption in manufacturing (tonnes, billions)



Importance of digital technology to target attainment

	TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1	**Ensure sustainable industrialisation**		
🟩	**9.2** Promote inclusive industrialisation and raise industry's share of GDP	Digital technologies are at the heart of inclusive industrialisation and improved productivity, offering the potential to realise smart and connected factories, predictive maintenance, optimised scheduling and automation.[9]	🔴 ↘
🟩	**9.4** Upgrade industries to increase sustainability and resource efficiency	In addition to increasing productivity, digital technologies will also be key to driving production line and supply chain optimisation, which, in turn, will decrease CO2 produced per unit of productivity and increase sustainability. The use of digital twins in particular will enable improved sustainability throughout the product lifecycle: from design and production, to use and disposal.[10]	🟢 ↘
2	**Foster innovation and enhance R&D**		
🟩	**9.5** Enhance R&D, tech capabilities and innovation of industrial sectors	Digital technologies are a key enabler of this target. VR and digital twins can augment and optimise product design and development, and prototyping. Digital technologies also enable enhanced connectivity and collaboration across borders, facilitating improved innovation.[11]	🟢 ↗
⬜	**9.B** Support R&D and innovation in developing countries	Achieving this target will primarily require policy coordination and additional forms of support, as it seeks to ensure there is a conducive policy environment for, inter alia, industrial diversification.	🟠 →
3	**Develop sustainable infrastructure**		
🟧	**9.1** Develop quality, reliable, sustainable and resilient infrastructure	Digital technologies will enable enhanced monitoring of current infrastructure as well as optimised design of new, sustainable infrastructure. However, there are other important enablers, including the physical construction of infrastructure and associated enabling investments.	🟢 ↗
⬜	**9.A** Support infrastructure development in developing countries	Achieving this target primarily relies on the provision of international aid and investment.	🟢 ↗
4	**Enabling targets**		
🟩	**9.3** Increase access of small- scale industrial enterprises to financial services	Digital technologies will be very important to achieving this target, e.g. through the rise of mMoney and other digitally-enabled financial instruments, especially given that small and micro enterprises often struggle to access traditional financial services.[12]	N/A
🟩	**9.C** Increase access to ICT and the internet, in developing countries especially	Achieving this target relies completely on digital technologies (with associated enabling policies), although internet technology is largely an end to itself in this case (i.e. widespread provision of internet is the impact, as opposed to the internet driving a secondary impact).	🟢 ↗

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

🟩 High impact
🟧 Moderate impact
⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

🟢 Positive progress
🟠 Limited progress
🔴 Negative progress

Cluster 1

Ensure sustainable industrialisation

In the face of a rapidly changing global economic landscape and widening inequalities, sustained economic growth must feature industrialisation that is inclusive, sustainable and productive.[13] The economic value add of the industrial sector, whilst improving in general, is unevenly distributed. In Europe and North America value add per capita is $4,500, whereas this figure for least-developed countries (LDCs) is $100. Similarly, the manufacturing output of more developed countries largely consists of medium- and high-tech products, whereas in LDCs med- and high-tech product share is only 10%.[14] In recent years, the sustainability of industry has been improving, with global CO2 emissions per unit of productivity decreasing by 19% from 2000 to 2015.[15] However, this reduction is per unit of productivity, and the volume of units produced has been increasing in many geographies. Reductions far greater than 19% are needed to meet the terms of the Paris Agreement.

Digital technologies have a large role to play, both in terms of increasing value add and decreasing the carbon intensity of industry. Industry 4.0 is digitally transforming and optimising manufacturing productivity by enabling the convergence of Operational Technology with Information Technology, allowing for more connected people and things and more efficient, sustainable and data-driven production processes. These digitally-enabled systems allow for the realisation of smart and connected factories and assets, predictive maintenance, and production optimisation and automation.[16] This convergence of the physical and the digital has also made the digitisation of the supply chain and "Logistics 4.0" possible, driving efficiencies throughout the supply chain, from smart warehousing and inventory tracking to optimised delivery routes.[17]

Digital technologies have the potential to drive large-scale transformative change against these SDG 9 targets, but they also must be carefully managed, due to the risks associated with the rise of autonomous machines that can both make decisions and replace human workers. It will require new AI governance and ethics models, upskilling of much of the workforce, and the careful management of workforce changes, as some factory roles will likely disappear, as well as emerge.[18] The limited scalability of more advanced technologies in developing countries that lack sufficient digital infrastructure is also a risk to be considered, as it could further widen the productivity and value add gap currently observed. Arguably, many developing countries have yet to transition from Industry 3.0 to Industry 4.0. Alongside digital transformation, the traditional drivers of sustainable industrialisation, including industrial zone planning, environmental regulations, and compliance related activities will continue to have an important role to play in achieving SDG9.[19]

Cluster attainment by technology table

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Blockchain technology enables transparent supply chains, lowering costs and reducing wastage Blockchain technology will enable companies to record every event or transaction within a supply chain on a distributed ledger – allowing companies to understand the exact location and flow of products within their supply chains. This allows for transparency and trust, and reduces the number of intermediaries, increasing efficiencies across the supply chain, enabling faster transaction settlement and lowering costs and emissions.[20] Replacing traditional supply chain processes with blockchain could have a transformative impact, of an estimated 5% increase in global GDP and 15% increase in trade volume.[21]	**Example:** IBM Blockchain creates supply chain solutions, with a particular focus on traceability, transparency and optimisation of business transactions in logistics. IBM and Maersk are undergoing a joint effort to streamline shipping and drive efficiencies across the shipping supply chain, through building an efficient and secure trade digitisation platform based on IBM Blockchain.[22]	Blockchain	Importance to SDG Role of digital technologies Scalability
IoT sensors, often combined with AI algorithms, allow for real-time analysis and optimisation of the production line A combination of IoT and AI technologies allows for real-time insight into: - **Quality:** notification of production faults, such as deviations from the recipe, that are likely to cause product quality issues.[23] - **Scheduling:** using production, machine and labour sensor data to optimise staffing and production. - **Inventory:** real-time tracking of raw materials, WIP and finished goods, as well as prediction of demand for certain products, allows synchronisation of supply and demand and optimisation of production. All of this optimises production line uptime, yield, and quality; and prevents wastage of raw materials and energy.[24]	**Example:** Bell Canada teamed with Icicle Technologies to deliver a remote tracking and monitoring solution that enhances food manufacturing safety to their industry customers.[25]	IoT	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT sensors & AI modelling lead to optimised supply chain logistics Monitoring and analysis of production information combined with information regarding number of orders, delivery locations, available staff and vehicles allows for optimised inbound and outbound logistics and delivery management. AI-powered models can predict future demand for certain products, as well as anticipate any future supply chain issues (such as disruption due to weather).[26] Overall, this can be used to optimise supply chain logistics, increasing efficiency and agility and minimising CO2.[27]	**Example:** UPS ORION routing system optimises routes for delivery trucks, saving roughly 100,000 Mt of CO_2 per year vs business-as-usual.[28]	IoT Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ■■■■■ Higher

Connected fleets, enabled through fleet telematics, enable optimised delivery routing Fleet telematics systems help resources be assigned where they will be most effective and routes be optimally planned, thus maximising the efficiency of fleets and deliveries.[29]	**Example:** Bell has worked with other technology innovators such as BeWhere and Trak-iT on the first fleet management and asset tracking solution delivered exclusively over the Bell LTE-M network. **Example:** AT&T and Geotab use IoT to manage companies' fleets, improving efficiency, productivity, safety and management of company logistics.	IoT Cognitive	Importance to SDG Role of digital technologies Scalability
IoT sensor data and other production data combined with AI algorithms allow for predictive maintenance Smart factory management systems couple physical asset data (through sensors) and other data with advanced prediction and machine learning models to predict asset / machine malfunctions and address them proactively.[30] Predictive maintenance allows for material reductions in cost and unplanned downtime, as well as for maximising and predicting the Remaining Useful Life (RUL) of production machines and equipment.[31]	**Example:** Armstrong Fluid Technology developed Pump Manager using IBM's Watson IoT platform. It is a cloud-based service that provides predictive maintenance for building operators. The platform continuously tracks and analyses equipment performance, sending real-time operating data, and alerts when an anomaly is identified, to users. This helps operators to avoid equipment failure and track operating efficiency. It reduced HVAC (heating, ventilation and air conditioning) energy use by 78% in one use case at Zheng Zhou University.[32]	IoT Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AI-powered robots can autonomously execute production processes & warehouse operations By the end of 2018, there were more than 1.3 million industrial robots at work in factories all over the world, driving increased productivity, uptime, and quality, as well as reduced costs and waste.[33] Advances in AI will be central to automation, by enabling robots to handle more cognitive tasks and make autonomous decisions based on real-time environmental data, further optimising processes.[34]	**Example:** A leading electronics company used a fully automated production system, complete with integrated machine control. The benefits of this automation included lower lead times for customers and lower overall costs, along with production capacity improvement of 25% and 50% fewer defective products.[35]	IoT Cognitive	Importance to SDG Role of digital technologies Scalability
VR/AR augments factory worker experience, improving safety and productivity VR/AR has a number of use cases in improving the safety of manufacturing, where both the stakes and the risks are high. VR can simulate various production processes, allowing workers to practice potentially hazardous manoeuvres and fine-tune workflows pre-production.[36] VR can also simulate important safety tests.[37] AR wearables, i.e. smart goggles, can boost productivity by placing a virtual layer over real life, giving multi-tasking employees more flexibility to do their jobs without juggling a device.[38]	**Example:** Lockheed Martin Corp. recently adopted Microsoft's AR HoloLens for manufacturing spacecraft. Now, a technician can use images projected onto the lenses to mark the locations for 309 fasteners to be attached to a curved panel. When the technician or the panel moves, the computer adjusts. The HoloLens has reduced what was traditionally a two-day task down to two and a half hours.[39]	Digital Reality	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 2

Foster innovation and enhance R&D

Innovation, understood as new forms of social practice and organisation, as well as new or improved products and business processes, is a critical enabler of all SDGs.[40] Globally, R&D expenditure has been increasing year on year. However, significant disparities exist between regions, with R&D expenditure totalling 2.4% of GDP in developed countries, 1.2% in developing countries and only 0.3% for LDCs.[41] Digital maturity plays a role in boosting innovation, with company level studies showing that digitally-mature companies are able to innovate at far higher rates than their less mature counterparts.[42]

Digital technologies can enhance and increase innovation by speeding up the diffusion of information, improving connections and collaborations amongst firms, minimising geographic limitations and increasing the efficiency of communication.[43] Additionally, the digitally-enabled systems brought about by Industry 4.0 provide new opportunities in areas such as product design and prototyping, allowing both improved visualisation of product design, and simulation of product function.[44] Finally, envisaging digital twins of potential products helps plan the best possible product configurations and most sustainable design, driving efficiency and sustainability throughout the product lifecycle.

Aside from digital technologies, other drivers of enhanced R&D and technological innovation include: ensuring that the population is digitally literate through age-appropriate STEM and e-skills education at all levels of schooling,[45] policies that incentivise the creation of new technologies and innovation,[46] stakeholder collaboration, and the use of public funding and relaxed IP laws to ensure critical projects and IP remain in the public domain (thus allowing the diffusion of knowledge to developing countries).[47]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Basic digital access and the internet enhances innovation by removing geographical borders and increasing connectivity Access to basic digital technologies can increase innovation by ensuring instantaneous access to information, allowing for flexible working conditions and social connections. These conditions can enhance engagement and connectivity, and increase the efficiency of communication in general.[48]	**Example:** Tech hubs are springing up across Africa, to foster "home-grown innovation". Larger hubs, for example iHub in Kenya, are designed to digitally connect technical experts, programmers, entrepreneurs and investors locally and around the world, to fuel innovation.[49]	Digital Access	Importance to SDG Role of digital technologies Scalability
Cloud-based platforms enable open innovation and idea sharing around the world Cloud-based tools and platforms are enabling an unprecedented wave of collaboration within and between enterprises. A survey of over 500 executives identified around 14% as cloud "leaders" – meaning that their companies support a full range of cloud-based collaborative technologies. Close to 90% of these leaders reported greater opportunities for innovation as a result of their enhanced cloud capabilities. By contrast, only 23% of companies not embracing cloud found that their collaborative efforts enhanced innovation.[50]	**Example:** EIT Climate-KIC has introduced Climathon, a year-round innovation and hackathon platform, translating climate action solutions into tangible projects, supporting climate positive businesses and start-ups and addressing local policy changes.[51]	Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Blockchain immutability can be applied to IP, leading to increased security of R&D Blockchain can be used as a tool to track the rights and transactions attached to a wide range of digital creative work using smart contracts – self-executing contracts that contain the agreement terms written directly into lines of code. This permits trusted IP transactions between anonymous parties without the need for an official government or legal system.[52]	**Example:** Although not yet live examples, potential use cases include: evidence of creatorship, registering and clearing IP rights; controlling and tracking the distribution of (un)registered IP; establishing and enforcing IP agreements, and transmitting payments in real time to IP owners.[53]	Blockchain	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Deep learning algorithms can allow for rapid generative product design, accelerating innovation Deep learning is set to transform product R&D in the near future. For example, it could soon be possible to enter a detailed brief as an input into an AI algorithm, which then explores every possible configuration and hones in on a set of suggested solutions. The proposed solutions can then be tested using machine learning, offering additional insight as to which designs work best. The process can be repeated until an optimal design solution is reached. This will accelerate innovation cycles, shorten design time and improve time to market of new products.[54]	**Example:** Google Brain is Google's deep learning research team, who are conducting research into deep learning and its potential application to product design and human life, with the aim of accelerating innovation and improving people's lives.[55] The team developed a real-time suggestions system, currently integrated in Gmail, that assists users to construct emails based on advanced machine learning and language recognition.[56]	Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AR/VR is being used to test and visualise product design, enhancing innovation AR/VR allows workers to pull an idea from a screen and drop it into a real or simulated world at full scale. It allows product visualisation much earlier in the design process, with a dramatically lower level of investment when compared to other forms of rapid prototyping. It can also streamline development, as it is flexible and possible to tweak and iterate design at a rapid pace. It also allows for design collaboration across geographies, with stakeholders all around the world able to test and feedback on potential products.[57]	**Example:** SGW DesignWorks uses VR to assist in the prototyping process, to review and test products quickly for consumers. It developed a VR prototype for client in the aerospace industry that meant two physical prototype cycles were avoided.[58]	Digital Reality	Importance to SDG Role of digital technologies Scalability

Lower ■■■■■ Higher

Cluster 3

Develop sustainable infrastructure

Infrastructure is a crucial enabler of industrialisation, as well as of community empowerment, income growth and improvement in health and education outcomes.[59] Poor access to infrastructure – notably for transportation, electricity and ICT– remains a major impediment of development and diversification in developing countries.[60] For example, African infrastructure constraints have been calculated to reduce firm productivity by around 40%.[61] The global infrastructure gap is estimated to amount to $1-1.5 trillion annually.[62] Globally, 2.6 billion people do not have access to constant electricity, 2.3 billion people lack access to basic sanitation, almost 800 million lack access to water, and about one third of the population is not served by all-weather roads.[63]

Digital technologies will enable improved monitoring of infrastructure and quicker reporting of issues, as well as optimised design of new, sustainable infrastructure. However, many drivers of impact against this group of targets are not led by digital technologies. Rather, they involve the construction of physical infrastructure, particularly for transportation, water, electricity and energy.[64] Investment in these areas and a long-term policy vision for sustainable national infrastructure systems, combined with digitally-enabled monitoring and design of such infrastructure, will expand market activity and allow individuals to access new markets and new job opportunities.[65]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile reporting of infrastructure damage / disrepair leads to safer and better quality infrastructure Mobile phones and apps can allow citizens to directly report infrastructural problems affecting them anywhere in the country to the local authorities, leading to safer and higher quality infrastructure and more reliable access.[66]	**Example:** In Johannesburg, South Africa, the "Find and Fix App" was developed to enhance the local authorities' reachability and accelerate infrastructure repairs. The app allows users to report road-related issues, such as potholes or broken traffic lights, instantaneously, by taking and uploading a picture of the issue, and registering its location.[67]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT sensors can monitor infrastructure integrity Aging infrastructure, including roads, railroads and bridges, pose a danger to human life and a costly burden to the state if maintenance issues are not caught in time. Advances in IoT technology are enabling enhanced monitoring of the structural integrity of infrastructure, with sensors able to detect impending structural issues, thus preventing incidents and improving the maintenance cycle.[68] This also reduces unnecessary travel emissions, as maintenance teams are only sent out when repairs are needed.	**Example:** MX3D equipped a smart bridge in Amsterdam with IoT sensors, which use innovative algorithms to stream smart data to the cloud, where the structural integrity of the bridge, as well as bridge traffic is visualised. This is a key feature for crowd control in the city's famous red light district. The sensors also help to analyse when the bridge needs maintenance, so repairs are made when needed, i.e. allowing 'just in time maintenance'.[69]	IoT Cloud	Importance to SDG Role of digital technologies Scalability

Lower Higher

Analyse, Optimise & Predict

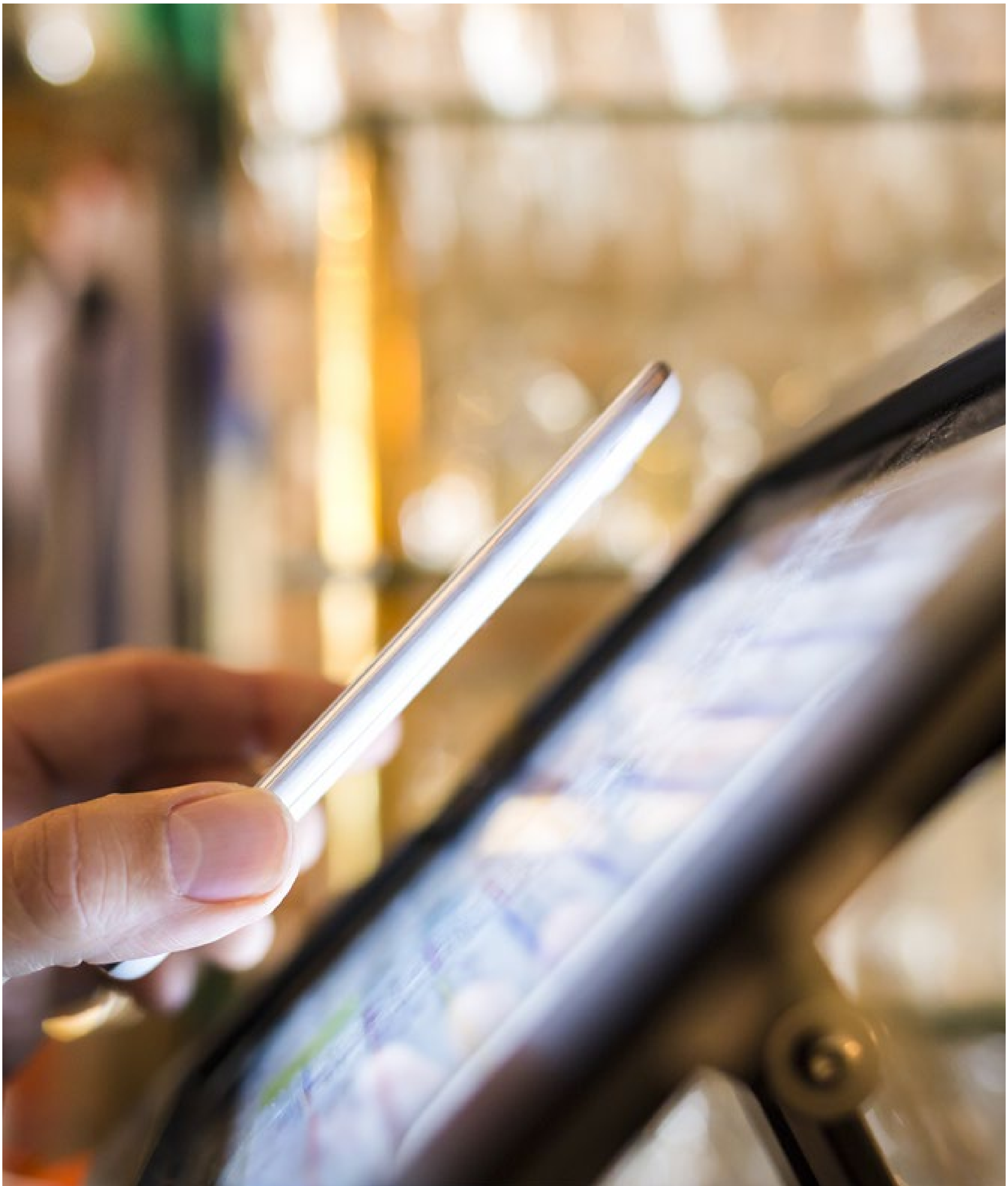
SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Drones and AI can quickly scan areas to build and rebuild infrastructure Image recognition algorithms can be used to analyse satellite or aerial drone images, in order to assess the damage and operability of existing infrastructure, e.g. after a disaster, or assist with planning of new infrastructure.[70]	**Example:** Studiomapp uses AI to analyse satellite and drone imagery, in order to monitor construction sites and infrastructure. They are working with Snam, Europe's largest natural gas infrastructure company, to further improve the monitoring of their 33,000km of pipelines. Studiomapp's AI-enabled analysis of satellite imagery is able to identify objects or activities that may damage Snam's pipelines, in order to prevent large-scale infrastructure damage and supply disruption. They also are working with Italferr, a company of the Ferrovie Dello Stato Italiane Group, experimenting with drone imagery analysis to monitor construction site progress, as well as to certify that there is no illegal dumping or waste in sites before construction work begins.[71]	Cognitive	Importance to SDG Role of digital technologies Scalability
Digitally-enabled building info modelling (BIM) allows for more efficient designing and planning of infrastructure BIM is an intelligent 3D model-based process that gives architecture and construction professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure. BIM improves the sustainability of the whole infrastructure project lifecycle, from enabling less wasteful construction, to more cost-effective design and sustainable operation.[72]	**Example:** BIM can measure and compare operational carbon emissions associated with different design options, allowing the most sustainable option to be chosen. It also drives efficiencies and cost savings, with BIM estimated to unlock 15-25% savings in the global infrastructure market.[73] However, BIM data and systems are largely missing from most infrastructure work carried out in developing countries, and a significant amount of work done in developed countries. If BIM systems were to be introduced into national institutions managing public infrastructure, improved design and operation of infrastructure would be possible.[74]	Digital Access	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
VR can be used to efficiently design infrastructure, with input from multiple stakeholders VR has significant potential to increase the quality of large-scale infrastructure projects, by providing a sense of scale, functionality and user experience.[75]	**Example:** Arup total design VR solutions can accelerate infrastructure programmes and provide far richer data sets, by creating 3D mesh models, complete with topographical and infrastructure features. This can help assist with concept designs, construction reviews and ongoing asset management. As a result, infrastructure projects can be conducted with greater speed, accuracy and less cost than before.[76]	Digital Reality	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

The ICT sector is driving progress against SDG 9 with a scale, speed, quality, accuracy and cost once unimaginable.



Cluster 4

Enabling targets

Increase access of SMEs to financial services

SMEs play a major role in most economies, particularly in developing countries. SMEs contribute up to 60% of total employment and up to 40% of national income (GDP) in emerging economies.[77] However, whilst 80% of SMEs have access to financial services, only 37% receive access to the credit they need to grow – with 200 million SMEs in emerging economies lacking any sort of access to formal savings or credit.[78] The problem is more severe with microenterprises (two thirds of which are in developing economies), with the SME financing gap estimated to be over of $3 trillion.[79]

Digital technologies have allowed for the proliferation of mMoney, and other unconventional forms of credit and capital raising, which are connecting SMEs to finance more quickly, allowing for faster growth. However, finance can also reach SMEs through other mechanisms, including the expansion of typical financial services and loans. SME growth can also be enabled through discouraging heavy or special taxes on digital technologies, encouraging R&D, and endorsing e-literacy and the dissemination of technologies (particularly to micro, small and medium-sized enterprises).[80]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile apps or web platforms can be used to set up crowdfunding pages and increase access to finance Crowdfunding enhances access to capital for SMEs globally while simultaneously democratising access to investments for ordinary citizens.[81]	**Example:** The eTrade-for-All initiative 13 provides a multi-stakeholder platform to leverage e-commerce for development by pooling resources of leading development partners, the private sector, and facilitating access to potential beneficiaries. The Better Than Cash Alliance (BTCA), hosted by UNCDF, is advocating the use of digital payments on the growing evidence base that these are more efficient and less wasteful than bulk cash payments.[82]	Digital Access	Importance to SDG Role of digital technologies Scalability
Mobile money and financial services providers provide faster and easier access to credit Mobile money is an engine for financial inclusion, as many SMEs lack access to the formal financial system or cannot get the funds they need quickly enough to grow their businesses from traditional banks.[83] These companies are instead choosing to work with mobile financial services providers, which can provide quick and transparent decisions on loan applications, as well as other services.[84]	**Example:** Ferratum Group provides digital and mobile financial services for consumers and SMEs, transcending the need for physical banking. It offers financial services with 24/7 customer services that is all accessible online or on mobile.[85]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Initial coin offerings can be offered to help SMEs raise venture capital / increase access to financing Blockchain technology presents many advantages for raising capital for start-ups, due to easier and faster access to capital. This in turn leads to improved innovation and economic growth, due to increased entrepreneurship.[86] Initial Coin Offerings (ICOs) are the blockchain equivalent to traditional Initial Public Offerings, and are one of the most prominent applications of blockchain for finance. With ICOs, entrepreneurs can sell tokens in exchange for a cryptocurrency like Bitcoin, and the value of the tokens is determined by the future financial success of the venture.[87] Since ICOs are sold globally online, they give entrepreneurs access to a large pool of investors. Over the past two years the use of ICOs has increased significantly.[88]	**Example:** Bitbond is the first global lending platform for small business loans. They leverage blockchain technology to connect creditworthy borrowers with individual and institutional investors, delivering instant funding and automated credit scoring.[89]	Blockchain	Importance to SDG Role of digital technologies Scalability
Tax, audit and invoice apps can help with previously manual and costly tasks, allowing for faster business growth Digitally-enabled public services help SMEs to interact with public administration online for purposes of payments, transfers and tax administration.[90] Free business service apps can also help manage security workflow, taxes, invoices etc.[91]	**Example:** An innovative and user-friendly national business registration system supported by UNIDO was launched in Vietnam in 2013. It developed e-signature, e-payment, online registration and online information service facilities to reduce the costs and risks of doing business in Vietnam (as before these cumbersome procedures were costing businesses, particularly SMEs, a lot of money). This took registration down from 15 days to three days, saving newly registered enterprises more than $4 million a year because of simplified registration procedures.[92]	Digital Access	Importance to SDG Role of digital technologies Scalability
Cloud platforms eliminate need for expensive hardware, and enable dynamic and rapid scalability of businesses Cloud reduces barriers to entry for SMEs by allowing for increased agility and deployment capabilities and encouraging entrepreneurship. With on-premise technology, the growth of the company is bound by budgeting cycles, as any investment has to be made up-front and capacity planning typically focuses far into the future. However, these constraints can be leapfrogged using the cloud.[93]	**Example:** In late 2014, a Deloitte team launched a new web-based document review application. However, each time it on-boarded a new project, it experienced a huge influx of document uploads (tens of thousands each week) and the onsite servers struggled to keep up, in turn affecting team performance. Then, the team migrated to a cloud-based application able to process millions of documents. The application is now able to perform up to 20 times faster than it used to. It also reduced the effort required to review documents by 95%, lowered hosting costs by 45% and yielded more than $100 million in revenue.[94]	Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Increase access to ICT and the internet

Internet penetration globally is now at 95%, yet 53% of the world's population remain offline.[95] Again, progress is uneven, with only 11% of houses in LDCs having internet access, compared to 84% in developed countries.[96] Internet access is a critical contributor to ending poverty, empowering women and marginalised groups, as well as enabling financial inclusion and participation in the digital economy; therefore, access must be improved.[97]

Though access to internet itself is enabled almost solely by digital technologies, ensuring sufficient coverage and connectivity does not necessarily translate into utilisation. Barriers such as lack of digital skills and literacy, low affordability, scarce local content, and lack of trust can reduce internet uptake, especially in poor areas. The ITU has called on policymakers, industry leaders and educators to work together to increase digital skills across developing countries.[98] Developing relevant internet content, strengthening regulatory frameworks and promoting trust can also help ensure that improved access leads to wider use.[99]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
ICT companies should work to extend internet access and uptake, in combination with ensuring trust of internet etc. The main driver of impact against this target is for ICT companies to extend internet network coverage to once unconnected populations, sometimes using innovative surveying techniques.	**Example:** Huawei has worked with 110 operators in more than 50 countries to deploy their RuralStar solution. The solution is designed specifically to bring affordable mobile network connections to remote spaces such as urban villages, rural areas, deserts, hills and tunnels. By the end of 2018, RuralStar had covered 40 million rural residents that previously had no access to internet.[100] **Example:** Telstra uses drones (UAVs) in Tasmania to provide rapid assessment of ICT infrastructure as well as to assess the suitability of new sites for infrastructure, in order to improve worker safety, reduce network downtime and expand networks.[101]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

SDG Interactions

In addition to positive reinforcements between SDG 9 targets, sustainable industrialisation positively reinforces sustainable production and consumption (SDG 12), and economic growth and decent work (SDG 8) – with every job in manufacturing creating 2.2 jobs in other sectors.[102] Due to this, industrialisation is also indivisible from the reduction of poverty (SDG 1) through improving the economy, and introducing high value add jobs in areas once dominated by lower value jobs such as subsistence agriculture.[103] Industrialisation also has well-known trade-offs with the biosphere SDGs, including increased usage of water and energy (SDGs 6 and 7), and increased carbon emissions, land and marine degradation (SDGs 13, 14 and 15).[104]

Enhanced innovation can benefit all SDGs through the introduction of new and improved forms of social practice, products and business processes.[105] Innovation is enabled by bringing groups of like-minded people together, and, as such, inclusive cities (SDG 11) are recognised as hubs of innovation.

Infrastructure is a precursor to economic growth, and directly or indirectly influences the attainment of all of the SDGs, including 72% of the SDG targets.[106] Developing infrastructure is indivisible from ensuring access to basic services for the poor (SDG 1).[107] Infrastructure, specifically transport and technology, also provides connectivity between people and markets, which has particularly positive impacts on hunger, education and health (SDGs 2, 3, 4). It also enables structural change through labour mobility into new jobs and industries.[108] Increasing coverage of infrastructure also leads to more vehicles on the road and in the air – in turn negatively impacting emission reductions (SDG 13).

SME finance is associated with a number of benefits, namely to the economy in terms of job creation and growth under SDG 8, financial inclusion under SDG 10, and SDG 5 (if access is extended to female-owned businesses).[109] Access to ICT services, especially the internet, is a critical contributor to ending poverty (SDG1), ensuring healthy lives (SDG 3), achieving food security (SDG 2), women's empowerment (SDG 5), and promoting exports (SDG 17).[110] If universal access to internet is delayed, the 2030 SDG targets will become impossible to achieve.[111]

As robots perform more and more jobs, workers could be trained for more advanced positions in design, maintenance and programming, where human insight and creativity is still essential.

Negative externalities

Impact of widespread use of digital technologies on achievement of SDG 9

Security of infrastructure and industry: As manufacturing information is increasingly stored digitally, IP may be put at risk, in turn affecting innovation. Digital information can be stolen especially with the diffusion of 3D printing where complete information about manufacturing is stored digitally.[112] Additionally, increasingly digital supply chains are more at risk of cyber attacks and cyber manipulation. Infrastructure that is increasingly reliant on digital technologies, such as smart grid systems, are also more at risk of cyber attacks, affecting the resilience of infrastructure. However, blockchain and the transparency, traceability and security it promises, may be able to mitigate this externality in some cases.

Impact of using digital technologies to achieve SDG 9

Emissions: Industrialisation will lead to an increase in emissions, as will infrastructure (through increased usage of electricity and the increased number of cars, planes and ships in use). Digital technologies will further increase emissions through both needing energy to run themselves, and through accelerating overall productivity and therefore energy use. This, in turn, could lead to an increase in power outages due to heightened energy demand. However, digital technologies also have the potential to mitigate energy usage through optimisation of factory production, logistics and supply chains.

E-waste: Digitally-enabled manufacturing and industry produce e-waste at two stages. First, through manufacturing scrap, e.g. old IoT sensors or outdated computers, and, second, through designing digital products that are hard to recover and recycle. To mitigate these externalities, the ICT industry can help by designing products specifically for durability and reuse in the first place, substituting out materials of concern and using AI and AR to test potential product configurations.[113]

Stagnation of development: Industrialisation plays a vital role in the economic growth and development of developing countries and their economies. However, the cost of operating autonomous robots, 3D printers and other digital technologies associated with manufacturing is decreasing, indicating that lower labour cost may no longer be a key determining factor when deciding where to locate factories. This could lead to changing geographies of production, and "reshoring" of manufacturing back to high-income countries, thus depriving developing countries of industrialisation opportunities.[114]

Inequality: Even distribution of digitally-enabled manufacturing solutions, access to the internet and access to credit must be ensured, as current access and manufacturing value add is far higher in more developed countries. The internet gender divide is also widening. ITU records that the digital gender divide grew from 11% in 2013 to 12% in 2016 (equivalent to a gap of about 200 million fewer women online globally) reflecting the fact that men are coming online earlier, and more rapidly, than women are. This growing digital gender divide is alarming, as it translates into millions of lost opportunities for individual women and girls, who will struggle to gain the skills and digital literacy needed to survive in the digital economy, limiting women's empowerment and independence.[115]

Job replacement: Increasing automation of production processes, made possible by cognitive AI in particular, is projected to cause the displacement of millions of manufacturing workers, particularly those at lower levels who conduct routine, labour intensive tasks.[116] Robots could replace up to 20 million manufacturing jobs around the world by 2030, with people displaced from those jobs likely to find that comparable roles in the services sector were also squeezed by automation.[117] A global net decrease in jobs could be especially challenging for developing countries where millions of young people are entering the job market every year.[118] However, this could be mitigated. As robots perform more and more jobs, workers could be trained for more advanced positions in design, maintenance, and programming, where human insight and creativity is still essential.

SDG 10 DEEP DIVE

Reduced Inequalities

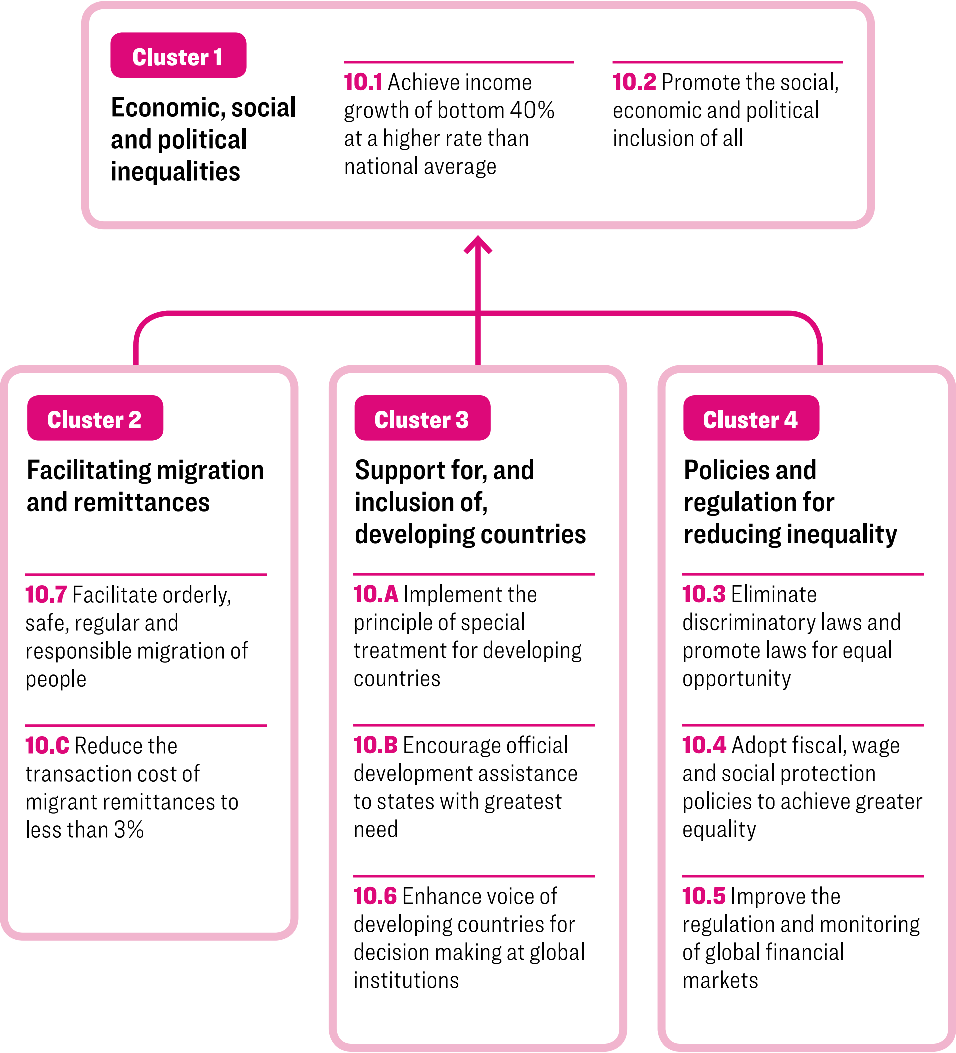
The central tenet of the SDGs is that “no one is left behind”. At the heart of this ambition, is the aim that sustainable development is shared with everyone, implying reducing and ultimately eradicating inequalities. Specifically, SDG 10 targets the reduction of social, economic, political and financial inequality, calls for an end to discrimination, an improvement in processes affecting migrants and greater inclusion of, and support for, developing countries.

Despite gains in reducing poverty, inequality continues to persist. The UN finds wide disparities between and within countries in access to basic services, e.g. health and education. At a local level, extreme inequality can be found in cities around the world.[1]

It is encouraging that in more than half of countries with sufficient data, the growth in incomes of the bottom 40% of the population exceeded the national average. However, this group still receives less than 25% of global income and, according to the UN Development Programme, overall income inequality is on the rise with the richest 1% taking an increasing share of global wealth and income.[2] Indeed, in 2018 the richest 26 individuals owned the same wealth as the poorest 3.8 billion people.[3]

Furthermore, the impacts of climate change are linked with inequality. The poor are generally more exposed to the effects of climate change and less able to cope with, and recover from, these impacts than the rich. For instance, the poor are more likely to live in areas and dwellings which are more likely to be hit by climate catastrophes and more susceptible to damage. They are also less likely to be insured or be able to afford to pay for recovery efforts than the rich.[4]

SDG 10 System



Cluster 1

Economic, social and political inequalities

10.1 Achieve income growth of bottom 40% at a higher rate than national average

10.2 Promote the social, economic and political inclusion of all

Cluster 2

Facilitating migration and remittances

10.7 Facilitate orderly, safe, regular and responsible migration of people

10.C Reduce the transaction cost of migrant remittances to less than 3%

Cluster 3

Support for, and inclusion of, developing countries

10.A Implement the principle of special treatment for developing countries

10.B Encourage official development assistance to states with greatest need

10.6 Enhance voice of developing countries for decision making at global institutions

Cluster 4

Policies and regulation for reducing inequality

10.3 Eliminate discriminatory laws and promote laws for equal opportunity

10.4 Adopt fiscal, wage and social protection policies to achieve greater equality

10.5 Improve the regulation and monitoring of global financial markets

The main focus of SDG 10 is the overall reduction in economic, social and political inequalities (Cluster 1). This refers to a need to ensure the poor earn a greater share of income and their access to essential services such as health and education is improved, thereby enabling economic, social and political systems to achieve sustainable development. The remaining targets under SDG 10 support this through a focus on components that are key to reducing inequality. The experience of migrants, in particular the management of migration and cost of remittances (Cluster 2), is important in enabling the inclusion of all. In addition, providing sufficient support and inclusion of developing countries (Cluster 3) will help these countries tackle inequality both within and between countries. Finally, the policy and legal environment (Cluster 4) must itself be non-discriminatory and provide adequate support for the most vulnerable, including effective regulation and monitoring of financial markets, which can help to reduce the risks of crises that may hit the poor the hardest.

The role of digital technologies in delivering SDG 10

Digital technologies have a key role to play in promoting the social, economic and political inclusion of all, reducing income inequality, and assisting with migration and the remittance of funds.

Mobile connectivity provides access to mobile money, which connects people to financial services and promotes financial inclusion for the poorest, leading to greater levels of income, savings, and access to finance. Mobile services lead to lower cost of remittances (money sent by migrants back to families and friends in their country of origin) which supports increased incomes for the poor in developing countries and sustainable development.[5] They also open up access to micro-insurance and micro-payment based finance, as digital payments allow people to transact in small amounts. These services are further augmented by digital technologies such as AI, making them faster, more efficient and scalable.

Digital access, where provided cheaply and ubiquitously, is a force for promoting inclusion and reducing inequalities. People previously excluded from the connected economy, can today, through digital access (either basic connections or through fast internet) connect socially via digital platforms and digitally-enabled communication; increase their economic participation through enhanced market and resource access via digital channels, and engage politically through online portals.

For the disabled and elderly, digital technologies augment and enhance quality of life by providing access to life-changing services. Mobile services now include accessibility functionality and wearable devices powered by AI-enhanced physical capabilities. In addition, digital reality is being used to combat extremism and promote inclusion among young people, as well as provide the elderly with inclusive access to new experiences.

Digital technologies have also become an essential part of safe and well-managed migration, by allowing access to real-time information for migrants and enabling them to remain connected or reconnect with loved ones. AI is being used to reduce the administrative burden of migration by augmenting processes. Blockchain can be used to provide digital identities and a record of certified documents for migrants, refugees and displaced people.

It is important for digital technologies to be supported by the wider policy environment (captured in cluster 4) in tackling inequality and promoting inclusion. In addition, policy and international coordination will be required to improve inequality between countries and also promote safe and well-managed migration. There is a need to build a knowledge and evidence base concerning inequality, where it exists and why, to improve understanding of the issue and how to tackle it.[6]

SDG 10 is also intrinsically linked with gender equality (SDG 5). Part of the social, economic and political inequality that exists today is gender-based, with women being less likely to be paid fairly, be able to find secure and stable employment and be involved in decision making.

Digital access, where provided cheaply and ubiquitously, is a force for promoting inclusion and reducing inequalities.

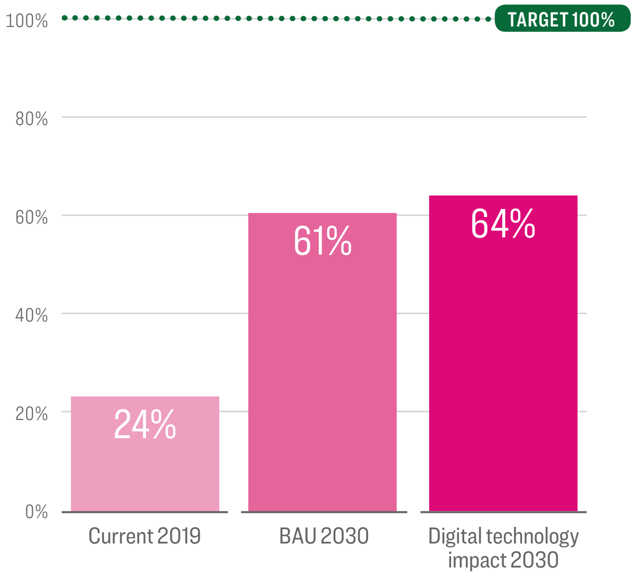
Impact projections to 2030

According to the UN Development Programme, under the 'business-as-usual' scenario, inequality is set to increase, with the global wealth share of the top 1% expected to increase from 33% in 2016 to reach 39% by 2050.[7] However, academic research suggests that digital technologies may have a role to play in mitigating this trend, by increasing incomes of the very poorest. At the country level, results of a study in Ecuador show that the introduction of broadband services in one municipality led to individual income gains of 7.5%,[8] while another study in rural China estimated that farmers who adopted digital technologies in their agriculture practice increased their income by approximately 15%.[9] However, the size of these gains may be limited by the extent to which technology is adopted at the top and the bottom ends of the income distribution.

Analysis conducted for this report suggests digital access, specifically mobile technology, will support the reduction of remittance costs (Target 10.C). The analysis of remittance service price data from the World Bank indicates that remittance services providers (RSPs) offering services via mobile are 37% cheaper than traditional RSPs,[10] which use agents or banks. Out of the remittance corridors tracked by the World Bank only 24% currently have an average remittance cost of less than 5p per £ as per Target 10.C. Although this is estimated to increase to 61% by 2030 based on current trends, wider adoption of remittance services using mobile could make this 64%.[11] Lower cost remittance services can substantially increase disposable income for remittance-receiving families, reducing inequality in migrants' home countries.[12] Based on the current volume of remittances greater adoption of mobile remittance services would represent an annual saving of $716 million in costs.

Digital technologies have a role to play in opening up opportunities to the poorest through more open access to information, markets and finance. However, there is no clear evidence of the impact of digital technologies on reducing overall inequality as adoption rates of digital technologies tend to be lower and grow more slowly for the poor.[13] New technologies such as AI are also more likely to be adopted by richer countries with greater capabilities. The ITU estimates that countries with a high readiness to benefit from AI achieve adoption rates of 23% higher than the low readiness countries.[14] This emphasises the need for policy, the ICT sector, and industry more widely to help ensure adoption of digital technologies does not perpetuate inequalities.

Corridors with an average remittance cost of less than 5p per £ (%)



Importance of digital technology to target attainment

		TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1		**Economic, social and political inequalities**		
	🟧	**10.1** Achieve income growth of bottom 40% at a higher rate than national average	Digital technologies enable greater growth of incomes through market access, access to information and resources, and financial inclusion. However achieving this target requires extensive social, economic and political measures to be implemented that are not directly related to digital technologies.	🟠→
	🟩	**10.2** Promote inclusion of all	Digital technologies promote inclusion of all people through their ubiquity and ability to connect people.	NA
2		**Improved experience of migrants**		
	🟩	**10.7** Facilitate orderly, safe, regular and responsible migration of people	Migrants and effective administration for migration increasingly rely on digital technologies to manage and improve the process.	NA
	🟩	**10.C** Reduce the transaction cost of migrant remittances to less than 3%	Digital technologies have a key role to play in offering cheap services through which migrants can remit funds.	🟢↘
3		**Support for and inclusion of developing countries**		
	⬜	**10.A** Implement the principle of special treatment for developing countries	These targets are driven primarily by international and domestic policy agendas, rather than digital technology interventions.	🟢↗
	⬜	**10.B** Encourage official development assistance to states with greatest need		🔴↘
	⬜	**10.6** Enhance voice of developing countries for decision making at global institutions		🟠→
4		**Policies and regulation for reducing inequality**		
	⬜	**10.3** Eliminate discriminatory laws and promote laws for equal opportunity	Achieving these targets is driven primarily by domestic policymaking.	🟠→
	⬜	**10.4** Adopt fiscal, wage and social protection policies to achieve greater equality		🟠→
	⬜	**10.5** Improve the regulation and monitoring of global financial markets	This relies predominantly on effective public policy and institutions.	NA

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

🟩 High impact
🟧 Moderate impact
⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

🟢 Positive progress
🟠 Limited progress
🔴 Negative progress

Despite progress, inequality in many forms remains a pervasive issue in both developed and developing countries. **Researchers have found that over recent decades, income inequality has increased in nearly all countries and regions of the world, although at different speeds.**

Cluster 1

Economic, social, and political inequalities

Despite progress, inequality in many forms remains a pervasive issue in both developed and developing countries. Researchers have found that over recent decades, income inequality has increased in nearly all countries and regions of the world, although at different speeds. While income inequality has increased rapidly in North America, China, India and Russia, it has eased in Europe.[15]

Against this backdrop, digital technologies have an important role to play in reducing inequalities and promoting inclusion. Digital technologies have enabled an increase in financial inclusion, which is key to increasing the incomes and wealth of the poorest who traditionally lack access to even basic financial services. Digital technologies also improve inclusive market access, allowing people to access essential and non-essential products and services more easily, and improve their economic participation as both producers and consumers. New digital technologies such as blockchain also have the potential to improve access to public services.

The ubiquity and connectivity that digital technologies enable, particularly digital access and fast internet, allows people from all backgrounds and circumstances to connect, interact, and engage in new and innovative ways digitally. This can foster a greater environment for tolerance where people may be less likely to be socially excluded.

Furthermore, digital technology-enabled assistance and augmentation improves outcomes for disadvantaged and vulnerable groups, such as rural women lacking formal education, the disabled and the elderly. This new technology, which encompasses digital services powered by AI and wearable connected devices, is improving the quality of people's lives.

It will be important for digital technologies to be supported by the wider policy environment (captured in cluster 4), and according to the UN policies in general should be universal in principle, paying attention to the needs of disadvantaged and marginalised populations.[16]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Improved digital literacy for excluded groups Mobile apps deliver digital literacy skills to those in need, e.g. women in poor communities. This is also relevant to SDG 4.	**Example:** The Self-Employed Women's Association of India (SEWA) is a trade union for poor, self-employed female workers. In 2004, it established the Rural Distribution Network (RUDI) which purchased products from local farmers and leveraged a large network of local sales women to sell to end consumers. In order for the system to function efficiently, an app was used to track orders and stock. This app was also designed to increase the digital literacy of the women using it, by providing access to training material.[17]	Digital Access	Importance to SDG Role of digital technologies Scalability
Increasing access to information and connecting people Digital access can be used to promote social inclusion, deliver information and connect people in marginalised groups.	**Example:** Sho is a real-time translation service in Sweden aimed at fostering inclusion. Newly arrived young people from different backgrounds, including refugees from Syria, come together to connect and make friends. After signing up, users who speak different languages can speak to each other using the service which translates in real time. The service was developed by Nokia and Tele2 based on Microsoft Translator technology.[18]	Digital Access Fast Internet / 5G Cognitive	Importance to SDG Role of digital technologies Scalability
Digitally-enabled opportunities for social participation and access to services Cheap and ubiquitous digital access enables people to engage socially and access online social services. Social media digital platforms and online public portals, accessed through computers, mobile phones and an increasing variety of other devices, enable this access and interaction.	**Example:** Telstra has committed over $2 billion (AUD) in benefits to vulnerable customers through its Access for Everyone programme since its inception in 2002. This programme ensures that people with low incomes and pensioners have access to digital services at home and helps around one million vulnerable people each year to stay connected.[19] **Example:** The ITU has a range of activities targeted at digital inclusion for people with specific needs, such as indigenous people, those with disabilities, women and girls, youth and children. For example, the ITU provides training and tools for the use of digital technologies to empower indigenous people by supporting capacity building, community development and the promotion and preservation of their cultures.[20]	Digital Access Fast Internet / 5G Cloud	Importance to SDG Role of digital technologies Scalability
Digitally-enabled opportunities for economic participation Digital access enables people to work and earn income in new and different ways. This includes being able to access new and flexible employment opportunities (which links with SDG 8), and increase utilisation of assets, e.g. homes and cars.	**Example:** LevelApp is a mobile app used by refugees and others on low incomes to connect with digital work remotely. The service connects businesses in need of manual data labelling services across a range of industries such as manufacturing and autonomous vehicles with a large and flexible workforce. The app enables users to cash out earnings instantly via mobile money, which provides an important and flexible source of income, and is already being used by thousands of refugees.[21]	Digital Access Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability
Digitally-enabled opportunities for political participation Digital access allows people to become more active in local/national debates and issues. Digital portals, accessed through mobile phones and computers, allow citizens to engage with governments and politics like never before.	**Example:** e-Democracia is an online portal in Brazil that has made the legislative process more transparent and provides citizens with numerous ways to contribute to debates and the legislative process.[22]	Digital Access Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Lower ■■■■■ Higher

Financial inclusion Digital access and, in particular, mobile money services, have made great strides in improving the access of the poorest to financial services. Particularly in countries and rural, under-developed areas where traditional banking infrastructure is lacking, mobile money services have become key to providing people with access to bank accounts, savings and finance.	**Example:** Huawei has partnered with mobile operators and banks in 19 countries across Africa and Asia to provide mobile money services based on its mobile money platform. Together, the services offered over Huawei's platform serve over 152 million users accounting for 22% of globally registered mobile money accounts and 50% of all transactions.[23]	Digital Access Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Increased access to experiences Virtual trips targeted at elderly people or those living with disabilities give them access to places and experiences.	**Example:** NomadVR is a Sydney-based start-up which provides elderly care and disability care facilities with virtual reality-based excursions. The service allows elderly or people living with disabilities to continue to explore the world and experience new or familiar locations which they may be unable to physically access.[24]	Digital Reality	Importance to SDG Role of digital technologies Scalability
Increased awareness of people's experiences Immersive experiences deliver a deep understanding about inequalities experienced by others. This can influence societal and workplace behaviour changes.	**Example:** Telstra set up the Remarkable Accelerator programme to identify and invest in technology that promotes social and economic inclusion of people with disabilities.[25] Equal Reality is an organisation that provides diversity and inclusion training through virtual reality, such as placing men in an office scenario as a 1.65 metre-tall woman (demonstrating how it feels to have to look up to people in meetings).[26] 99% of users understood what discrimination felt like and 96% felt prepared to act in the workplace following their training.[27]	Digital Access	Importance to SDG Role of digital technologies Scalability
Enhancing physical capabilities and mitigating disabilities Human augmentation is currently being rolled out using digitally-enabled devices, whether it be using digital reality or AI-inspired devices.	**Example:** AT&T and Aira have worked together to deliver wearable technology, enabled by artificial intelligence, which can aid the blind and those with low vision. Using AI and with the help of a remote professional agent, the wearer can be provided with a real-time description of what is around them. They can also be used to access public transportation, navigate busy streets, shop in stores or recognise people, without another person to physically accompany them.[28] **Example:** Microsoft's Seeing AI app helps the visually impaired by translating text into spoken words. It is also able to describe surroundings, people and objects. There is also functionality which describes the emotions people are exhibiting.[29]	Digital Access IoT Cognitive	Importance to SDG Role of digital technologies Scalability
New products and services that cater for different people's needs, in particular the disabled Digital technologies are enabling more accessible products and services, for example producing audio of text or audio description for the blind.	**Example:** Bell offers numerous accessible products and support services, including devices with screen readers and hearing aid compatibility, video conferencing, assisted messaging, and voice calling services. In particular, the Mobile Accessibility app integrates with the Android operating system to enable blind and low-vision customers to better navigate their devices.[30]	Digital Access Cognitive	Importance to SDG Role of digital technologies Scalability

Lower Higher

Cluster 2

Improved experience of migrants

It is estimated that there were 258 million international migrants worldwide in 2017, an increase from 220 million in 2010 and 173 million in 2000. In addition, in 2019 there were over 29 million refugees and asylum seekers.[31] Migration can contribute to positive development outcomes for countries and individuals. It is also a way for people to better their quality of life and escape oppression, injustice and the impacts of climate change. There are, however, significant risks associated with migration, especially when migrants use unofficial or illicit channels in order to migrate, which can put lives at risk. It is therefore important that migration be managed effectively and safely.

As diaspora play a key role in transferring funds from richer to poorer countries, it is important that the costs of remitting funds is not excessive, and is supportive of reducing inequality and the wider development agenda. While it is estimated to have declined, the average remittance cost in 2017 was 7.2% of the amount remitted – over twice as high as the 3% aim listed by Target 10.C.[32]

Digital technologies have become a vital tool in migration and remittances. Many migrants rely on digital access through their mobile phones or internet connections in order to access real-time information and reconnect with family and friends. Digital access, in particular mobile services and mMoney, have become a key component of efforts to reduce the cost of remittances. The GSMA estimates that the average cost of sending remittances via mobile money is 1.7% and that the cost of using mobile money is already below the 3% aimed for by Target 10.C for 96% of remittance corridors they analysed.[33]

Furthermore, advanced technologies such as AI are being used to facilitate migration and improve the remittance process. It is expected that blockchain technology will be able to provide migrants with digital identities that will make the administrative side of migration more efficient.

Beyond technology, better-managed and safer migration will require policies and international coordination. In addition, lowering the cost of remittances requires more choice and competition in market for providing remittance services in all remittance corridors.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Access to information Digital technologies are a key access point for information before and during migration. Migrants can plan routes, travel and get real-time information that affects their migration.	**Example:** MigApp is a service developed by the UN's International Organisation for Migration that provides information, notifications and access to services to migrants via smartphones. It is designed to contain accurate and comprehensive migration-related information. Given the breadth of material that migrants may require it uses big data analytical techniques to sort and provide migrants with the information they require.[34]	Digital Access Cognitive	Importance to SDG Role of digital technologies Scalability
Connectivity across borders Digital access, in particular mobile and internet connectivity, helps people stay in touch with friends and family and reconnect with loved ones.	**Example:** REFUNITE is a project which maintains a global database for refugees and displaced peoples to search and connect with missing loved ones via a mobile phone or computer. More than one million people are registered on the database and through it over 40,000 families have been reconnected.[35]	Digital Access Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability
Increasing reach of low-cost remittance services Mobile-based remittance services allow migrants to remit funds at a low cost. This has particular impact on remittance corridors where services are expensive or inaccessible.	**Example:** Digicel, a mobile network operator and mobile money service provider, and KlickEx, a digital remittance service provider, have partnered to allow remittances to be sent directly to a mobile phone. The service is available for customers sending money from New Zealand to pacific island states such as Samoa, Tonga and Fiji and it is estimated that 70% of formal remittances to these islands are processed through the service.[36]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital identity for refugees and migrants Digital access and blockchain technology can be used to give migrants and refugees digital identification to facilitate border crossing and administrative processes.	**Example:** The UN Refugee Agency is currently looking to develop a blockchain-based solution to host an e-registry consisting of certified documents relating to refugees and ultimately provide digital identities to refugees.[37]	Digital Access	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Facilitating migration Digital technologies such as AI and blockchain can be used to assist with the administration and process that facilitates orderly migration. This can make the process more efficient, quicker and transparent.	**Example:** Migranet is a digital platform which uses AI to assess potential migrants' eligibility to relocate and provides access to up-to-date regulations and application forms which are checked by AI. Information and certified documents is all stored securely using blockchain.[38]	Cognitive Blockchain Cloud	Importance to SDG Role of digital technologies Scalability
Faster remittance processing AI is being used to facilitate and automate remittance processing, which speeds up the process and may lead to lower costs. In addition, remittance customer services powered by AI can handle customer queries, work 24/7, and be faster and more accurate than human agents.	**Example:** SimbaPay uses an AI-powered chatbot service that allows users to order remittances by SMS. Users provide the recipients phone number and then the AI obtains bank details and processes the transaction. The service is accessible as it only relies on SMS, so users do not even need a smartphone. It is lower cost and scalable, able to process thousands of transactions and enquiries per hour.[39]	Digital Access Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Interactions with other SDGs

Reducing inequality is strongly associated with reducing levels of poverty (SDG 1) and increasing access to essential services such as health care and education (SDG 3 and SDG 4). SDG 10 is also indivisible from achieving greater gender equality (SDG 5). Greater equality may also be associated with reduced violence and criminal activity (SDG 16) and enhancing inclusive and sustainable urbanisation (SDG 11).

The goal is also related to achieving decent work and economic growth (SDG 8) as these factors can boost the incomes and standards of living of the poorest, if growth and employment are inclusive. In addition, remittances are associated with greater levels of income and economic activity and digitally-enabled financial inclusion, which is an important tool for reducing inequality and is a key component of decent work and economic growth.

There are also implications for climate action (SDG 13) as inclusion of people most vulnerable to climate change in decision making is more likely to result in positive change towards achieving this goal, particularly in building resilience and mitigating impacts of climate change. In return, combatting climate change and building resilience to its impacts are important for reducing inequality, given the disproportionate negative impacts climate change has on the poorest and most vulnerable globally.

Digital technologies have also become an essential part of safe and well-managed migration, by allowing access to real-time information for migrants and enabling them to remain connected or reconnect with loved ones.

Negative externalities

Impact of widespread use of digital technologies on achievement of SDG 10

Exacerbating inequality: Digital technologies are already proving an effective tool in reducing inequality and with great capacity has even greater effect; however, it may also exacerbate inequality. Digital technologies have the potential to increase inequalities both within countries and between countries. There is currently a lack of equality of access to digital technologies and services; barriers to access include lack of infrastructure, digital skills and financial barriers. This within-country digital divide means that the benefits of digital technologies generally accrue to the wealthier and more educated, increasing rather than reducing inequality. This not only applies to within countries but also between countries, as more developed countries are likely to have the infrastructure, investment and capabilities that increase capacity for technology absorption which ultimately leads to the benefits being shared unequally between nations.[40] As an illustration of this 'digital divide', it is estimated by the ITU that in 2018 over 80% of the population in developed countries had access to the internet in contrast to 45% in developing countries and less than 20% in least-developed countries.[41]

Labour market divide: Greater use of digital technologies could lead to labour market polarisation and job displacement, which links in with SDG 8 regarding employment and decent work. Automation and digital distribution might mean that some workers are able to produce and therefore earn far more, while others see the demand for their labour diminish with the automation of routine work. Some research suggests that digital technologies complementing 'high-wage jobs' and substituting for more routine 'middle-wage jobs' may drive this polarisation and greater wage inequality.[42] This may also cause job displacement through adoption of digital technologies, for example through greater automation, which is more likely to affect the poor, low skilled, young, and women, exacerbating inequalities.[43]

In order to understand how to mitigate inequalities caused by adoption of digital technologies it is important to consider the extent to which the development of tech, its use, and the benefits it generates, is shared:

- Development: The digital technologies being considered are generally developed and produced in developed countries, by the more well-off, where levels of investment, infrastructure and capabilities are highest. This is not necessarily a problem if use and benefits are shared more widely; however it also means that tech is less likely to be created with developing countries and the poor in mind, or with their input, and so is less likely to apply to the situations of these people and countries.
- Use: If tech is not made accessible to all then it is hard for benefits to be shared by all. This relies on a level playing field for the deployment of tech, which can be a challenge given lack of basic infrastructure and digital skills that the tech covered in this report often relies on in some places.
- Benefit: Sharing the benefits of tech is most important in terms of directly reducing inequality. Although this often requires sharing of development and use of tech there may be cases where it does not. For example, the insights of data analysis using AI may be useful to policymakers in developing countries, helping the benefits of that analysis to be shared, even if the use remains in one place. In this way, 'delocalising' benefit from use is key to mitigating negative impacts on inequality.

This highlights the importance of development of digital technologies including the poor and developing countries; deployment of digital technologies reaching poor areas and developing countries; delocalising benefit from use to share positive impacts with the poor and developing countries.

Impact of using digital technologies to achieve SDG 10

Promoting exclusion: Digital technologies can also be used to promote exclusion, intolerance and hate. Hate speech and extremist content being shared via digital channels and social media is a problem that is receiving increasing attention. Spread of misinformation about certain groups of people can also lead to increased problems of discrimination.

Introducing biases: Increasing reliance on AI can introduce pervasive biases against certain groups of people, for example, in its use in administrative processes such as with migration. Given the complexity of these programmes and algorithms, these biases can be hard to detect and correct. In addition, further use of digital identities is still being debated given concerns around privacy and giving states the ability to track people.

Concentration of corporate wealth and power: Finally, increasing returns captured by big technology companies can also increase inequality. With the wider adoption of digital technologies, big technology companies are likely to experience increasing economic returns as their scale, reach and access to data increases. This may lead to an increasing concentration of income, wealth and power among the individuals who own and manage these companies and, most prominently, increase the wealth of the richest individuals relative to the rest of the population.

11 SUSTAINABLE CITIES AND COMMUNITIES

SDG 11 DEEP DIVE

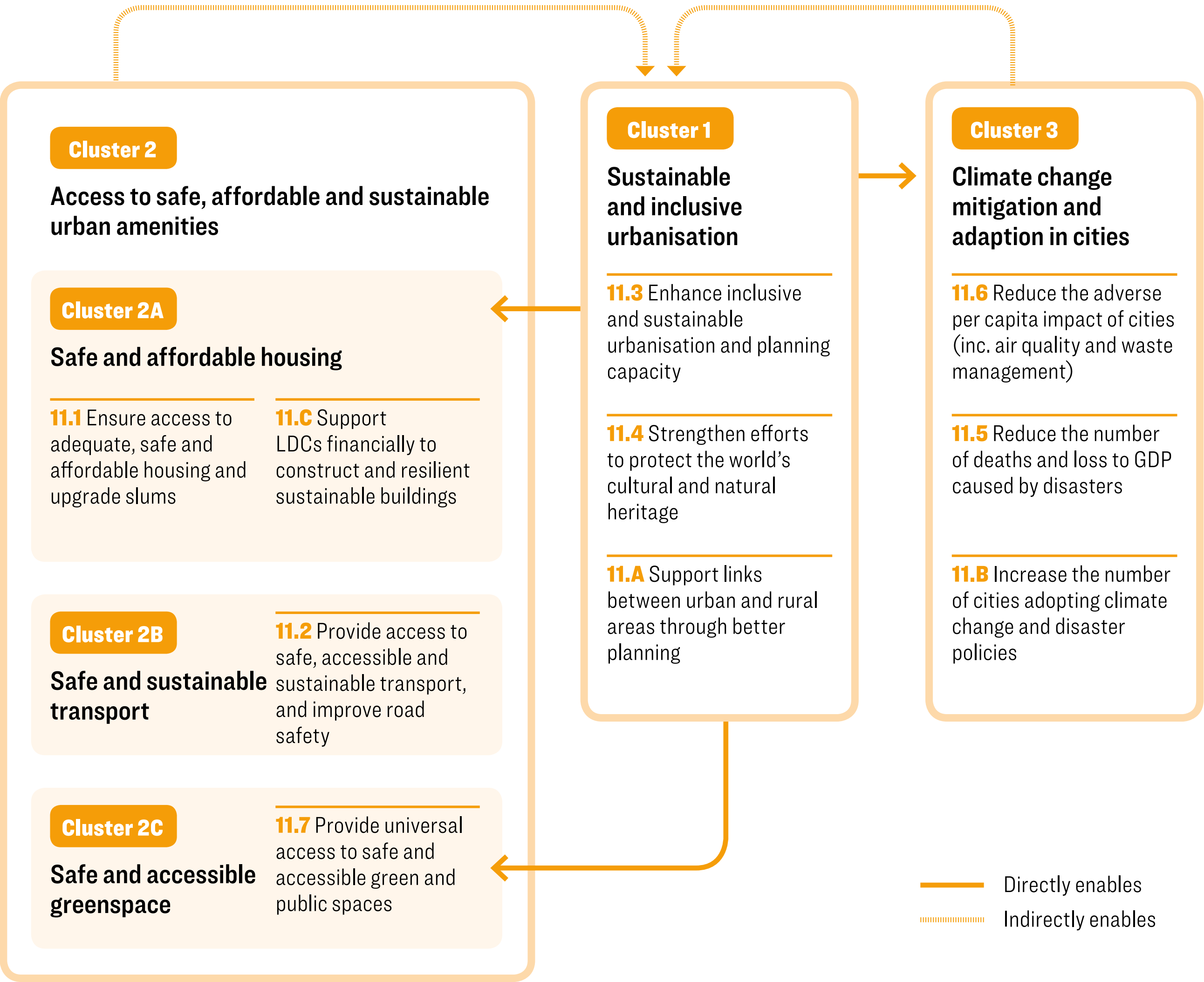
Sustainable Cities and Communities

SDG 11 covers aspects of sustainable development largely confined to urban areas, including implementing sustainable urbanisation and urban planning, ensuring access to urban amenities and infrastructure, and encouraging cities to both mitigate and adapt to climate change and environmental degradation.

SDG 11 is crucial to achieving sustainable development, given that urbanisation is one of the most important drivers of societal and environmental change, with many cities around the world already facing acute challenges associated with rapid urbanisation.[1] These challenges include stark socioeconomic inequalities, poverty, unemployment, crime, air pollution and large environmental impacts. While cities occupy just 3% of the Earth's land, they account for 60-80% of global energy consumption and 75% of global carbon emissions.[2]

These challenges will intensify as the proportion of the world's population living in cities or urban centres grows from 55% in 2007 to over 70% by 2050.[3] As the future will be urban for a majority of people, and because climate change, water scarcity and other environmental pressures are mounting for urban populations, what happens in cities over the next couple of decades will influence the well-being of most of humanity and global prospects for sustainable development. However, urban areas also lend themselves well to discovering, testing and scaling solutions to some of the greatest issues facing humanity, due to their density, economies of agglomeration and developed governance systems.[4]

SDG 11 System



Cluster 2

Access to safe, affordable and sustainable urban amenities

Cluster 2A

Safe and affordable housing

11.1 Ensure access to adequate, safe and affordable housing and upgrade slums

11.C Support LDCs financially to construct and resilient sustainable buildings

Cluster 2B

Safe and sustainable transport

11.2 Provide access to safe, accessible and sustainable transport, and improve road safety

Cluster 2C

Safe and accessible greenspace

11.7 Provide universal access to safe and accessible green and public spaces

Cluster 1

Sustainable and inclusive urbanisation

11.3 Enhance inclusive and sustainable urbanisation and planning capacity

11.4 Strengthen efforts to protect the world's cultural and natural heritage

11.A Support links between urban and rural areas through better planning

Cluster 3

Climate change mitigation and adaption in cities

11.6 Reduce the adverse per capita impact of cities (inc. air quality and waste management)

11.5 Reduce the number of deaths and loss to GDP caused by disasters

11.B Increase the number of cities adopting climate change and disaster policies

— Directly enables

┈ Indirectly enables

Due to the rapid urbanisation predicted to occur over the coming decades, core to achieving SDG 11 is achieving sustainable and inclusive urbanisation (Cluster 1), which involves improving urban planning, supporting urban-rural linkages and ensuring urbanisation does not harm the world's cultural and natural heritage. Ensuring equal access to safe and affordable urban amenities (Cluster 2), addresses the most tangible assets (and indeed rights) of urban living, including access to housing, transport, and green and public spaces. Climate change mitigation and adaptation in cities (Cluster 3), involves both reducing the current environmental impact of cities and protecting cities from future disasters and climate-induced events. Effective urban planning (Cluster 1) directly enables Clusters 2 and 3, and in turn achieving aspects of Clusters 2 and 3 reinforces the implementation of sustainable cities.

The role of digital technologies in delivering SDG 11

Sustainable urbanisation and urban amenities, and smart urban management will be significantly accelerated by digital technologies. Digital technologies connect people to urban services like public transport or government elections. Digital technologies also enable real-time monitoring of a variety of different issues occurring within urban areas – pollution, disasters, unsafe housing, and homeless or displaced people.

Combining IoT and AI enables “smart” urban management - including smart traffic lights and street lights, smart waste disposal, smart utilities and smart buildings – all of which optimise energy usage and reduce the environmental impact of cities. In future, autonomous transport options are expected to transform urban transport, and improve urban-rural linkages. Sitting one layer above this is the concept of a Smart City, a digitally-enabled amalgamation of all or some of the above digital services, where all relevant data is collected and controlled from a “digital command centre” or similar. These smart city command centres can control aspects of mobility, safety, energy and the environment, enabling provision of smart services in a co-ordinated way across multiple city domains.

Many of the above examples are characterised by a need for high broadband connectivity – to connect urban residents, but more importantly to connect devices that power urban amenities and services. It is anticipated that 50 billion devices will be connected to mobile networks by 2020 – with devices ranging from public rubbish bins to streetlights to autonomous vehicles. Therefore, to carry the weight of a smart city of the future, mobile networks will need to be fast and stable enough to handle such large volumes of data. The arrival of 5G internet, and the low latency (end-to-end transmission time) it brings, will enable large-scale device-to-device communication, and enhanced applications of digital technologies in urban services, such as transport and emergency services. Thus, ensuring universal access to 5G will be of paramount importance to maximising the impact of digital technologies to support the achievement of SDG11.[5]

Sustainable urbanisation also demands a good deal of sustainable and resilient physical design, the foundation over which digital technologies are layered. Such physical design includes sustainable housing, open and green space, transport infrastructure and “natural” disaster buffers. All of this must be supported with sufficient levels of investment and regulation to ensure such urban attributes are safe, affordable and sustainable.[6] Sustainable and inclusive cities also require adequate social safety nets to cater for the increasing numbers of urban poor, as well as functioning governance systems that promote the rule of law and security for all citizens.

Sustainable urbanisation and urban amenities, in addition to smart urban management, will be significantly accelerated by digital technologies.

Impact projection to 2030

Road transport is a large contributor to air pollution in cities, and it is growing. A study by the WHO showed that tailpipe emissions of primary particles from road transport accounts for up to 30% of fine particulate matter.[7] Mean annual exposure to PM2.5 measures the atmospheric air pollution to which a population is exposed. Specifically, it measures the average levels of exposure to concentrations of suspended particles measuring less than 2.5 microns in aerodynamic diameter. Due to the size of these particles, in large quantities they can threaten public health.

According to the WHO, average life expectancy in the most polluted cities could be increased by approximately 20 months if long-term PM2.5 concentration was reduced to the Air Quality Guideline (AQG) of less than an annual average of 10 micrograms per cubic metre.[8] Currently, mean global levels are around 46 micrograms per cubic metre, with the value varying by both region and level of development. Based on projections by the Global Burden of Disease Study, this figure could reach 51 micrograms per cubic metre in 2030 (a 10% increase).

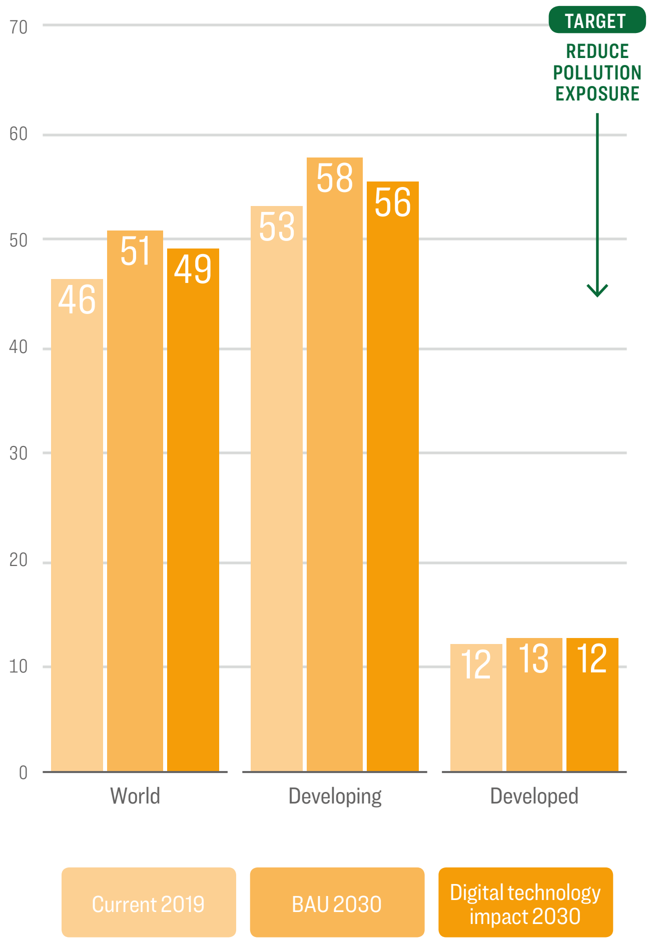
Intelligent transport systems go some way to managing this pollution by improving efficiency. Real-time traffic flow management, improved public transport information and predictive maintenance of infrastructure can all improve the way in which people move around cities.

Targeted implementation of intelligent transport systems to improve the means and efficiency with which populations travel around cities could reduce the mean global level of PM2.5 to 49 micrograms per cubic meter in 2030, equivalent to a reduction of 3.6% against the business-as-usual scenario.

High exposure to PM2.5 raises a special concern in developing countries, where mean levels could increase to 58 micrograms per cubic metre, compared to 13 micrograms per cubic metre in developed countries in 2030.

The level of PM2.5 in developing countries is estimated to be 3.7% lower in the scenario with digital technology adoption compared to the business-as-usual scenario. This is a slightly greater relative reduction than the global average, though there is still room for improvement. A survey of experts noted that behavioural changes and more integrated infrastructure would be required to truly make a difference.

Mean annual exposure to PM2/5 (micrograms per cubic metre)



Importance of digital technologies to target attainment

	TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1	**Sustainable and inclusive urbanisation**		
🟩	**11.3:** Enhance inclusive and sustainable urbanisation and planning capacity	Digital technologies allow for more efficient, optimised urban planning, as well-integrated smart city management, which will be important to sustainable urbanisation going forward. They also enable participatory urban planning, through digital engagement methods.	N/A
⬜	**11.4:** Strengthen efforts to protect the world's cultural and natural heritage	Besides enabling virtual experiences and monitoring the security of world heritage sites, digital technologies will have less direct impact on protecting the world's natural and cultural heritage than strengthening such policy efforts themselves.	N/A
⬜	**11.A:** Support links between urban and rural areas through better planning	This target primarily relies on public policy, as it focuses on the implementation of urban and regional development plans.	N/A
2	**Access to safe, affordable and sustainable urban amenities**		
🟧	**11.1:** Ensure access to adequate, safe and affordable housing and upgrade slums	Digital technologies enable more efficient housing construction and help ensuring that housing is safe, affordable and accessible. However, this target primarily relies on the physical provision of housing and upgrading of slums.	🟢↘
⬜	**11.C:** Support LDCs financially to construct & resilient sustainable buildings	Besides potentially enabling digital transactions, digital technologies have limited direct impact on finance flows to LDCs to support infrastructure development.	N/A
🟩	**11.2:** Provide access to safe, accessible and sustainable transport, and improve road safety	Digital technologies are key enablers of road safety, and can ensure that transport is accessible to disabled people and improve the sustainability and efficiency of transport.	N/A
⬜	**11.7:** Provide universal access to safe and accessible green and public spaces	Digital technologies have little impact on providing universal access to green and public spaces, as this relies largely on the planning and physical layout of urban areas. Digital technologies play an important role in ensuring these spaces remain safe, however, which is addressed in SDG 16.	N/A
3	**Climate change (and environmental degradation) mitigation and adaptation in cities**		
🟩	**11.6:** Reduce the adverse per capita impact of cities (inc. air quality and waste mgmt.)	Reducing the environmental impact of cities will rely heavily on digital technologies for optimising city processes, such as utilities or waste collection. Additionally, digital technologies can monitor levels of pollution, enabling public sector and other organisations to respond and mitigate.	🔴↗ 🟠→ *
🟩	**11.5:** Reduce the number of deaths and loss to GDP caused by disasters	The management of natural hazards and associated disasters in cities relies heavily on digital technologies for early warnings, monitoring during and after disasters, and adaptation.	🟠→
⬜	**11.B:** Increase the number of cities adopting climate change and disaster policies	Digital technologies have little specific impact on the process of adopting climate change and disaster policies, although can provide the underlying evidence and assist in the form of current and future impacts.	🟢↗

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

🟩 High impact
🟧 Moderate impact
⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

🟢 Positive progress
🟠 Limited progress
🔴 Negative progress

*Varies significantly according to development level, with increases observed in developing countries and relatively static levels observed in developed countries

Cluster 1

Sustainable and inclusive urbanisation

Cities are rapidly growing, often without sufficient urban planning: 30% of cities have not been planned or laid out at all.[9] Poor urban planning is also giving rise to declining urban densities and urban sprawl – where cities physically expand at a faster rate than their populations grow.[10] Between 1990 and 2015, cities in developed countries increased their urban land area by 80%, but urban populations only increased by 12%.[11] The way such unprecedented urban growth is managed in the years ahead will be crucial to ensuring sustainable urbanisation, as the consequences of excessive unplanned urban expansion are numerous, including increased demand for mobility, environmental degradation, increased cost of providing basic services per capita (water, sanitation, drainage) and reduction in economies of agglomeration.[12] Inclusive urban planning is also vital for sustainable urban development. Results of a recent survey reveal that only 48% of cities engaged civil society prior to urban developments, such as new roads.[13]

Digital technologies can facilitate participatory and inclusive urban planning allowing urban citizens to easily communicate their preferences and concerns. Deep learning models can optimise urban design and planning for resilient and human-centric cities, whilst digital reality can augment the urban design process, allowing urban planners and citizens alike to interact with planned changes. In the future, it is expected that cities will be increasingly designed as, or converted to, “smart cities”, allowing for optimised and often autonomous management of various urban services and processes, such as mobility, safety and waste collection (covered individually in Clusters 2 and 3).

Attainment of sustainable urbanisation must also involve effective planning, development and enforcement of inclusive policies and environmental protection plans. Furthermore, greater investments in sustainable and accessible urban amenities and services will be required. Effective planning should focus on the creation of dense and vertical cities, as opposed to wide, sprawling cities, as this improves sustainability through discouraging private car use and through generating economies of agglomeration (benefits and resource-sharing efficiencies arising from the close proximity of people, housing and businesses).[14] Municipal governments and urban committees also need to promote and facilitate different forms of civil participation in traditional ways, including through formal petitions, town hall meetings, neighbourhood advisory committees, public hearings, campaigns and elections (all of which could also be held digitally).[15]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile platforms and gamified apps engage members of the community with urban planning Digital technologies can connect citizens to the urban planning process, through interactive planning apps, voting apps, phone/internet based town halls etc. This makes the urban planning process more inclusive and efficient.	**Example:** UN-Habitat's "Block-by-Block" platform, based on the game Minecraft, was introduced to engage communities in public space planning and regeneration, and link civil society to decision making bodies.[16]	Digital Access	Importance to SDG Role of digital technologies Scalability
Digital technologies make cities more inclusive for those with disabilities Digital kiosks or smart objects within cities can transmit information in different formats to people with disabilities, making cities more accessible to them.	**Example:** Fully accessible LinkNYC digital kiosks have transformed the way the nearly one million New Yorkers with disabilities receive information.[17]	Digital Access IoT	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Deep learning and predictive modelling can optimise the designing of sustainable, resilient and human-centric cities Deep learning models can rapidly test a variety of urban configurations before putting forward the most efficient options. They can also identify areas where design efficiency could be improved, or discover correlations between design decisions and the impact on people's daily lives in order to make urban areas more human-centric.[18]	**Example:** Spacemaker is an AI-assisted design and construction simulation software. The software lets its users (architects and developers) generate a multitude of site proposals, and conducts detailed analysis in order to identify the best proposal, with the aim of creating sustainable cities with the help of AI.[19] **Example:** STUDIOMAPP, specialises in AI and advanced ICT innovation for quality of life improvements. They apply AI to Geo-Computation and Geospatial Data to deliver design solutions for Smart Cities. They developed a Location Intelligence system called Qirate that rates quality of life of neighbourhoods by integrating heterogeneous data types and sources. The algorithm displays the information in a map and aggregates them using different indicators that can be used to plan and measure the impacts of urban regeneration actions.[20]	Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AR and VR headsets improve urban design and make the design process more inclusive and interactive Digital reality is rapidly becoming mainstream to urban development, design, and planning. Urban planners use this technology to visualise prospective projects and their impacts on infrastructure and the environment in order to gain an understanding of how the project fits into the wider urban landscape, and to produce more involved feedback and designs with less fatal flaws. It also enables participatory urban design, with members of the community able to visualise, interact with and provide feedback on planned changes,[21] allowing urban planners "to create better, more socially just places".[22]	**Example:** 'Palimpsest', a University College London project, seeks to explore the ways in which communities can be affected by new developments and to provide an empathetic way for planners to experience such an impact. The project is currently examining HS2, a planned high-speed railway in the UK, and its potential impact on local inhabitants.[23]	Digital Reality	Importance to SDG Role of digital technologies Scalability
Smart cities – adaptive urban management through AI-enabled urban dashboards Smart cities combine technologies and drivers of impact covered throughout this report, to allow for fully integrated and adaptive urban management. IoT sensors are laid over the physical elements of a city, such as buildings, roads, green spaces, utilities. Smart city architecture combines data from these sensors, as well as from people and agencies, onto adaptive urban control platforms. The platforms then can monitor, analyse and automate a range of elements, enabling or improving services such as licensing, predictive security, intelligent parking, water quality and circular economies. Existing cities can be retrofitted to become smart cities, and new cities should be planned to be smart cities from conception.	**Example:** Deloitte Blueprint enables cities to implement various smart city services using a systemic framework and management platform that amalgamates city domains including mobility, safety, energy, environment and others. Using such methodology, Deloitte worked with Cascais City, Portugal to develop a Digital Command Centre capable of integrating, designing and controlling 12 city-wide managed services in the same place. As an example, Cascais is able to integrate waste management data with traffic and public infrastructure data, like road construction and repairs. Using this real-time data, the city can identify the optimal route and time for garbage collection, which aims to reduce operational costs by up to 40% with an expected savings of €900,000. Cascais is planning to integrate additional city information, including citizen inputs, in subsequent phases.[24] **Example:** Nokia recently successfully demonstrated its AI-powered Integrated Operations Centre (IOC), a smart city management solution, to Viettel in Hanoi, Vietnam. Once deployed, the IOC will allow Viettel to efficiently manage several smart and safe city use cases such as traffic monitoring, pollution detection and water quality monitoring, all from the same automated dashboard.[25] **Example:** The city of Boston is using Verizon's Smart Communities technology to optimise traffic flow, understand road-user behaviours and control outdoor public lighting, leading to a safer, cleaner city.[26]	Fast Internet / 5G IoT Cognitive Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Cluster 2

Access to safe, affordable and sustainable urban amenities

Within this cluster, digital technologies have the highest potential impact against housing and transport. These amenities will be explored separately due to the high volume of identified use cases.

2A Housing

Inadequate housing and sprawling slums continue to plague urban areas. Despite a reduction in the proportion of the global urban population living in slums from 28.4% in 2000 to 22.8% in 2014, the actual number of people living in slums has increased from 807 million to 882 million.[27] Housing affordability is also a growing concern. Over the past 50 years, housing prices in high-income countries increased three times more than the price of other basic services.[28]

Digital technologies can improve the safety, affordability, sustainability and efficient use of housing in urban areas, although actual access to housing is enabled by availability of houses themselves. They can connect potential occupants to empty houses quickly, as well as help monitor the safety of houses and occupants within houses. More advanced technologies can analyse large amounts of image and satellite data to identify and target areas of unsafe housing, monitor and optimise energy and water usage within individual houses, and automate the design and construction of houses.

Access to safe and affordable housing in general can be facilitated by housing affordability policies,[29] as well as unit and land taxation designed to incentivise efficient and compact building design in order to reduce rent prices.[30] Additionally, modularising existing housing stock and building new housing stock will be required to house the increasing number of urban dwellers. In fact, it is estimated that 400-600 million new housing units will need to be provided by 2030.[31] In addition to the above interventions, design and materials innovation, such as developing cheaper and faster to produce building materials, will also help in ensuring everyone in cities has access to adequate housing.[32]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile and digital techs enable peer to peer accommodation platforms, accelerating access to housing These platforms can help individuals looking for housing to find a home faster by connecting them to rentals. They can also connect individuals to other individuals looking for a housemate, increasing housing usage and decreasing the number of empty rooms in a city.	**Example:** Roomi is an app that allows users to instantly post and find available rooms and roommates in a selected number of cities. The app offers background checks and secure in-app messaging to improve security of housing.[33]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

Specific driver / use case	**Use** case example	TECH	IMPACT
IoT sensors in homes monitor various conditions and home threats, improving overall safety of housing Sensors can monitor events such as break ins, fires and elderly fallers, and alert relevant emergency services if they do occur, leading to improved home and building safety.	**Example:** Bell Smart Home uses fast internet and IoT to provide a range of home monitoring services and, building on the acquisition of AlarmForce, continues to expand connected home services to include new home security solutions.[34] **Example:** Taiwan Mobile Home Security offers real-time, remote monitoring of households using high-quality video image surveillance transmitted through broadband. The service offers emergency notifications, family relationship support, and can deters burglaries and crime.	IoT	Importance to SDG Role of digital technologies Scalability

Lower Higher

Moving the housing market onto blockchain could enable smart, traceable and efficient housing contracts Blockchain networks could address a number of issues that currently exist in the housing market. For example, many middlemen are involved with the real estate process (e.g. brokers, lawyers, banks etc.), each coming with their own fees. These costs could be bypassed if an individual were able to buy or sell a property over blockchain using cryptocurrency. Not only, therefore, could blockchain improve the affordability of housing, but it could also increase speed of access (by removing dealings with a number of superfluous parties).	**Example:** Rentberry is one of the first companies in the world to implement blockchain technology into the rental market. The Rentberry platform employs smart contracts between landlords and tenants, removing any need for expensive brokers. It also put forward a solution to the high security deposit fees renters have to pay when signing a new lease. Instead of an individual tenant having to put down the full deposit, they can opt to crowdsource their deposit with the Rentberry community. With this solution, the tenant will only have to put down 10% of the security deposit upfront, and pay back the remaining 90% to the Rentberry community each month.[35]	Blockchain	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AI algorithms can be applied to drone or satellite images, to identify homeless people and insecure housing conditions Accurate identification of slums, unsafe housing and individuals enable authorities to initiate targeted interventions to individuals in need of housing, or to slums in need of retrofitting. Overall, this leads to better access to adequate and safer housing.	**Example:** The city of Bengaluru recently conducted a study using satellite imaging and machine learning. The study recorded around 2,000 informal settlements, compared to the 600 in government records. The government will use this to improve access to adequate housing & housing services such as sanitation.[36] Similarly, in Guatemala City, images and algorithms were used to locate "soft-story" buildings (buildings at least two storeys high that have a structurally weak first floor) to flag them for further safety inspection. After scanning 4,967 homes, the computer detected 503 possible soft-stories with 85% accuracy.[37]	Cognitive	Importance to SDG Role of digital technologies Scalability
AI algorithms can model efficient housing design options and identify flaws before housing is physically built This leads to faster planning overall, reducing building fees. Improved and efficient design leads also to reduced operating costs (and therefore affordability) once the house is occupied.	**Example:** Parametric Support is a start-up that uses mathematical methods and AI algorithms to scan a pool of housing design options and indicate the best performing options within hours, rather than days. This design optimisation enables a 40% reduction in raw material used in building and 20% reduction in energy savings.[38]	Cognitive	Importance to SDG Role of digital technologies Scalability
Predictive models can be applied to property data to predict the probability of a building being unsafe Historical property data patterns, e.g. on property inspections passed or failed, can help city governments build powerful predictive models in order to detect unsafe buildings before they deteriorate to the point of collapse. This leads to improved overall safety of housing.	**Example:** Urban Spatial used data from Philadelphia's Department of Licenses and Inspections on buildings demolished due to safety concerns to train a model to predict the probability of a current building of being unsafe.[39]	Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Autonomous robots can construct specific building parts and work together to construct buildings efficiently and quickly This enables housing to be constructed faster and more efficiently, leading to improved access and affordability overall.	**Example:** Robotic swarm construction, developed by researchers at Harvard and designed based on how termites work together in a swarm. Construction robotics are programmed to work together in this manner, with each one programmed to build a certain design feature or part of the house. They are also equipped with sensors to detect the presence of other robots, so that they can work together.[40]	Cognitive IoT	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

2B Transport

A good, sustainable transport system is synonymous with the growth of many urban economies and the quality of life found in cities. Experts believe sustainable transport should have four attributes: universal accessibility, efficiency (monetary, energy and space efficiency), safety, and climate resilience (i.e. clean systems of transport must address climate change through mitigation and adaptation).[41] Currently, urban transport systems often lack one or more of these attributes. The transport sector is responsible for approximately 23% of energy-related greenhouse gas emissions, and 3.5 million premature deaths resulting from outdoor air pollution annually.[42] Road transport claims the bulk of transport-related fatalities worldwide, accounting for 97% of transport-related deaths, with 40-50% of traffic-related fatalities occurring in urban areas. Global public transport demand is also rising; demand grew by an estimated 20% between 2000 and 2014.[43]

Digital technologies enable a variety of intelligent transport solutions. Specifically, they can improve the sustainability of transport by connecting people to ride sharing and lower impact transport options, and help those with accessibility challenges access transport options too. They also can monitor driver and road safety in real time, to improve overall safety of transport systems. Digital technologies can also optimise public transport routes, to make taking public transport as quick and easy as possible, while improved traffic and parking capabilities can reduce congestion and emissions. Finally, autonomous vehicles will change the nature of urban transport, improving safety and reducing emissions and traffic.

In addition to implementing smart transport technologies, cities should promote sustainable transport policies, investments and economic incentives.[44] These can be grouped into three principal categories:[45]

- AVOID: reduce or avoid the need to travel through compact urban planning and integrated land use planning;
- SHIFT: encourage a shift to more environmentally friendly modes of transport, such as non-motorised transport of public transport, e.g. through bike to work schemes; and
- IMPROVE: improve the energy efficiency of private transport through the use of cleaner fuels and lower emission/electric vehicles.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile apps enable bike rental and ride sharing Transport rental or sharing apps encourage lower impact transport options to be chosen by connecting people easily to bikes, car sharing opportunities or other forms of transport. Overall, this improves sustainability of city transport by leading to fewer cars on the road and increasing utilisation of greener forms of transport.	**Example:** Journify is a car-pooling app used by companies to enable employees to car-pool on their daily commutes into the office, lowering the companies' carbon footprint and encouraging collaboration amongst employees.[46]	Digital Access	Importance to SDG Role of digital technologies Scalability
Mobile apps help those with accessibility challenges access transport options Apps can connect people with accessibility challenges to alternative accessible transport options, or communicate instructions to those with vision or hearing impairments in order to enable them to use public transport more easily.	**Example:** The UberWAV app connects wheelchair users to wheelchair accessible vehicles, with an average wait of about 15 minutes. Another app, Wayfindr, helps people with vision impairments navigate train stations using audio technology.	Digital Access	Importance to SDG Role of digital technologies Scalability
Mobile apps reward use of public transport, leading to increased use of public and sustainable transport	**Example:** Ciclogreen is an app that gives users a point every time they travel 100 metres on sustainable transport (defined as cycling, walking/running, public transport, sharing a car or skating). Once users gather up enough points, they are able to redeem them on various prizes within the city, such as food or entertainment.[47]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT-enabled driver wearables monitor driver behaviour and health to improve road safety IoT-enabled wearables can sense if a driver is becoming sleepy or behaving abnormally, and notifies them to stop driving. This can reduce the number of road accidents, improving the safety of transport systems and of individual drivers.	**Example:** Fujitsu has introduced The Driver Drowsiness Detector, a wearable device that is worn round the neck with a small sensor clip attached to the driver's earlobe. The sensor monitors the driver's pulse and gauges drowsiness levels, notifying the driver via vibrations on the neck if there is a risk of impairment to reaction times. The aim of the detector is to reduce number of accidents that occur due to driver fatigue.[48]	IoT	Importance to SDG Role of digital technologies Scalability
IoT-enabled smart roads will soon be able to manage traffic flow in real time and relay valuable information to drivers Smart roads will be able to monitor and feedback information, such as traffic and weather conditions, in real time into vehicles' GPS receivers, giving drivers valuable driving information. This will improve road safety, and reduce congestion (and therefore air pollution).[49]		IoT Cloud	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile apps analyse transport data in real time to produce optimised travel routes and increase usage of public transport "Mobility-as-a-Service" systems offer various routing solutions that optimise personal mobility options and usage of public transport, for example by offering a part-bus-part-walking journey option. One key component of these systems is the real-time collection and dissemination of public transport information.	**Example:** The Departures App provides real-time departure info regarding New York public transit, based on transport authority data. Users access departure times and service alerts without having to enter any information manually, they simply have to hold their smartphone in the direction of the station. This makes public transport more convenient and less stressful to use.[50] **Example:** WhereIsMyTransport is a technology company based in London and Cape Town that provides services that harness advanced public transport data from African cities. The services include data collection, data access and public transport journey planning.[51]	Digital Access Cloud	Importance to SDG Role of digital technologies Scalability
IoT sensors can monitor the availability of parking spaces, and algorithms can advise on the optimal route to get to the space Information on parking availability can be fed back in real time to drivers, via apps or vehicle GPS, enabling them to efficiently locate parking in cities. This reduces congestion and therefore air pollution in cities.	**Example:** ZTE has created a cloud-based smart parking programme that combines IoT technology, wireless communications technology and GIS and applies them to help users query, book and navigate urban parking spaces. The smart parking system optimises the user's parking experience, improves the efficiency of urban parking and also effectively relieves urban traffic jams and environmental pollution.[52] **Example:** Deutsche Telekom has introduced an app called Park and Joy to over 80 German cities, which helps users identify and navigate towards open parking spaces. The app is highlighted as an in-depth case study within this report.	Digital Access Cloud IoT Cognitive Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT sensors enable optimised traffic light and traffic flow management IoT sensors provide real-time road traffic data, and analytical models use this data to automatically control traffic signals. This, in turn, optimises traffic flow through cities, reducing congestion, air pollution and emissions.	**Example:** Verizon offers an advanced traffic management service for public agencies. The service leverages in-ground wireless vehicle-detection sensors and intelligent, cloud-based data collection systems managed by Verizon. It helps public agencies optimise signal timing and traffic flow, on the basis of real-time traffic data. Overall, this leads to 40% fewer traffic delays, 25% less travel time, 10% fuel savings and 22% fewer emissions.	IoT Cognitive Cloud Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability
A number of digital technologies combined will soon allow for autonomous (and ideally electric) vehicles Humans naturally create stop and go traffic, make inefficient driving decisions and have generally poor reaction times. Autonomous vehicles, using data transmitted from other vehicles, will be able to predict congested routes, and make driving decisions to decrease congestion and fuel usage. They will also be able to identify and react to potential safety issues far faster than humans. Therefore, autonomous cars will ultimately transform short-haul mobility, by improving road safety and optimising fuel usage, thereby reducing road traffic incidents, greenhouse gas emissions and air pollution.[53] Research has determined that even a small percentage of autonomous vehicles, e.g. 5% of total road vehicles, could have a significant impact on eliminating traffic waves; reducing total fuel consumption by up to 40% and braking events by up to 99%.[54]	**Example:** Verizon's MCity pilot is testing how autonomous vehicles communicate with other vehicles, pedestrians, bicycles and the surrounding infrastructure, in order to improve passenger safety.	IoT Cognitive Cloud Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

While cities occupy just 3% of the Earth's land, they account for 60-80% of global energy consumption and 75% of global carbon emissions.

Cluster 3

Climate change (and environmental degradation) mitigation and adaptation in cities

Cities have both a large impact on climate change and the environment, and significant vulnerability to climate-induced disasters. As noted above, cities account for 60-80% of global energy consumption and 75% of global carbon emissions.[55] Air pollution is also a pressing issue; in 2016, 91% of the urban population worldwide were breathing air that does not meet the WHO air quality guidelines for particulate matter (PM 2.5), resulting in an estimated 4.2 million premature deaths in 2016.[56] Additionally, an estimated two billion people do not have access to regular waste collection, and even when waste is collected it is often not disposed of in an environmentally-sound manner. In sub-Saharan Africa, less than half of municipal solid waste is collected, causing adverse effects on the health of residents.[57] In terms of climate-related disasters, urban areas are often vulnerable due to their high concentration of population and infrastructure, and due to their locations (i.e. many large cities are situated on the coast or rivers).[58] Damage to housing attributed to disasters shows a statistically significant rise from 1990 onwards, with water-related disasters (floods and heavy rain) accounting for over 55% of total damage) and lower-income countries and households being affected far more frequently.[59] Conversely, cities are increasingly also at risk of water shortages, especially in countries prone to drought such as South Africa.

Therefore, there is a need to improve both climate change mitigation and adaption within cities, and digital technologies have a large role to play. Digital technologies are used to communicate targeted messages to urban dwellers, to both raise awareness of disasters and send early warning alerts. They monitor various environmental parameters, such as waste, water and air pollution levels, in order to inform decision making and activities. Finally, they allow cities to become smarter and self-optimising through various digitally-enabled “smart” phenomena, including smart buildings, smart grids and smart street lighting.

Digital technologies must be supported by and work together with a range of policy instruments and other interventions aimed at mitigating the environmental impact of cities and adapting cities to be climate resilient.

In terms of air pollution mitigation, policies linked to greening urban infrastructure must be implemented. Usage of renewable energy sources and “green” vehicles must also be encouraged and rewarded.[60] Effective urban waste collection requires continuous use of three policy instruments: direct regulation, economic instruments that provide incentives for specific waste practices, and social instruments based on communication and interaction with stakeholders.[61] In developing countries especially, biological waste management (such as anaerobic waste digestion) is a low-cost alternative preferable to the open incineration of solid waste.

For adaptation, many built environment interventions can be introduced to reduce disaster risk in vulnerable urban areas. These include investments in drainage infrastructure in flood-prone areas, appropriate building codes,[62] and the use of natural buffers such as vegetation corridors and reed beds to soak up water and partially defend against the effects of natural disasters.[63]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile phones and AR can raise citizens’ disaster awareness and reduce risk of catastrophic natural hazards Mobile phones and social media can be used strengthen public awareness of natural disasters and disaster risk, and promote a culture of disaster prevention and responsible citizenship.[64]	**Example:** Fujitsu Limited and NPO SEEDS Asia conducted a field trial in India that utilises a smartphone app that includes AR technology to counter flooding and to raise citizens' disaster awareness. The field trial seeks to measure flood water levels and to map out and visualise conditions of urban flooding. The trial was conducted in India's Varanasi, an urban area prone to flooding damage, between July and September 2018 when localised and torrential rains are frequent. [65]	Digital Access Digital Reality	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Mobile phones enable governments to send out targeted early warning messages These messages enable faster evacuation of cities at risk of dangerous natural hazards, in turn reducing loss of life.	**For example,** during the Indian Ocean Tsunami, around 85% of lives could have been saved if even a simple early warning system had been present.[66] See SDG 13 for more details.	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Connected home devices allow consumers to manage energy use remotely Smart devices give residents the opportunity to monitor their homes, whether in the house or away, particularly to check and adjust energy usage.	**Example:** Telstra's range of smart home devices allow consumers to control their lighting and thermostat through a central app. With this app, consumers can reduce unnecessary energy usage, particularly if they are away, by remotely switching off devices or setting automatic timers for lights and power plugs.[67]	Digital Access IoT	Importance to SDG Role of digital technologies Scalability
IoT-enabled smart drains monitor and react to water conditions, leading to reduced risk of flooding Given that cities are particularly vulnerable to water-based disasters, smart drain technology will protect cities from climate-induced water-based hazards, such as floods and hurricanes.[68]	**Example:** Fujitsu has introduced a 'smart drain' solution that has the potential to significantly reduce the risk of flooding due to overflows from storm water drains. The solution uses a network of sensors to monitor drains in real time, as well as cloud technology and software developed by EYEfi to provide alerts for rising water every 15 minutes. It negates the need to have manual drain inspections and enables deployment of response and maintenance teams before a blocked drain causes flooding.[69]	IoT	Importance to SDG Role of digital technologies Scalability
IoT sensors monitor and map air pollution levels in real time Sensors installed around cities can monitor and map air pollution levels in real time and provide accurate immediate forecasts, in order to enable city administrators to make decisions regarding road closures, congestion charges etc. in certain areas to ameliorate pollution levels. Some sensors can also automatically filter out air pollutants to reduce air pollution levels.[70]	**Example:** Nairobi City council installed IoT monitoring units across the city. The monitoring units can detect the level and sources of key air pollutants such as sulphur dioxide, nitrous dioxide, particulates, carbon monoxide and a range of other more specific gases. Readings, many times a minute, are mapped to show concentrations of pollutants. In 2016, Nairobi City Council used the network to quantify traffic emissions and make air quality improvements by closing off streets and reducing traffic in the central business district.[71]	IoT	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Real-time mobile analytics informs emergency disaster response and helps track climate-displaced people Organisations can use mobile and social media data to analyse and geographically pinpoint where people are post disaster, in order to aid humanitarian decision making and ensure aid is first directed towards areas that need it the most	**Example:** The UN World Food Programme, the US Federal Emergency Management Agency and mobile operators partnered to analyse mobile phone location and social media data to pinpoint where people are gathering in cities during/after disasters to improve decision making. This included the usage of AI to mine data from social media and provide quick analysis.[72]	Digital Access Cognitive	Importance to SDG Role of digital technologies Scalability
IoT data can be linked up with spatial data to monitor hazards in real time and map the best possible evacuation routes	**Example:** One identified solution collects the data from various IoT networks formed by traffic lights, traffic surveillance cameras, etc. and combines them to obtain the best and fastest evacuation routes, as well as a mapping of roads accessible to the emergency services units. This enables faster city evacuation and faster treatment of disaster victims.[73]	IoT Cognitive	Importance to SDG Role of digital technologies Scalability

Lower Higher

IoT sensors monitor waste levels and enable optimised waste collection routing IoT sensors on waste bins combined with AI-enabled dynamic routing of waste collection routes can improve waste management in cities, and reduce their environmental impact.[74]	**Example:** Telecom Italia is collaborating with the municipality of Florence on project REPLICATE, which is focused on developing an IoT connectivity platform for monitoring and managing smart waste management services, as well as smart urban furniture (bus stops and benches). The project was launched in 2016 and will last for 5 years.[75] **Example:** Ecube Labs have installed over 150 smart waste solutions in Seoul South Korea. Their smart waste solution includes fill-level sensors monitoring the quantity of waste in each bin, a big data platform gathering the information from the bins and a platform that automatically refines manual collection routes based on machine-learning algorithms, optimising waste collection.[76]	IoT Cognitive	Importance to SDG Role of digital technologies Scalability
IoT sensors monitor water and energy usage within a city, and identify areas where savings and efficiencies could be made IoT can enable remote meter and usage monitoring, real-time load control, and dynamic pricing and grid management to deliver reduced electricity theft, better voltage management and fast power restoration using secure data-centric technology.	**Example:** To prevent leaks and optimise distribution costs, Telecom Italia is experimenting with multi-utility smart metering solutions that monitor water, gas and electricity usage in real time. The solutions are based on widespread networks like IoT Narrowband, which are based on a new radio interface that can be used on a portion of LTE signal band, or independently in portions of the spectrum created by the release of frequencies.[77]	IoT Cognitive Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AR and VR headsets can be fed AI-generated disaster models, in order to visualise and stress test city evacuation plans Digital reality disaster models can be used by city planners to help in visualising and stress testing "what-if" disaster scenarios, to mitigate potential city design and development flaws vulnerable to natural disasters, and ensure city-wide disaster preparedness.[78]	**Example:** EON Reality was selected by the Singapore Civil Defence Force (SCDF) to promote emergency preparedness through the use of immersive VR technology. EON's technology simulates various emergency scenarios such as typhoons, earthquakes, tsunamis, and fires. It can be used to prepare all citizens, from first responding safety officers to school children, on how to safely react and make decisions in the face of disaster.[79]	Digital Reality	Importance to SDG Role of digital technologies Scalability
IoT-enabled smart buildings and smart street lighting automatically react to conditions and optimises energy usage Smart building and street lighting solutions monitor various parameters (light, temperature etc.) and react as necessary. These reactions optimise energy usage and reduce environmental impact of cities.[80]	**Example:** Google's Nest is a smart thermostat (using IoT and AI) for homes that optimises energy consumption by automatically adapting to user behaviour, resulting in monthly energy savings of 10-12% on heating and 15% on cooling.[81] Similarly DABBEL is an AI-enabled, autonomous smart building solution that optimises building performance – including through automatic ventilation and temperature adjustments - resulting in 75% average cost savings and 30% average energy savings.[82] **Example:** ZTE's IoT based smart street lighting solution automatically adjusts street light brightness based on the surrounding environment, achieving more than 70% secondary energy savings.[83] **Example:** Deutsche Telekom's Smart Street Lighting solution enables cities to implement environmentally responsive lighting in order to reduce costs. Their solution is cloud-based, allowing for fast communication. Smart Street Lighting can save CO2 emissions and up to 70% of electricity costs, as well reduce maintenance costs through intelligent controls and notifications of damage.	IoT Cognitive Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

SDG interlinkages

Urban areas will be increasingly critical for achieving all SDGs, as more than half of the SDG targets have an urban component.[84] In turn, poorly managed urbanisation constitutes a major threat to achieving the SDGs, either through its direct or indirect effects on issues such as climate change, ecosystems, energy security, waste management and human health outcomes.

Sustainable, inclusive and well-managed urbanisation will have a number of positive interactions with other SDGs. Inclusive and sustainable cities are key to driving economic growth and prosperity (SDG 8), as they foster innovation, entrepreneurship, consumption and investment. Ensuring inclusive cities are intrinsically linked, also, to addressing social, economic and racial inequalities (SDG 10) that often play out in urban areas is important. Careful urban planning and security solutions implemented within cities will also help ensure peace and justice (SDG 16). Finally, well-managed urbanisation that, in particular, limits urban sprawl, can improve sustainable consumption patterns (SDG 12), reduce land degradation (SDG 15) and ocean pollution (SDG 14), and reduce greenhouse gas emissions (SDG 13), as less residents have to commute long distances by car to reach the city centre.[85]

Ensuring equal access to basic urban amenities, such as housing and basic services, will reduce the vulnerability of the urban poor, who often lack access to such services (SDG 1). Investment in infrastructure, industrialisation and innovation (SDG 9) will also be key to making urban amenities, including housing and transport, safe and sustainable. Access to greenspace, basic housing and safer transport systems within cities also have a significant positive impact on human health (SDG 3), through improving mental health, reducing water-borne diseases associated with slums, and reducing deaths linked to traffic accidents and pollution.[86]

Climate change and environmental impact mitigation within cities will help drive progress towards improving energy efficiency and water efficiency (SDGs 6 and 7), as well as resource-use efficiency (SDG 12). Cities are particularly vulnerable to natural disasters, so ensuring effective climate change adaptation in cities will reduce impact of natural disasters (Target 13.1), and reduce the impact of disasters on the poor and vulnerable in particular (Target 1.5).[87]

Negative externalities

Impact of widespread use of digital technologies on achievement of SDG 11

Non-inclusive cities: Smart cities, and the digital technologies and innovations that enable them, can exacerbate inequalities within cities as they are often not designed to work for the more than one billion people with disabilities around the world, or for some of a city's most vulnerable inhabitants, e.g. refugees or the homeless. The impact that limited accessibility in technology and innovation can cause is easy to see, especially in smart cities. For example, a municipal digital payment system that times out after a certain amount of time might not work for a person with a cognitive disability. A "mobility as service solution" for planning and executing a trip across several different modes of public transportation that does not provide alternative delivery of textual information might not work for someone who is blind. Accessible and universal technological design must therefore be considered when implementing smart city solutions. As a useful point of reference, AT&T and Business for Social Responsibility (BSR) outline four key ways to ensure that smart cities are also inclusive cities.[88]

Widening gap between rich and poor cities: Some advanced smart city technologies will require a fast internet connection, ideally 5G. Many poorer cities in developing countries lack such connectivity, and thus these cities will not benefit as quickly from the emerging smart city technologies, widening the gap between the rich and the poor.

Impact of using digital technologies to achieve SDG 11

Emissions: Digital technologies have the ability to drive large-scale emission efficiencies in compact, well-managed smart cities. However, digital technologies also could facilitate access to services for those living outside the city, enabling the continuation of urban sprawl and suburbanisation, and increasing emissions as more people choose to live in the suburbs but drive into the city.[89]

Although smart cities can improve citizen safety through constant monitoring of urban areas, this also has obvious implications for citizen privacy. Mobile and social media data, IoT sensors, camera data and citizen-wearable data can also be hacked to pinpoint citizen location and manipulate citizen activities. Espionage, terrorism, manipulation of social media, i.e. "fake news" and other malpractices can all become systemic risks associated with the use of digital technologies in cities.[90]

E-waste: Smart cities will be based on data, which will be provided by sensors. Research suggests that over one trillion sensors could be deployed by 2020, almost all of which will require batteries. The resulting energy consumption and e-waste of producing and deploying one trillion batteries will be enormous, yet powering sensors on electricity will present design problems too.[91]

Cyber attacks and terrorism: As smart cities rely on data to properly function, the hacking of data or data control systems could potentially bring a digitally-enabled smart city to a standstill. For example, the 2015 digital hacks of Ukraine's ICT-enabled energy grid compromises the information systems of three energy distribution companies in Ukraine and caused widespread power outages. In similar scenarios, hacking of autonomous traffic control systems could cause traffic jams or accidents.[92]

Surveillance and loss of privacy: The volume of data needed to power smart city services is massive – and a lot of this data is personal information. This personal information combined with the installation of sensors and monitoring devices could lead to ubiquitous surveillance and significant loss of privacy, and, if hacked, compromises citizen safety. This data may be used to provide better services, efficiency, and other smart city goals. That said, this also means lots of data, including personal information, is collected, stored, and used in a smart city. This will make smart cities a very tempting target to attack for hackers.[93]

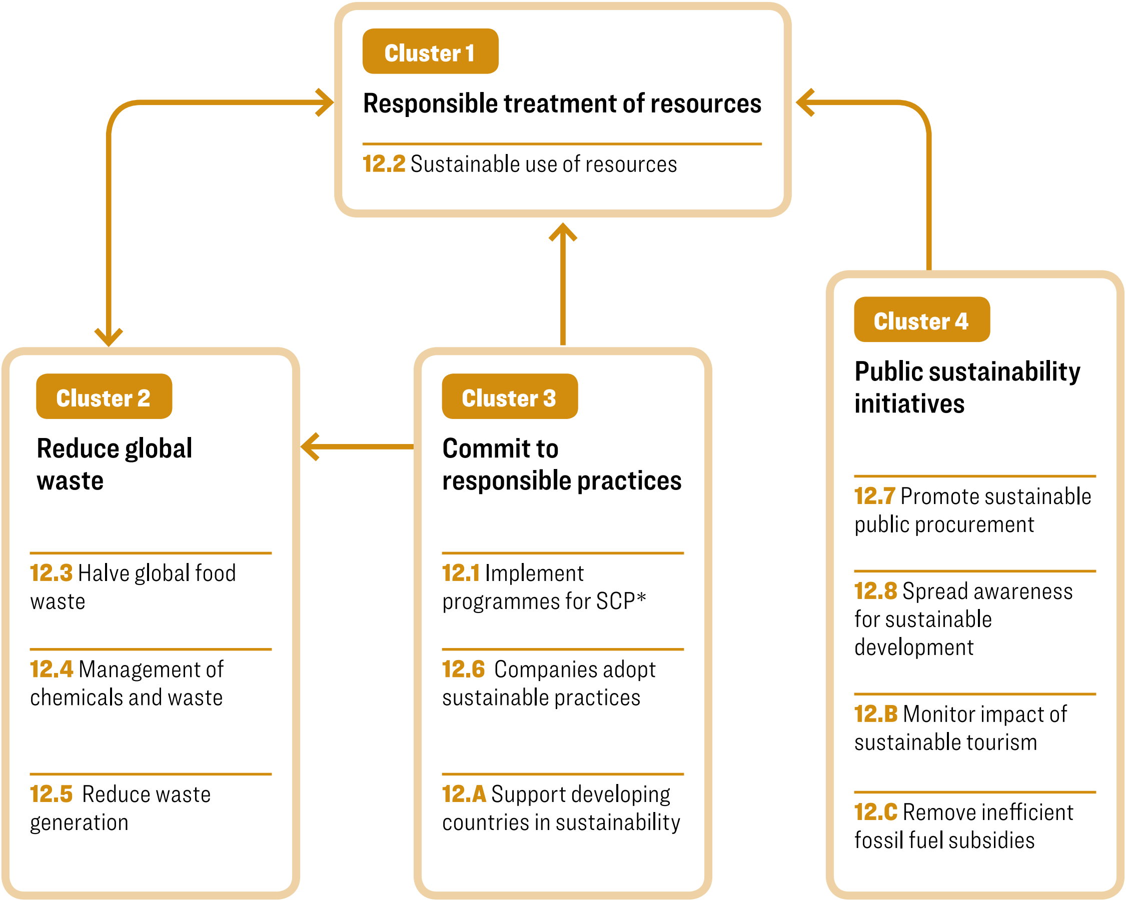
12 RESPONSIBLE CONSUMPTION AND PRODUCTION

SDG 12 DEEP DIVE

Responsible Consumption and Production

At the heart of SDG 12 are two aims – to ensure responsible treatment of resources and to reduce global waste. To drive these aims, organisations must commit to responsible practices and countries must implement public sustainability policies. Achieving responsible consumption and production will play a large part in climate change mitigation. The worldwide material footprint continues to grow, which is causing over-extraction of natural resources and could lead to irreversible environmental damage.[1] This will have severe knock-on effects, not just for the biosphere but also for society in general. As such, "achieving sustainable consumption and production will deliver not only SDG 12, but simultaneously contribute to the achievement of almost all of the other SDGs, directly or indirectly."[2]

SDG 12 System



Cluster 1

Responsible treatment of resources

12.2 Sustainable use of resources

Cluster 2

Reduce global waste

12.3 Halve global food waste

12.4 Management of chemicals and waste

12.5 Reduce waste generation

Cluster 3

Commit to responsible practices

12.1 Implement programmes for SCP*

12.6 Companies adopt sustainable practices

12.A Support developing countries in sustainability

Cluster 4

Public sustainability initiatives

12.7 Promote sustainable public procurement

12.8 Spread awareness for sustainable development

12.B Monitor impact of sustainable tourism

12.C Remove inefficient fossil fuel subsidies

*Sustainable consumption and production

Responsible treatment of resources (Cluster 1) is the central aim of SDG 12; it aims to decouple material usage from economic growth. Reducing global waste (Cluster 2) is linked closely with this, for example improved recycling rates will tend to lead to more sustainable use of natural resources. Commitment to responsible practices (Cluster 3) will drive progress against these aims, promoting better resource management in the private and public sector. Additionally, public sustainability initiatives (Cluster 4) can encourage and enforce responsible treatment of resources.

The role of digital technologies in delivering SDG 12

Digital technologies enable greater transparency across product cycles and through supply chains. This allows organisations to track, analyse and enhance their global supply chains, reducing inefficiencies and material wastage. These technologies empower consumers, providing the ability to verify how sustainable their purchases are. In addition, there has been a rise in new marketplaces for conscientious individuals and organisations to buy and sell sustainably sourced (or second-hand) products.

The integration of digital technologies into processes creates smarter waste management networks. These can improve the rate of recycling and its efficiency. Likewise, IoT monitoring and advanced analytics can optimise food management, reducing food loss throughout the supply chain.

Finally, the adoption of digital technologies allows greater control over sustainability reporting, as organisations begin to incorporate this into their annual reporting to identify key risks and opportunities. Increased accuracy of reporting will help organisations and governments work towards tangible goals to reduce their material footprint.

While digital technologies provide one channel through which progress can be made, other drivers must provide the impetus to achieve SDG 12. In particular, governments should use policy to promote sustainability amongst consumers and organisations. Integrating sustainability into mainstream education influences younger generations to live and consume more responsibly.[3] Likewise, regulation can push companies towards better practices, e.g. responsible waste management and reporting on sustainability. Collaboration between organisations and nations will also advance progress against SDG 12; shared responsibility of the challenges at hand will promote system-wide change.

Impact projections to 2030

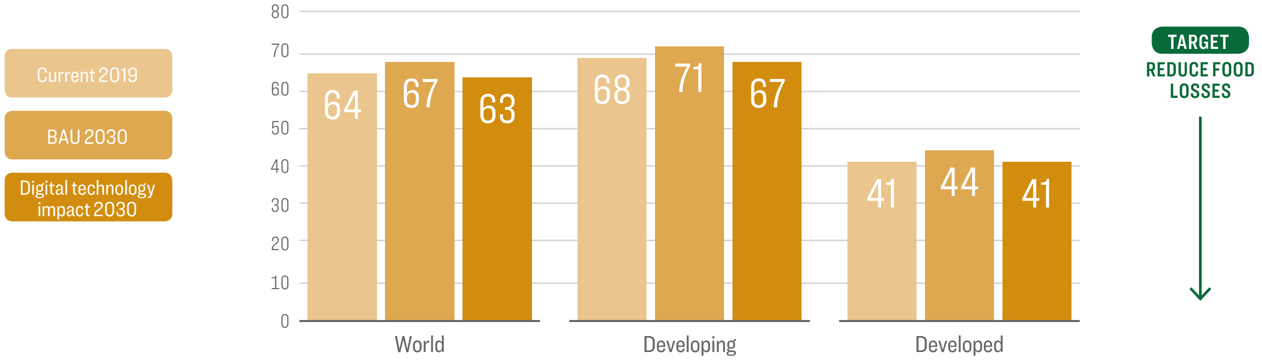
Globally, it is estimated that a third of all food produced is lost in the supply chain or goes to waste, despite being safe for human consumption.[4]

Food loss in the supply chain, defined as food lost at any stage from production to food reaching the market, currently stands at around 64 kilograms per person annually. Based on the expected growth trends in food production and population, this figure could increase to 67 kilograms per person annually by 2030 under a business-as-usual scenario.

A literature review, validated by a survey of experts, identified that some of this food loss could be avoided with the adoption of digital technologies such as smart logistics solutions to reduce spoilage and AI to identify and target supply chain food loss more accurately. The adoption of such technologies could reduce supply chain food loss in 2030 to 63 kilograms per person globally, i.e. 0.3% lower than the current figure, or 5.7% lower than the expected business-as-usual figure.

The impact would be more significant in regions with high supply chain food loss, in particular developing countries, e.g. Brazil, Paraguay. The implementation of relevant digital technology in developing countries is expected to have a greater impact: supply chain food loss in developing countries is estimated to fall 1.1% (from 68kg per person to 67kg) between now and 2030 under a digital technologies scenario, compared with increasing by 4.8% (to 71kg per person) under a business-as-usual scenario. It should be noted that supply chain food loss is typically higher in developing countries compared to developed countries due to hot humid climates and inadequate transportation and storage infrastructure. This is especially the case for more perishable foodstuffs that might need to be stored for a long time in a tropical climate. Comparatively, food loss at the point of retail or consumption is typically much higher for developed countries, where this is largely driven by consumer behaviour.[5]

Food loss in the supply chain (kg per person per year)



Importance of digital technology to target attainment

		TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1		**Responsible treatment of resources**		
	🟩	**12.2** Sustainable use of resources	Digital technologies raise awareness, create marketplaces and ensure transparency, which are critical to achieving the sustainable use of natural resources.	🔴 ↗
2		**Reduce global waste**		
	🟩	**12.3** Halve global food waste	Digital technologies will drive reductions in food waste through accurate monitoring of perishable produce and providing routes to utilise food waste.	🔴 ↗
	🟧	**12.4** Management of chemicals and waste	Digital technologies help to monitor and improve hazardous waste processing. However, this is secondary to the international cooperation and commitments also required to achieve universally sound management of chemicals and waste.	🟢 ↗
	🟩	**12.5** Reduce waste generation	Digital technologies can greatly optimise recycling processes and the reuse of goods. Smart waste technology and peer-to-peer marketplaces are key drivers of progress in this space.	🟢 ↗
3		**Commit to responsible practices**		
	⬜	**12.1** Implement programmes for sustainable consumption and production	Digital technologies have a limited role in the adoption of sustainable programmes – this is primarily a policy issue.	N/A
	🟩	**12.6** Companies adopt sustainable practices	Digital technologies enable organisations to collect, track and assimilate clear information on their sustainability. However, additional international collaboration is required to maximise the efficacy of sustainability reporting.	N/A
	⬜	**12.A** Support developing countries in sustainability	Aid programmes are the primary mechanism for supporting developing countries in their sustainability efforts. Digital technologies therefore have limited impact.	N/A
4		**Public sustainability initiatives**		
	⬜	**12.7** Promote sustainable public procurement	Government policy is the key driver of public procurement practices.	N/A
	⬜	**12.8** Spread awareness for sustainable development	Digital technologies can educate consumers on sustainability, as discussed in Target 12.2. However, this target focuses on the use of government policy to incorporate sustainability education within national school curricula.	N/A
	⬜	**12.B** Monitor impact of sustainable tourism	Digital technologies allow better monitoring of sustainability impacts, as discussed in Target 12.6. However, this target focuses on the implementation of policy to monitor sustainable tourism.	N/A
	⬜	**12.C** Remove inefficient fossil fuel subsidies	Government policy is the key driver of subsidies.	N/A

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

- 🟩 High impact
- 🟧 Moderate impact
- ⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

- 🟢 Positive progress
- 🟠 Limited progress
- 🔴 Negative progress

Cluster 1

Responsible treatment of resources

The current pattern of global consumption is unsustainable. If the global population reaches 9.7 billion by 2050, as predicted by the UN[6], “the equivalent of almost three planets could be required to provide the natural resources needed to sustain current lifestyles”.[7] Furthermore, worldwide material consumption per capita is still increasing - the rate of extraction has risen every year since the turn of the millennium.[8] Decoupling material extraction and consumption from economic growth is central to achieving the responsible treatment of resources.[9]

Digital technologies influence the responsible treatment of resources at both a consumer and organisational level. Using digital technologies, supply chains become transparent and verifiable. This provides a tangible link between consumption choices at the point of sale and the impact made through the rest of the supply chain. Through this, organisations can make more responsible procurement decisions and consumers can put pressure on those that have not done so. Furthermore, digital platforms connect consumers with each other and with responsible suppliers to make purchasing sustainably simple.

While digital technologies provide the means to monitor and maintain sustainable supplies of goods, there must also be intent to act sustainably from the supply side. In other words, organisations (particularly in markets dominated by a few players) should be compelled to offer more sustainable products. In part, demand pressures can drive this, but commitment to responsible practices and government regulations will also play a crucial role in improving resource-use efficiency.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Online petitions amplify consumers’ voices to drive responsibility in production Online platforms allow people to create, sign up and share petitions globally. This increases the power of citizens and, in some cases, is used to put pressure on companies or governments to implement sustainable activities.	**Example:** Change.org is an open platform that hosts campaigns and allows people to sign up in support to these campaigns. One petition launched on the platform to ‘End the sales of eggs from caged hens’ by Tesco (a UK retailer) received c. 280,000 signatures. This pressure led to the company committing to end this practice by 2025.[10]	Digital Access	Importance to SDG Role of digital technologies Scalability
Apps designed to inform consumers about sustainable purchases A number of smartphone apps have been developed that contain a database measuring the sustainability of retail products. Consumers use the apps to inform their everyday consumption, encouraging them to choose products based on how responsibly they have been produced.[11] Evidently, these apps are contingent on the current availability of information on what is truly sustainable, which can be muddled and limited.	**Example:** Giki is a mobile app that awards badges to products based on their impact on the environment and how ethically they were sourced and produced. Consumers scan the barcodes of products before they make a purchase to determine how sustainable the product is.[12] It also suggests alternative brands or products that meet consumers’ sustainability expectations. This empowers consumers to purchase responsibly and, through shaping consumption habits, can influence suppliers to source products more responsibly. Over 80% of users polled report changing products as a result of Giki. Giki’s information is openly available to other organisations whose goal is to encourage more sustainable behaviours.	Digital Access	Importance to SDG Role of digital technologies Scalability
Marketplaces for ethically sourced products The establishment of marketplaces for responsible producers, with a screening process before featuring products on the marketplace, connects consumers to sustainable products without them needing to search or research at length. This allows consumers to purchase sustainably without the need to research extensively. Providing easy access to sustainable products is important, given that 81% of consumers viewed this as the largest blocker to purchasing more sustainable products.[13]	**Example:** Veo is an ‘earth friendly’ online marketplace that connects consumers to sustainable and ethical products. It screens suppliers before allowing them to join the marketplace to ensure only responsibly produced goods are featured.[14]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower Higher

Platform technologies increase the sharing of personal resources Digital platforms offer an easy way for individuals to share goods, reducing demand for further resource extraction and manufacturing.	**Example:** US car sharing firm Getaround is a peer-to-peer car rental service. It claims that each Getaround vehicle replaces six private vehicles, which are typically stationary for many hours of the day.[15]	Digital Access	Importance to SDG Role of digital technologies Scalability
Trading platform that shows sustainability alongside cost Trading platforms, built using blockchain and available real-time records from suppliers, can connect buyers with products that have been sourced or produced sustainably. This allows greater weight to be placed on the sustainability of a product, differentiating it from its competitors (rather than a sole focus on price).[16]	**Example:** Xpansiv has established a commodities trading platform that collects and presents information on the sustainability of commodity extraction, transportation and storage. It allows consumers to select and purchase commodities based on an immutable record of the sustainability of the goods, encouraging more sustainable production and consumption of commodities.[17] Xpansiv has partnered with CBL Markets, which is an environmental commodities spot trader, operating primarily in the US and Australia.[18]	Blockchain	Importance to SDG Role of digital technologies Scalability
Positively reinforcing sustainable purchases Apps that offer incentives for consumers to buy sustainably aim to cultivate more responsible consumption habits. The focus could be placed on increasing awareness of the impact of spending to encourage consumers to save more.[19] Conversely, the app may offer rewards for purchasing from approved sustainable retailers.	**Example:** Impak is a platform encouraging responsible shopping. It contains a registry of sustainable businesses that consumers can use to guide their spending. Impak uses online questionnaires including a machine-learning algorithm to screen businesses and determine whether they are socially and environmentally responsible to provide them with a rating. The platform also operates its own cryptocurrency (impak Coin), rewarding consumers for making purchases at impact-verified businesses, with either impak Coins or a national currency.[20]	Digital Access Cognitive Blockchain	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Improve traceability of supply chains The use of blockchain within supply chains can increase trust between suppliers and their customers. This allows organisations to better monitor the sustainability of their suppliers and report this to their own customers.	**Example:** Provenance provides a blockchain-powered transparency platform that allows organisations to trace their supply chains to verify their claims, such as origin, suppliers involved and environmental impact. In one case study, Provenance worked with The Co-op (a UK-based retailer) to track the journey of their fresh produce, which allowed the business and its consumers to see a verified record of where the product had originated and how it was produced. Using this, consumers can understand the footprint of their purchases and adjust their consumption habits to select products that are sustainably produced.[21]	Blockchain Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Designing products using virtual reality At the design stage of a product lifecycle, virtual reality is being used to reduce the reliance on physical prototyping. It allows designers to create, test and adjust products without using physical materials. This leads to improved resource efficiency in production.[22]	**Example:** SGW DesignWorks uses VR to assist in the prototyping process, to review and test products quickly for consumers. It developed a VR prototype for client in the aerospace industry that meant two physical prototype cycles were avoided.[23]	Digital Reality	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 2

Reduce global waste

The rate of recycling and reuse must be increased to not only reduce the global reliance on the extraction of natural materials but, also, to minimise the many negative consequences of waste production. Currently, global waste is expected to rise by 70% by 2050[24], which has critical implications for both society and the biosphere, particularly given that "over 90% of waste is openly dumped or burned in low-income countries".[25] Specific focus is applied to food waste (Target 12.3), as food availability (which is already not universal) will need to increase by 70% by 2050.[26] Reducing food loss and waste – estimated to be one third of all food produced – would greatly improve the planet's ability to meet rapidly rising demand.[27]

Digital technologies facilitate the creation of platforms and communities that allow the sharing and recycling of surplus goods, providing an outlet for what would have previously been landfill waste. Real-time monitoring of supply chains can ensure that far less is lost or wasted before it reaches the consumer. In addition, advanced analytics and image recognition can drive the rate of recycling, as well as informing future production.

Reducing waste relies on assistance from national and local governments to both encourage individuals to recycle and to increase capacity to repurpose waste. This requires concerted efforts and investment to improve waste management systems and to make recycling easier for consumers.[28] For organisations, collaboration and knowledge-sharing is important and will accelerate progress towards circular economies – a key example of this is CE100, established by the Ellen MacArthur Foundation.[29]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Online guides for repairing and reusing goods The prevalence of internet access allows expert knowledge to be shared almost instantaneously across the world. This enables guidance and videos to be shared to enable consumers to repair and reuse their devices when broken.	**Example:** YouTube has facilitated the general sharing of instructional videos (from both individuals and companies), providing a resource for advice on repairing goods. Every day, over one billion learning-related videos are watched on the platform.[30] **Example:** iFixit, more specifically, is a platform that shares repair guides for electronic devices, attempting to reduce the amount of e-waste produced and increase the product cycles for electronic devices. It collects guides from its global community, allowing knowledge sharing from around the world.[31]	Digital Access	Importance to SDG Role of digital technologies Scalability
Blogs, video sharing and websites help consumers to reduce food waste Social media and the widespread use of the internet allows organisations and individuals to spread key messages on reducing food waste. As well as alerting households to the scale and cost of food waste, leftover recipes and advice on how to reduce food waste can be shared.	**Example:** WRAP, a UK charity, established Love Food Hate Waste to target food waste in the UK. Its website raises awareness about the issue of food waste and enables consumers to reduce their waste at home. It features advice on how to shop for and store food, and recipes to make best use of leftovers.[32]	Digital Access	Importance to SDG Role of digital technologies Scalability
Connecting surplus food to local communities using digital platforms A number of apps now allow businesses and individuals to share surplus food, via an online platform, to local communities or foodbanks.	**Example:** OLIO is a cloud-hosted mobile app where users post surplus food items. Neighbours are then able to request and pick up the food, preventing it from being thrown away. At the time of writing, over two million portions of food had been shared via the app.[33]	Digital Access Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Online marketplaces for recycling second hand goods Online marketplaces provide the means to reuse or recycle goods through peer-to-peer selling and letting. While sustainability may only be a minor motivator for many of the users of such platforms, they provide sufficient incentive to encourage responsible behaviour.[34]	**Example:** This is not a new concept - there are a number of successful platforms in this space. eBay, the e-commerce platform, has about 180 million active users and has allowed users to sell their unwanted goods to the highest bidder.[35] **Example:** Vestiaire Collective offers an online marketplace for individuals to buy and sell pre-owned luxury fashion.[36] Waste in the fashion industry is a particularly big issue; a study in the UK found that the majority of clothes are sent to landfill after only seven wears.[37]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Smart logistics solutions prevent food loss and waste Digital technologies enable intelligent food monitoring from the harvesting of fresh produce, to the storage of this produce in the fridge of a consumer.[38] This provides accurate information to the user about the perishable food to ensure it is used before it spoils.[39]	**Example:** Zest Fresh uses IoT sensors and SaaS-based predictive analytics to monitor pallets of produce at and after harvest. The sensors and software provide better accuracy on the shelf life of the produce that can then be communicated down the supply chain. The improved accuracy reduces food waste from premature spoilage and ensures retailers know the actual shelf-life of the food they receive to ensure delivered freshness and customer satisfaction.[40]	IoT Cloud	Importance to SDG Role of digital technologies Scalability
Connected pallets reduce resource usage and supply chain loss IoT-connected, reusable pallets can replace traditional wooden pallets to prevent loss in the supply chain and improve the lifecycle of pallets.	**Example:** AT&T has developed a resilient connected pallet with RM2. It is equipped with IoT sensors, which allow users to track the pallets at all points of transit. This reduces loss of both the goods being transported and the pallets themselves in the supply chain. The lifecycle of the connected pallet is five times that of a wooden pallet, which reduces resource consumption throughout supply chains, too.[41]	IoT	Importance to SDG Role of digital technologies Scalability
Connected bins improve recycling efficiency Bins equipped with IoT sensors can be integrated with waste management systems to improve the efficiency of recycling. The sensors detect when the bins are full and communicate this to expedite collection.[42]	**Example:** Fujitsu has developed a Smart Bin solution to tackle e-waste recycling. When the Smart Bin detects it is full, it books its own collection slot with a courier to empty the bin. This makes e-waste recycling easy for companies, encouraging greater usage. On average, each bin diverts a tonne of e-waste from landfill annually.[43] **Example:** Telecom Italia deploys IoT sensors to monitor fill levels of various recycling centres in real time, sending collection vehicles out to the centres only when necessary. This results in reduced time and expense, and prevents roadside bins overflowing with municipal rubbish. It is also looking into IoT solutions to reduce illegal waste dumping.[44]	IoT Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AI modelling can lead to optimised supply chains and reduced food loss Analytics tools using AI and machine learning can assess logistics and supply chain data to determine the root causes for food loss. These insights then allow companies to target high loss areas and reduce supply chain wastage.	**Example:** A number of companies are currently exploring opportunities to integrate AI modelling and machine learning into their supply chains to identify and reduce food loss.	Cognitive Cloud	Importance to SDG Role of digital technologies Scalability
Record and analyse food waste to control future production Food waste in restaurants is recorded before it is thrown out, to identify trends in wastage. Businesses and chefs can then adjust their food purchasing decisions accordingly, reducing their spending and tackling a fundamental problem of food waste: overproduction. This informs the portion sizes and allows restaurants to adapt menus to the consumer demand.[45]	**Example:** Winnow has developed an AI-based solution to reduce food waste in the hospitality sector. The solution uses AI to identify food waste and record this automatically, minimising the manual input required to record food waste accurately. The real-time food waste data is then analysed and reports are returned to inform kitchen staff on how production should be adjusted to reduce waste. The solution is being employed by IKEA in a number of stores and has reduced food waste by 50%.[46]	Cognitive Cloud	Importance to SDG Role of digital technologies Scalability
Dynamic pricing to reduce food waste Currently, retailers manually markdown perishable goods as they approach their expiration date to incentivise consumers and reduce food waste. By utilising dynamic pricing, retailers can more effectively reduce waste and increase the profitability of perishable goods. A real-time analysis of inventory levels and product sell-out, coupled with product expiration dates and demand projections, allows the retailer to offer consumers products at the optimal price point to minimise waste and maximise profitability.[47]	**Example:** Wasteless created a dual-function pricing algorithm that offers the optimal price to reduce food waste and increase perishable food revenue. The solution utilises inventory data, sell-out data, product expiration date, price elasticity, and demand projections to identify the ideal product price. The consumer is incentivised to buy the product with a shorter expiration date, thereby preventing food waste. Applying this technology reduced waste by 88% and increased sold volumes by 97% in a recent use case for a customer in Italy.[48]	Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Autonomous recycling systems Image recognition technology and AI is employed to sort waste and recycling. This speeds up the recycling process and can eliminate the chance of human error. Additionally, applying this technology at the waste disposal stage makes recycling far more appealing, and easier, for individuals.[49]	**Example:** Apple created 'Daisy', using AI and robotics, to disassemble old iPhones. This robot supports its efforts to repurpose e-waste collected from consumers, as Daisy can recover materials more efficiently and at a faster rate than humans.[50]	Cognitive	Importance to SDG Role of digital technologies Scalability

Organisations are increasingly incorporating digital technologies into their processes for reporting on sustainability. They enable more efficient collection and analysis of data and provide transparency on sustainability, not just for the organisation but also for society as a whole.

Cluster 3

Commit to responsible practices

Organisations are increasingly recognising the need to integrate sustainability into their reporting mechanisms. 93% of the world's 250 largest companies, by revenue, report on sustainability, as do three quarters of the top 100 companies in 49 countries.[51] However, the impact of these reports is often hindered by an inability to measure sustainability-related goals and outcomes.[52] Addressing this issue will encourage more organisations to place sustainability-related goals at the heart of their business.

Organisations are increasingly incorporating digital technologies into their processes for reporting on sustainability. They enable more efficient collection and analysis of data and provide transparency on sustainability, not just for the organisation but also for society as a whole.[53] Greater transparency promotes engagement between organisations and consumers in driving sustainability.

Although there are mandatory ESG disclosure requirements for organisations in a high proportion of the largest economies in the world, there are a number of different reporting frameworks.[54] This means that ensuring consistency in reporting is difficult and, in some cases, can be ineffective. Cross-border (and cross-sector) collaboration is required to streamline and align sustainability reporting, promoting clarity across reports.[55] Common taxonomies, e.g. the SDGs, are needed to allow companies to collaborate and share reporting methods.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Creation of third-party big data sets aid sustainable decision making Organisations can use open-source and reliable big data sources on sustainability to guide business decisions.	**Example:** The Open SDG Data Hub collects all authoritative SDG data sources in one place, allowing businesses to easily view progress against SDGs and their targets. It also hosts an API to retrieve individual datasets and information on the SDG indicators.[56]	Cognitive Cloud	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Centralised platform to collect and monitor sustainability data While financial reporting is well integrated into reporting processes, sustainability reporting is much more challenging for companies. Organisations can use digital technologies to manage the collection and assimilation of sustainability data, providing an efficient ESG reporting system.	**Example:** Ecochain offers corporate sustainability software, to provide detailed and accurate data to organisations. Its environmental platform measures an organisation's footprint at both the aggregate level but also on an activity basis to highlight key areas of risk or that require improvement.[57]	Digital Access Cloud Cognitive	Importance to SDG Role of digital technologies Scalability
Blockchain can validate the achievements of organisations and social enterprise projects All information about projects can be stored in a blockchain and then independently validated to determine if the project is meeting its sustainability goals. This progress data is then publically accessible, allowing stakeholders to monitor and compare projects.	**Example:** Alice operates a blockchain network that aims to increase the transparency of social projects for the benefit of donors, impact investors and the organisations running the projects. Publically available impact data allows donors to track the progress of projects and organisations to share data for collaboration.[58] **Example:** Impak Finance has developed impak IS², a solution to assess, score and track the global impact of businesses and investment portfolios. Their analysis - based on the Impact Management Project framework and the UN's SDG - contains a qualitative grid, an impact score and information on the data collected by the business regarding its impact activities.[59]	Blockchain	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Efficient sustainability analysis AI can be integrated into sustainability analysis and reporting to provide clear and accurate insights for organisations.	**Example:** Datamaran provides an evidence-based perspective into regulatory, strategic and reputational risks and opportunities as well as enables a business process for continuous issues monitoring. The organisation offers a Software as a Service (SaaS) solution that centres on AI-driven data analysis. This incorporates real-time data from the organisation and external sources, e.g. on regulatory measures, to provide insight on the most critical socio-environmental issues for the organisation.[60]	Cognitive Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Interaction with other SDGs

Promoting the responsible treatment of resources has knock-on benefits for the biosphere. First, by minimising the need to extract new natural materials, the habitats of fauna and flora (SDG 14 & 15) are better protected. Second, reduced demand for new products will reduce energy consumption across supply chains (processing recycled materials almost always saves energy in comparison to extracting and processing new materials).[61] This will have a positive impact on climate change (SDG 13).

Reducing waste generation also carries large benefits for the biosphere; most significantly it will decrease the pollution of ecosystems caused by untreated or dumped waste (SDGs 6, 14 & 15). The reduction of food waste is intrinsically linked to ending hunger (SDG 2). By minimising the amount of food lost and wasted, more will be available to be distributed to those still in need in society. Reducing food waste will also decrease land degradation for farming (SDG 15).[62] More broadly, achieving sustainable economies will be central to enabling the growth of safe and prosperous cities (SDG 11).[63] Dependency on efficient waste management will rise as the world's population increasingly migrates to urban centres.

An improved ability to measure sustainability impacts will help co-ordinate partnerships and policies for sustainable development, and assign accountability for the SDGs (SDG 17).

Negative externalities

Impact of widespread use of digital technologies on achievement of SDG 12

E-Waste: The proliferation of digital technologies has generated a global e-waste problem. Only 20% of e-waste is recycled and, while ICT companies are making strides to correct this through device recycling programmes, the problem is being compounded by increasingly short product lifecycles.[64] To counter this, the churn of electronic devices must be reduced (both by consumers and producers continually introducing new device models) and more concerted recycling measures must be put in place.[65]

Increased resource extraction: The shortening life-cycles of electronic devices also leads to increasing resource extraction - the production of a smartphone requires "an average of 28.6kg" of raw materials. [66] Until ICT companies are able to close the loop on the production of new devices, i.e. using recycled materials, significant resource extraction will be required to produce electronic devices.

Heightened consumerism: More generally, digital technologies appear to be fuelling consumerism. Online retail has made shopping faster and easier for consumers – online sales of non-food items in the UK rose from 11.6% in 2012 to 24.1% in 2017.[67] Social media, too, encourages fast consumption. Social media influencers, who promote brands that sponsor them, encourage their followers to purchase products that they use and wear.[68] In-app links then redirect users to the brand mobile site to buy the product. In 2019, Instagram launched a checkout in-app, making the purchase process even easier for the average feed-scrolling user.[69]

Impact of using digital technologies to achieve SDG 12

Misinformation through social media: The rise of social media has allowed users to share information about sustainable, or unsustainable, practices. While this can grant greater influence to consumers over companies, it can accelerate campaigns based on misinformation. For example, Iceland, a leading UK supermarket, launched a campaign that caused many consumers to boycott producers that used palm oil in their products. At the time, the advert heading the campaign was shared and viewed by 70 million people on social media.[70] However, it has been noted that palm oil, in and of itself, is not inherently bad for environmental ecosystems (rather the unsustainable cultivation methods used by some). Furthermore, switching to other oils can have a worse impact on the biosphere.[71]

13 CLIMATE ACTION

SDG 13 DEEP DIVE

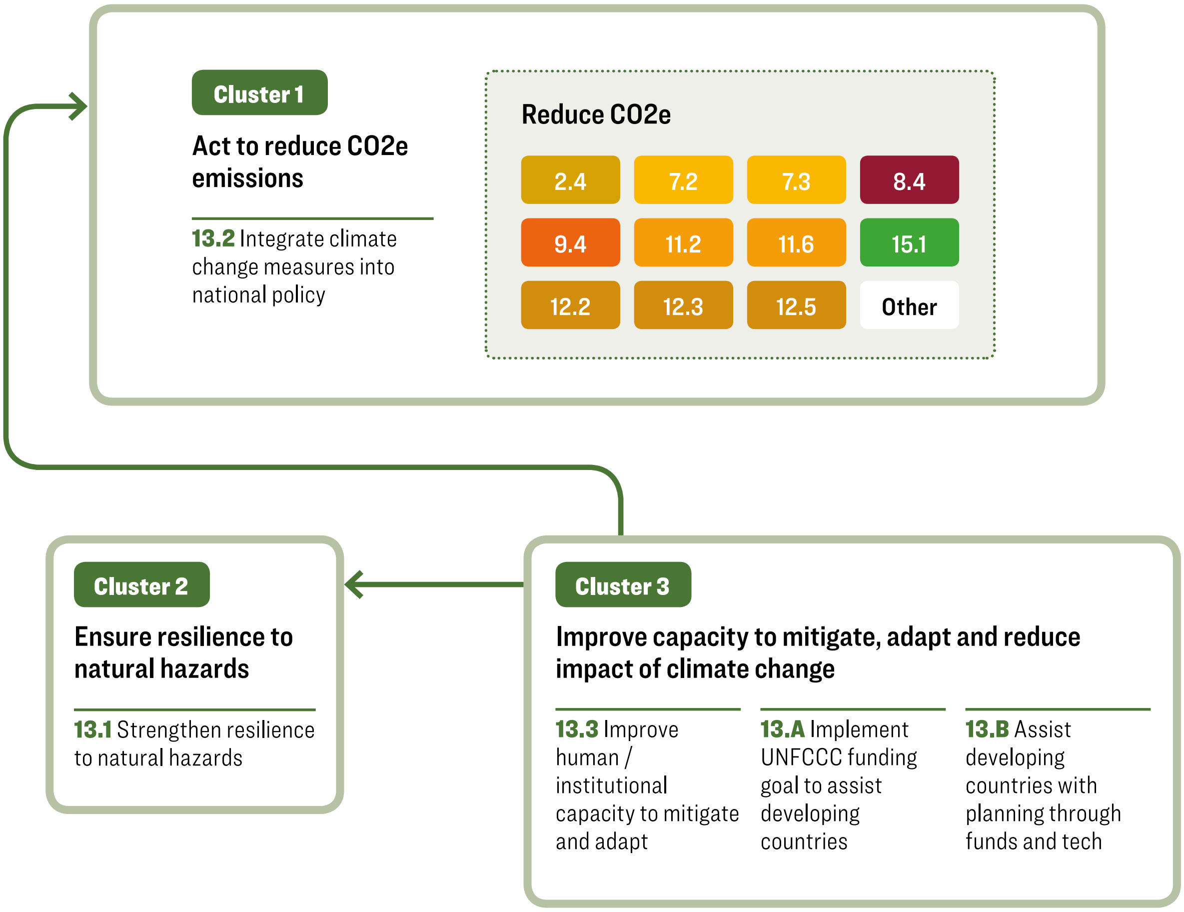
Climate Action

SDG 13 seeks urgent action to combat climate change and its impacts, through acting to reduce greenhouse gas (GHG) emissions, ensuring resilience to the natural disasters associated with climate change, and by improving global capacity to ensure all parties are able to adapt to and mitigate against the impacts of climate change.

The urgency to address climate change has never been greater,[1] and the cost of inaction is incomprehensible; the social cost of carbon, e.g. the cumulative economic impact of global warming, exceeded $16 trillion in 2017 alone[2] and is only expected to rise.[3] Atmospheric CO2 continues to rise at accelerating rates, with current levels last seen three million years ago.[4] As a result, multiple international government bodies are undertaking synchronous efforts and commitments to deal with climate change. The UN and SDG 13 recognises the UNFCCC as the primary international, intergovernmental forum for negotiating the global response to climate change,[5] and therefore by extension, the goal supports and aligns with the aims of the Paris Agreement ratified by the UNFCCC.

The primary goal of the Paris Agreement is to keep the average global temperature to well below a 2 °C increase above pre-industrial levels and as close to 1.5 °C as possible.[6] Critically, keeping global temperature rise below 1.5 °C versus pre-industrial levels will have substantially fewer impacts than a rise to 2 °C. [7] Digital technologies to help reduce CO2 emissions are needed urgently.

SDG 13 System



Reducing carbon emissions in line with the Paris Agreement is at the core of SDG 13 (Cluster 1). Specifically, Target 13.2 calls for the integration of climate change measures into national policies, strategies, and planning, whilst 11 targets throughout other SDGs specify the mechanics and sectors through which this aim will be achieved.

Cluster 2 aims to strengthen resilience to natural hazards (13.1); both those arising from climate change, and more broadly. Cluster 3 aims to improve the capacity of countries to mitigate, adapt and reduce the impact of climate change. This includes focusing on education, awareness raising, and capacity building (13.3), as well as giving particular attention to raising the capacity of small-island developing states and least-developed countries (13.B). The cluster is underpinned by a target to uphold the UNFCCC goal of mobilising $100 billion annually (13.A).

The role of digital technologies to deliver SDG 13

The adoption of digital technology will have a critical role in delivering many aspects of SDG 13, but particularly in acting on the central aim to reduce CO2 emissions, and in the prediction, monitoring, and management of natural disasters.

Digital technologies will help reduce CO2 emissions primarily by modernising the energy sector through the deployment of the smart grid and the ability to integrate increasing amounts of large-scale and locally-produced renewable energy into the electricity network. Other sectors such as agriculture and manufacturing will also see CO2 emission reductions from the application of digital technologies which allow greater precision in the use of energy and inputs to produce both crops and products.

Natural disasters are increasingly prevalent, and exacerbated by climate change.[8] The most basic digital technologies are particularly powerful for saving lives, through the monitoring and tracking of hazards which then enable early warning systems to be enacted and for populations to move to zones of safety. More advanced digital technologies (AI, IoT) are also used to predict the occurrence of disasters and to inform scenario planning.

Digital technologies also play a role in capacity building by disseminating information, empowering civil society and deepening understanding of the long-term impacts of climate change.

Whilst digital technologies will help deliver SDG 13, there are a number of other drivers which are critical to success. From a global perspective, there is a need for strengthened, legally-binding national commitments to carbon reduction goals as well as for specific industry targets to get the Earth back on track to the relatively safer level of below a 1.5 ºC increase in temperature. Given current trajectories, it is also likely carbon sequestration technologies will have to be funded, developed and deployed to remove carbon from the atmosphere and to alter the current trajectory of the Earth's bio-chemical systems. Cluster 3 supports these aims through calling for the mobilisation of financial aid to help developing countries and for promoting mechanisms to raise capacity to enact planning for climate change and management of its consequences.[9]

Supply side adjustment is important, but widespread behavioural change from consumers, particularly in high-income countries will be critical. For example, the burgeoning of the mass tourism industry means it now accounts for 8% of global greenhouse gas emissions[10] and is currently threatening the achievement of the Paris Agreement.[11] Other lifestyle factors matter. If the world moved from current western-style diets to a diet excluding animal products, there would be a reduction in food's global GHG emissions of nearly half, which is equivalent to reducing emissions of 6.6 billion metric tons of CO2e per year.[12]

The adoption of digital technology will have a critical role in delivering many aspects of SDG 13, but particularly in acting on the central aim to reduce CO2 emissions, and in the prediction, monitoring and management of natural disasters.

Impact projection to 2030

The use cases studied in this report demonstrate a number of substantial ways in which ICT can reduce the GHG emissions contributing to climate change. In aggregate, these examples could lead to abatement of 1.34 Gt in 2030 against the business-as-usual scenario, offsetting growth in the ICT sector emissions footprint between 2019 and 2030 by 189%. To give a sense of scale, the emissions of Germany, France and the UK combined in 2016 was the same share of global emissions as 1.3Gt in 2030. The total abatement is made up of:

SDG 11: Intelligent transport systems have the potential to manage pollution in cities by improving efficiency. Real-time traffic flow management, improved public transport information and predictive maintenance of infrastructure are all ways that improve the way in which people move around cities. Adoption of such technology could reduce emissions by 0.39 GT CO2e annually by 2030.

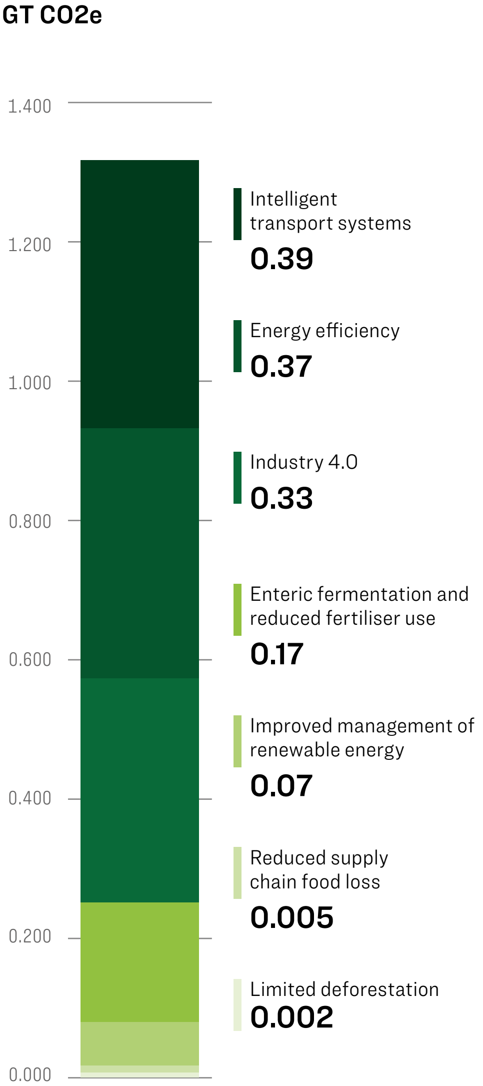
SDG 7: Smart electricity grids use digital communications and other advanced technologies to detect local changes in usage, and manage demand and supply accordingly. Smart grids allow consumers to become 'prosumers', by supplying the grid with energy produced by their own renewable sources, and can increase energy efficiency using data to enable automated processes. As a result of increased energy efficiency and consumption of renewable energy, digital technology could reduce annual emissions by 0.43 GT CO2e by 2030.

SDG 9: Not only is Industry 4.0 expected to produce substantial productivity gains by 2030, but also efficiency improvements. Industry 4.0 enables industry to become more connected, efficient and smart, and digital technologies are the underlying drivers: big data, machine learning, IoT and cloud computing allow for autonomous and intelligent manufacturing, predictive maintenance, and optimise production and supply chains. These efficiency improvements have the potential to reduce emissions in 2030 by 0.33 GT CO2e.

SDG 2: Precision agriculture uses digital technology to increase productivity. The types of technology used in an agricultural setting will depend on the size of the farm and level of development, though the goal of increasing yields with fewer inputs is the same. For example, a smallholder farm in a developing country might rely on mobile phones and data access to provide basic information, whereas a large farm may implement IoT sensors and AI to monitor and automatically react to changes in crop health so as to optimise yields. By improving efficiency in the use of nitrogen-based fertilisers and livestock management, precision agriculture could reduce annual emissions by 0.17 GT CO2e by 2030.

SDG 12: Food loss in the supply chain, i.e. at any stage from production to food reaching the market, could be reduced with the adoption of digital technologies such as smart logistic solutions to reduce spoilage and AI to identify and target supply chain food loss more accurately. Ultimately, these practices could reduce the amount of food that needs to be produced. As a result, lower food loss in the supply chain could lead to lower annual emissions of 0.005 GT CO2e (5.4 MT) by 2030.

SDG 15: Limiting deforestation would improve net emissions from biomass in forests. Digital technology has the potential to contribute to reducing deforestation: fast internet technology, e.g. 5G, to connect solar powered audio monitoring systems that use AI for sound recognition could detect illegal deforestation, and the application of big data stored in the cloud enables generation of detailed biological models that enable improved forecasting of events such as the spread of invasive species or the impact of climate change. It is estimated that 0.002 GT CO2e (2.3 MT) of emissions in 2030 could be abated by slowed deforestation.



Importance of digital technologies to cluster and target attainment

		TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1		**Act to reduce CO2e emissions**		
	⬜	**13.2** Integrate climate change measures into national policies, strategies and planning	Digital technologies will have limited direct impact on the establishment and integration of strategies and plans to adapt to the adverse impacts of climate change.	🟠 →
	🟩	**Multiple** Act to reduce CO2e emissions	Digital technologies have a substantial impact on the operationalisation of the policies, strategies or planning laid out by 13.2.	🔴 ↗
2		**Ensure resilience to natural hazards**		
	🟩	**13.1** Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters	The management of natural hazards and associated disasters relies heavily on digital technologies for monitoring, prediction, management and adaptation.	🔴 ↗
3		**Improve education, awareness and capacity to act**		
	🟧	**13.3** Improve education, awareness raising and human and institutional capacity on climate change	Digital technologies help improve citizens', companies' and governments' awareness of climate science, and give them improved capacity to measure climate change.	N/A
	⬜	**13.A** Implement commitment to mobilise $100 billion annually by 2020	Besides potentially enabling better measurement of impact and providing the necessary data flow to capital markets, digital technologies have little impact on improving the likelihood of global climate finance flows.	🟠 →
	⬜	**13.B** Promote mechanisms for capacity raising in LDCs & Island states	Beyond potentially enabling better measurement of support and impact, digital technologies have little specific impact on raising capacity in least-developed countries.	N/A

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

🟩	High impact
🟧	Moderate impact
⬜	Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

🟢	Positive progress
🟠	Limited progress
🔴	Negative progress

Cluster 1

Act to reduce CO2 emissions

Decarbonising the global economy is a truly global challenge, and it will be necessary for the world to reach net zero emissions by 2050 to avoid irreparable damage to the biosphere and to sustain society and the economy. However, CO2 emissions continue to rise[13], outpacing decarbonisation efforts.[14] Despite the promise of the Paris Agreement, collective national targets pledged during the process are predicted to allow a global average temperature increase of 2.7 ºC.[15] This is a best-case scenario, assuming all pledged targets are met. It is widely accepted that maintaining global temperature rise at 1.5 ºC will have substantially better global outcomes than letting temperature rise to 2 ºC.[16] The effects of an increase approaching above 2 ºC will be even worse.[17] For example, 3 ºC of warming would fundamentally redraw the world map, drowning large parts of coastal cities including Shanghai, Hong Kong, Osaka, Alexandria, Miami and Rio de Janeiro, with 275 million people worldwide living in areas that will be flooded.[18]

Digital technologies could have a substantial impact on the reduction of CO2 emissions. In particular, digital technologies will play a key part in enabling the large-scale energy transitions required to lower GHG emissions and contribute to the objectives of the Paris Agreement.[19] Technology can also contribute to the reduction of carbon emissions in agriculture (which currently account for 20-30% of total global emissions[20]) by more precisely monitoring and optimising the use of inputs to farming, increasing efficiency, and improving education. Digital technologies are also being increasingly deployed to change the destructive patterns of consumption and production humankind is currently pursuing.

It is clear that the challenge is huge, and immediate. Alongside national commitments, concerted, joined-up and immediate efforts from all industries will be needed to reverse this trend and meet the global challenge. There is no time to wait for top-down regulation.

Cross-SDG key impacts of digital technologies on reducing CO2 emission

Across the SDGs, a range of uses cases have been identified that will help to reduce CO2 emissions. These are summarised below. For further details and use cases please refer to the relevant chapter.*

	TARGET	KEY IMPACTS OF DIGITAL TECHNOLOGIES ON REDUCING CO2 EMISSION
2 ZERO HUNGER	**2.4** Ensure sustainable and resilient food production systems	There will be substantial impacts from digital access on disseminating information about sustainable farming, as well as from AI and IoT for monitoring and optimising sustainable farming practices. Using optimal energy and fertiliser input into farms can reduce the use of excess energy.
7 AFFORDABLE AND CLEAN ENERGY	**7.2** Increase the share of renewable energy in the global energy mix	Digital access will have a substantial impact on abating carbon emissions through facilitating new PAYG solar business models and AI and IoT will improve the function of the current grid to increasingly integrate locally-produced renewable energy. Renewable energy may displace the use of fossil fuels.
	7.3 Double the improvement in energy efficiency	IoT will improve grid efficiency, through improved monitoring and tracking of energy use through the smart grid which prompts behavioural change. Autonomous systems are also able to automatically optimise energy efficiency within buildings. Reducing energy use will ultimately reduce the pressure on supply of non-clean fuels.
8 DECENT WORK AND ECONOMIC GROWTH	**8.4*** Improve global resource efficiency in consumption and production	Digital technologies will have a range of impacts on decoupling environmental degradation from economic growth, typically through creating greener business models. These broad system-wide impacts are covered in detail within the SDG 13 use cases in the following section, given they focus more on cross-sector environmental friendly practices for work, rather than inclusive economic growth.
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	**9.4** Upgrade industries to increase sustainability & resource efficiency	IoT and AI will be key to driving production line and supply chain efficiencies, which in turn will decrease CO2 produced per unit of productivity. Specifically, blockchain-enabled transport supply chains could reduce waste, whilst supply-chain logistics could be enhanced and made more efficient by IoT and AI. IoT and AI could also allow for real-time production line and delivery analysis and optimisation.
11 SUSTAINABLE CITIES AND COMMUNITIES	**11.2** Provide access to safe, accessible and sustainable transport & improve road safety	Digital access will improve the sustainability and efficiency of transport primarily encouraging the use of sharing platforms for car-pooling and cycling, leading to CO2 emission reduction.
	11.6 Reduce the adverse per capita impact of cities (inc. air quality and waste mgmt.)	Digital access, IoT and AI will reduce the environmental impact of cities through optimising city processes such as utilities or waste collection, as well as by monitoring levels of pollution. Process optimisation typically entails a reduction in energy used.
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	**12.2** Sustainable use of resources	Digital access will raise awareness of sustainability issues, create marketplaces for reusing goods and will also ensure transparency. Reusing reduces the need to extract further resources from the earth, saving energy in both extraction and production.
	12.3 Halve global food waste	AI and IoT drive reductions in food waste through improved monitoring and tracking as more data becomes available. Reducing waste will ensure less energy is needed to grow, process and transport food.
	12.5 Reduce waste generation	Digital technologies will optimise recycling processes, thus stimulating the move towards a closed-loop economy requiring less processing and mining of natural resources.
15 LIFE ON LAND	**15.1** Conserve, restore and sustainably use terrestrial ecosystems	IoT and blockchain will improve the ability to conserve forests through improving the monitoring and tracking of carbon credits arising from maintaining forest cover and stopping degradation.

---

*Please note, as this is a summary table of use-cases across SDGs, it is not scored like other impact function tables. For further details including scoring please see relevant chapter.

SDG 13 key impacts of digital technologies on reducing CO2 emission

Beyond the sector-specific targets outlined above, there are broader CO2 reducing impacts which digital technologies engender.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Use of tele-conferencing reduces the need for work-related travel Worldwide, flights and car travel are responsible for a large proportion of carbon emissions. Digital technology may be able to reduce this through providing high-quality videoconferencing and tele-commuting alternatives.	**Example:** Dell's work from home initiatives helped internal US employees save over one metric ton of CO2e per year, a collective saving of over ~35,000 metric tonnes CO2e per year in 2015. Dell also estimates their technology plays a direct role in over 20% of the tele-commuting related savings in the US workforce.[21]	Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability
Transitioning to cloud has considerable energy savings, by enabling businesses to scale only as much as they need to Cloud makes business more efficient as energy used in centralised data centres is less costly and more efficient on-premises services.[22] Previous GeSI estimates suggest that if an 80% adoption rate of cloud computing were experienced in China, 2.0 million tonnes of CO2e would be saved versus current adoption.[23]	**Example:** Deutsche Telekom's B2B cloud solutions decrease CO2 emissions for businesses, meaning SMEs could save up to 1% of their total annual CO2 emissions.[24] **Example:** SAP has been running 100% of renewable energy in all of its data centres and facilities since 2014, and is committed to becoming carbon neutral by 2025.[25]	Cloud	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Blockchain enables carbon trade on the individual and organisational level Blockchain strengthens the transparency of existing carbon trade initiatives and creates new initiatives, which attracts more people and organisations to reduce or offset emissions.[26]	**Example:** CarbonX is a peer-to-peer carbon trading platform. CarbonX distributes offsets generated from carbon reduction investments as crypto-tokens on a rewards programme. Retailers, organisations and brands can offer tokens as incentives for climate actions.[27]	Blockchain	Importance to SDG Role of digital technologies Scalability
Blockchain can support the development of a transparent global carbon-trading market Currently trading carbon across borders is complex, and it is critical for the functioning of an effective carbon trading system that products are verified, and that there is no double-counting within the system.[28, 29]	**Example:** Pocs show blockchain can provide the flexibility and robust accounting to establish a framework that incorporate the UNFCCC rules through which national registries can perform transactions.[30]	Blockchain	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
CO2 emissions are live-tracked to enable current state observation Satellite networks are able to observe power plants from space, using AI technology to process the images and detect power plant emissions.[31]	**Example:** Carbon Tracker used satellite imagery to estimate the utilisation of fossil fuel power plants.[32] They found that satellite imagery can independently derive coal power plant capacity, which is beneficial in markets where plant utilisation data is untimely, unreliable, or not publically available.	Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ■■■■■ Higher

Cluster 2

Ensure resilience to natural hazards

SDG 13 aims to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries. This is in the context of increasingly frequent, intense and consequentially damaging extreme weather events. [33] For example, in 2017 natural disasters including hurricanes, earthquakes, and wildfires cost $306 billion worldwide, nearly double 2016's cost of $188 billion.[34] From 2007-2017 the average year has seen 354 disasters, 68,000 deaths and 210 million people affected.[35]

Natural hazards and their associated disasters rely heavily on digital technologies for monitoring, prediction, management, and adaptation.[36] The ability to monitor and track environmental changes (IoT) can be critical for simple mass hazard warning systems when disasters are unfolding, saving lives. Meanwhile, AI and IoT are increasingly being applied to disaster management, to improve the analysis and short-term prediction of events, although this remains challenging.[37] Alongside basic smartphone access, fast internet and temporary mobile infrastructure are used for connecting aid workers to each other and to victims, and for communicating information on hazards. AI technologies can augment the response process, triaging incoming information to improve the allocation of response resources.

In this arena, some of the most powerful technological solutions are the simplest. For example, during the Indian ocean Tsunami, around 85% of lives could have been saved if even a simple early warning system had been present.[38] However, even simple "easy win" technological solutions depend on the mobile penetration of a population, and whether a sufficient mass exists in the most deprived sections of society for them to be effective. More advanced technologies will require sufficient training and financing for them to be effective (SDGs 13.A, 13.B).

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Mobile access facilitates SMS early warning systems to help people get to safety Ensuring populations have early warning of hazards is an effective means to safely and efficiently evacuate them to safety where possible.	**Example:** researchers in Bangladesh found that SMS colour coded impact-based flood warnings were an easy and understandable way to link forecasts to risk mitigation activities.[39]	Digital Access	Importance to SDG Role of digital technologies Scalability
Mobile access enables the locating of victims, and communicating with them via SMS Locating victims is made easier by the setting up and management of emergency phone lines to allow the mass dissemination of messages, and to allow disaster agencies to pinpoint the location of victims.	**Example:** TERA SMS text system is an application which allows aid agencies and mobile phone users in disaster areas to interact and listen in real time, giving early warning, detailed advice and feedback, and management of inbound messages.[40], [41]	Digital Access	Importance to SDG Role of digital technologies Scalability
Cloud and digital access increases co-ordination to improve disaster response times Many agencies are in the crowd in the days after a mass incident, and co-ordinating relief efforts are critical.	**Example:** Fujitsu has developed a proprietary smartphone app to aggregate information quickly from multiple disaster sites, initially in the North Sumatra region of Indonesia.[42] The app enables employees to easily and quickly send disasters information and casualty numbers, and the command centre helps aggregate and visualise disaster real-time information as it is received. **Example:** ITU assists countries in developing and deploying digital technologies for communicating during, and dealing with, natural disasters.[43]	Cloud Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
IoT enables simple hazard monitoring to understand when an event is beginning to occur Placing monitors to monitor changes in environmental parameters means governments and agencies can be informed of when a hazard is beginning to occur.	**Example:** IoT solar-powered sensors on the Liboriana river in Columbia are used to reduce land-slide disasters, by automatically sending a text message to village authorities if a risk is detected. Data is then stored in the cloud for others to access.[44]	Digital Access IoT	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Continual monitoring and predictive data analytics predict where damage will occur after disasters Advanced data analytics can be used to pinpoint statistically probable locations for damage to occur after a range of stimulated disasters.	**Example:** One Concern offers a suite of AI-based products for natural hazards, including Fire Concern, which maps how and where fires might spread in simulations, as well as incorporating hyper-local live information to improve disasters response and resiliency plans. The tools are able to learn from previous disasters and improve.[45]	Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AI is used to improve triaging and fulfilment of emergency calls through integrating more types of data[46] During an emergency, there is an influx of calls into first-response lines, and sorting through the calls to allocate resources in the most needed places is a challenge. AI is increasingly used to triage and analyse these calls.	**Example:** Association of Public-Safety Communications (APCO) are using IBM's Watson to improve operations and public safety through integrating more types of data, e.g. video, audio to help make quick assessments.[47] Likewise, Infermedica triages patients to improve patient outcomes.[48]	Cognitive	Importance to SDG Role of digital technologies Scalability
AI filters and classifies social media messages related to emergencies and disasters[49] An influx of social media messages on multiple platforms can be analysed and sorted through intelligent classification of messages to find out when and where disasters are occurring, as well as which people may urgently need help.	**Example:** AIDR is a free and open platform which uses machine intelligence to tag up to thousands of messages and images per minute.[50]	Cognitive	Importance to SDG Role of digital technologies Scalability
Machine learning enables targeted disaster relief management through image recognition and classification Use of satellite imagery available before and after a hazard can help to determine areas of greatest need for disaster relief.	**Example:** Rescue Global and Orchid project used machine learning following the Nepal Earthquakes in 2015 to carry out rescue activities by taking pre-and post-disaster imagery with crowdsourced data analysis and machine learning to identify areas affected by quakes that had not yet been assessed or received aid.[51]	Cognitive	Importance to SDG Role of digital technologies Scalability
AR is used to visualise the adaptive infrastructure needed to cope with climate change Planning and implementing climate change adaptation solutions requires large amounts of capital infrastructure. AR helps improve decision making in this process.	**Example:** Intertisement has developed a dialog-supporting visualisation tool in AR to demonstrate sustainable drainage solutions.[52]	Digital Reality	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Cluster 3

Improve education, awareness and capacity to act

Improving global capacity to act on climate change is critical to implement effective carbon-capture and geo-engineering technologies, create the most efficacious national policies, and to harness global momentum to act on climate change.

However, climate change efforts are widely challenged due to a lack of political-will. Short-termism can mean that climate change is rarely a key agenda item. Conceptualisation of the true long-term impact of climate change and the cost of not acting can be difficult, and apparent trade-offs for policymakers between economic growth and working to reduce emissions are seen to be challenging.[53] Strong and inclusive leadership is needed from countries with the technology and finances to effect immediate change.

Developing countries in particular still lack the necessary financial and technical resources to undertake climate action[54] and current global capacity building efforts require greater global co-ordination and tracking of outcomes.[55] It is also challenging to capture the extent of the problem; there is no globally-agreed methodology to track capacity building.[56]

Capacity improvement will be primarily enabled by international cooperation, permanent institutional arrangements[57], and in particular the large-scale resource transfer advocated in 13.A. Still, digital technologies can go some way to addressing issues. In particular, a lack of public awareness and support for climate action within countries is a constraint to action[58] which could be addressed by connecting citizens to each other, and also to education bodies communicating climate change messages to them. Digital technologies also engender better capacity to predict the future-state of the Earth's climate and the incremental bio-physical impacts into the future, at a system, rather than specific hazard, level. This is enabled by action from the likes of ITU who develop the regulatory and technical bases for the development and deployment of climate monitoring and data dissemination systems.[59] Better education and certainty around these scenarios will be helpful when determining how and where to improve capacity.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
VR and fast internet increase public understanding of magnitude and effect of climate change Climate change is an intangible concept, so using virtual imagery to deepen insight into the effects of climate change can be a powerful tool. Digital can also be a powerful force for change as social media connects individuals, allowing them to participate in civil society movements, e.g. Extinction Rebellion.	**Example:** The majority of participants who experienced immersive VR demonstrating the effects of climate change, had improved knowledge, and in some cases more positive environmental attitudes following exposure.[60]	Digital Reality Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AI can be deployed to improve long-term climate model projections Long-term climate forecasting is fraught with challenges, due to the limits of computer power and the complexity and interactions of the parameter involved. AI can unearth new insights from the conflicting and complex climate simulations generated by climate modellers.[61]	**Example:** A research team used AI to determine the best weighting of long-term climate models by assessing the reliability, improving the accuracy of climate change projections versus the average model prediction, which is the default practice in climate science[62, 63, 64]	Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Interaction with other SDGs

SDG 13 is unique in that it is almost entirely dependent on other SDGs for its achievement and they are so critical that they have been considered under the banner of the goal. The rationalisation of fossil fuel subsidies, as called out in 12.1, is one example of a key dependency for SDG 13.

The symbiotic interactions of SDG 13 with SDGs 1, 2, 4, 14, 15 and 16 are examples of the dependency between the effective management of the biosphere, and social and economic development. Attaining SDG 13 is dependent on the success of all of these SDGs, and also enables their success. Failure to achieve SDG 13 will therefore have negative impact on overall SDG attainment.

For example, climate change affects the relationship between poverty (SDG 1) and agriculture (SDG 2). Climate change impacts could "represent an obstacle to the sustained eradication of poverty" [65] because poor people are more vulnerable to natural hazards such as floods, and price changes in agricultural crops from climate change, having less access to support to cope and adapt.[66] Unchecked climate change will reduce crop yields; global production of wheat is estimated to fall by 6% for each 1ºC increase experienced.[67]

For developing societies dominated by agriculture there are further knock-on effects. For example, climate warming has been shown to lower school attendance rate (SDG 4) in Central Africa, due to reduced parental wealth.[68] Heat damaging crops in growing seasons is estimated to have been responsible for 59,300 suicides in India over the past 30 years, and this effect is also demonstrated in the USA and Mexico.[69] Climate change is also increasingly shown to be responsible for increasing asylum seeking through increasing conflict (SDG 16) as resource scarcity is exacerbated.[70]

Conversely, there is increasing evidence that climate-sensitive development has "significant 'double wins' for both poverty alleviation and gender equality.[71] The preservation of natural resources and ecosystems (SDGs 14 and 15) is critical to ensure the continual drawdown of carbon from the atmosphere and reduce climate change and in turn will reduce climate-driven ecosystem breakdown due to rapid changes in temperature and/or moisture levels. Many communities are dependent on natural resources such as fish stocks which are sensitive to the increasing acidification and warming of the oceans and a reduction in biodiversity may also reduce the ability to research and develop critical drugs. The committed protection of these natural environments is essential to also protect some of the most at-risk communities.

Negative externalities

Please see the "ICT Sector" chapter for a detailed consideration of the emissions and material impact resulting from the deployment of digital technologies.

Impact of widespread use of digital technologies on achievement of SDG 13

Emissions: Progress against SDG 13 could also be slowed by the widespread application of digital technologies, which create growth and stimulate industrialisation, which is liable to create more emissions.

Impact of using digital technologies to achieve SDG 13

Emissions: Moreover, emissions caused by the creation and deployment of new digital technologies to tackle SDG 13 could retard progress against SDG 13 attainment if they create more emissions than they abate.

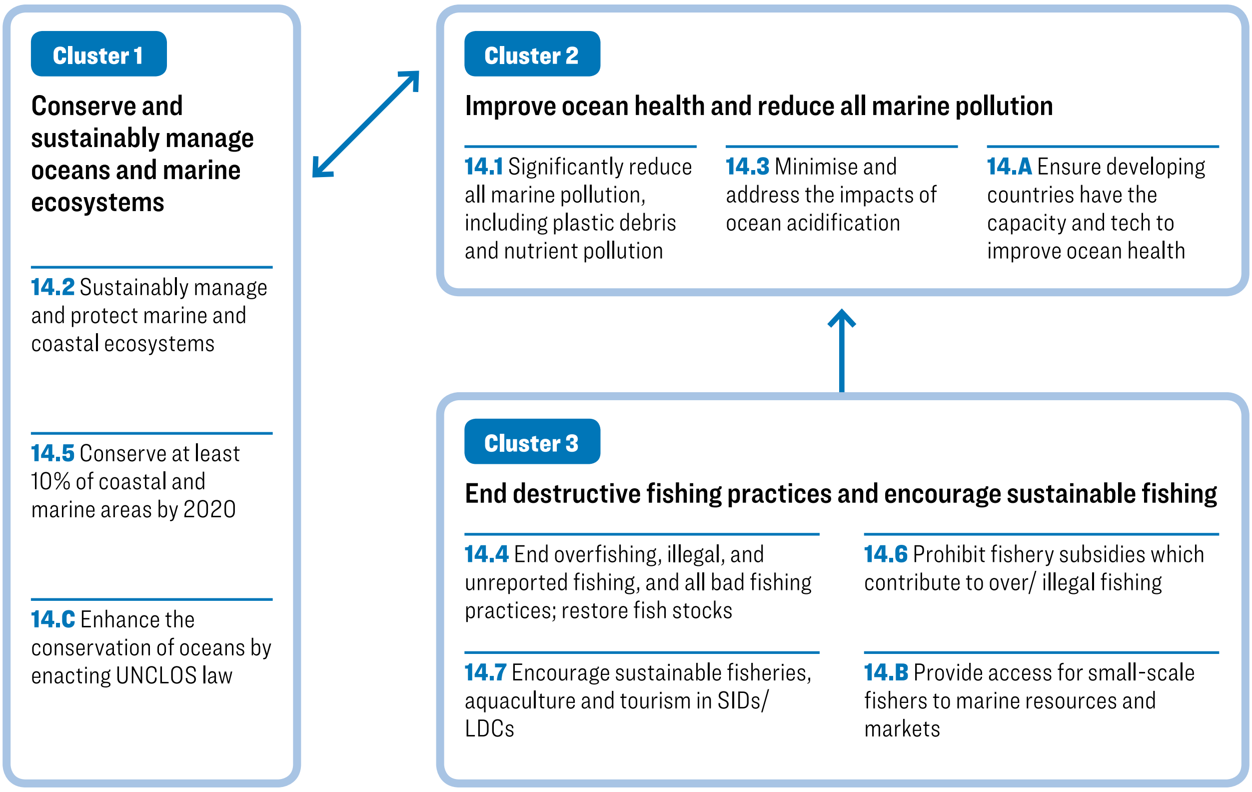
SDG 14 DEEP DIVE

Life Below Water

The world's oceans create global systems that make the Earth habitable for humankind. SDG 14 safeguards and manages those systems by focusing on human interactions with the ocean, seas and marine resources.[1] SDG 14 aims to reduce marine pollution and improve ocean health, enhance the conservation and sustainable use of oceans and marine resources, end illegal fishing and over-exploitation of fish stock, and to encourage sustainable fishing practices.

Oceans contain 97% of the world's water and cover more than two-thirds of the Earth's surface.[2] Oceans are the primary regulator of global climate, generate over 50% of the world's oxygen, absorb nearly one third of carbon produced[3], and account for 80% of the planet's biodiversity.[4] At the same time, over three billion people depend on marine and coastal resources for their livelihoods. However, oceans are being degraded by human activities that create marine and nutrient pollution, deplete resources, undermine coastal communities, and negatively affect human health. Currently, over 40% of the world's oceans have been severely impacted by human activities.[5]

SDG System



Cluster 1

Conserve and sustainably manage oceans and marine ecosystems

14.2 Sustainably manage and protect marine and coastal ecosystems

14.5 Conserve at least 10% of coastal and marine areas by 2020

14.C Enhance the conservation of oceans by enacting UNCLOS law

Cluster 2

Improve ocean health and reduce all marine pollution

14.1 Significantly reduce all marine pollution, including plastic debris and nutrient pollution

14.3 Minimise and address the impacts of ocean acidification

14.A Ensure developing countries have the capacity and tech to improve ocean health

Cluster 3

End destructive fishing practices and encourage sustainable fishing

14.4 End overfishing, illegal, and unreported fishing, and all bad fishing practices; restore fish stocks

14.6 Prohibit fishery subsidies which contribute to over/ illegal fishing

14.7 Encourage sustainable fisheries, aquaculture and tourism in SIDs/ LDCs

14.B Provide access for small-scale fishers to marine resources and markets

The protection and sustainable management of oceans and coastal ecosystems (Cluster 2) can be directly achieved by improving ocean health and reducing all marine pollution (Cluster 1), as more good practices and controls are adopted to mitigate ocean and marine harm. In turn, the conservation of marine and coastal ecosystems will ensure the reduction of pollution of all kinds within the ocean. Similarly, the objective to end destructive fishing practices and encourage sustainable fishing (Cluster 3) substantially contributes to the achievement of sustainable oceans and marine ecosystems.

The role of digital technologies in delivering SDG14

Access to information and research knowledge are helping achieve and expedite progress on SDG14 by allowing better collection and use of data to inform ocean and marine conservation efforts.[6] Through digital access and cloud-based data repositories, relevant data can be stored and shared, while conservation approaches and methods can be exchanged. Additionally, digital technologies have taken on increased importance in monitoring ocean health, as well as the activities that impact the oceans. By having better visibility into the human impact on oceans, seas and marine resources as well as habitats related to the ocean, action plans, policies and frameworks supporting SDG 14 can be designed and implemented. Through cloud, analytics and remote monitoring, it is possible to track fishing vessels and activities, as well as sourcing and supply management of marine products, supporting efforts to end destructive fishing practices.

Wider availability of information about the ocean's health has significantly contributed wide recognition of the importance of safeguarding marine sustainability. Through digital access, blockchain and other technologies, awareness amongst audiences is increased, and sustainable action is encouraged. By educating fishing communities who source fish and other marine products, as well as inspiring a sustainable mindset amongst consumers, digital technologies can drive sustainable management practices among fisheries, aquaculture and tourism.

The application of digital technologies, particularly for open ocean and deep sea areas, needs to be paired with increased international cooperation for maximum impact. Ocean governance is a complex web of interrelated, intertwined, converging and competing demands and interests. The modern governance framework for this special international space is currently highly fragmented with 576 bilateral and multilateral agreements. These legal instruments are spread across countless sectors in international, regional and national organisations that share responsibility for monitoring implementation but often lack the means and authority to ensure compliance and enforcement.[7]

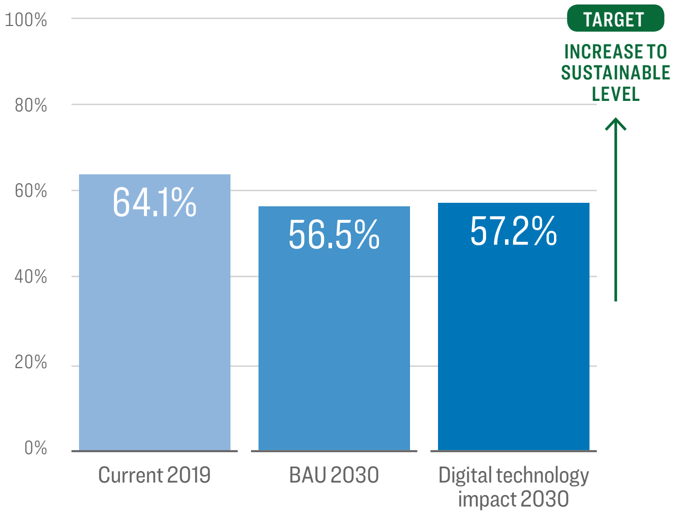
Adequate governance structures and institutional coherence are therefore crucial to effectively respond to growing pressures on the world's ocean and are inextricably linked to achieving global sustainability.

Impact projections to 2030

The proportion of fish stocks fished within biologically sustainable levels has fallen consistently from 91.5% in 1978 to 66.9% in 2015. Based on the historic trend, by 2019 this is expected to have fallen further to 64.1% and by 2030 the proportion could fall to below 56.5%. The sustainability of fisheries is essential to the livelihood of billions of people in coastal communities around the world, especially in developing communities where 97% of fishers live.[8]

Digital technologies, such as smartphones collecting data from vessels and using AI to detect illegal activities, could be used to tackle unregulated and unreported fishing. Adoption of such technologies could slow the depletion of fish stocks so that in 2030, the proportion of fish stocks within biologically sustainable levels could fall to a slightly higher 57.2%.[9]

Fish stocks within biologically sustainable levels (%)



Importance of digital technology to target attainment

	TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1	**Conserve and sustainably manage oceans and coastal ecosystems**		
🟩	**14.2** Sustainably manage and protect marine and coastal ecosystems	Digital technologies are the main enabler in accessing the information needed to formulate relevant conservation policies, and navigate conservation initiatives, even though sustainable management and conservation of marine resources and ecosystems are highly linked to international cooperation and policy enforcement.	NA
⬜	**14.5** Conserve at least 10% of coastal and marine areas by 2020	Digital technologies will have limited impact in allocating conservation areas and regulating the conservation of oceans, as conservation goals are to be set across jurisdictions taking into account national and international legal, policy and institutional frameworks.	🟢↗
⬜	**14.C** Enhance the conservation of oceans by enacting UNCLOS law		🟢↗
2	**Improve ocean health and reduce all marine pollution**		
🟩	**14.1** Significantly reduce all marine pollution, including plastic debris and nutrient pollution	Digital technologies can help detect and remove marine pollution, and monitor and respond to ocean changes, whilst raising awareness amongst populations regarding marine conservation.	NA
🟧	**14.3** Minimise and address the impacts of ocean acidification	Digital technologies can assist in monitoring acidification levels in the oceans and seas, even though the adoption of wider policies and actions to control the impact of climate change are necessary.	NA
⬜	**14.A** Ensure developing countries have the capacity and tech to improve ocean health	Digital technologies can facilitate the transfer of marine technology to improve ocean health through the provision of accessible networks and platforms, but the most significant factor will be the allocation of research budget through the application of international policies and independent development of research capacity.	NA
3	**End destructive fishing practices and encourage sustainable fishing**		
🟩	**14.4** End overfishing, illegal, and unreported fishing, and all bad fishing practices; restore fish stocks	Digital technologies can significantly drive continuous control and facilitate the prevention of illegal human activities to support the termination of destructive fishing practices that damage fish stocks.	🔴↘
⬜	**14.6** Prohibit fishery subsidies which contribute to over/ illegal fishing	Digital technologies will have little to no impact in monitoring fishery subsidies, the management of which will be through the implementation of international instruments and policies.	NA
🟧	**14.7** Encourage sustainable fisheries, aquaculture and tourism in SIDs/LDCs	Digital technologies and digital access allow the use of marine resources through education, better monitoring and access to information to cultivate the improvement of sustainable management practices in fisheries, aquaculture and tourism.	NA
🟩	**14.B** Provide access for small-scale fishers to marine resources and markets	Digital technologies can build the networks and platforms required to facilitate market participation in the seafood and sea produce industry for small-scale fishers and local communities.	NA

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

🟩 High impact
🟧 Moderate impact
⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

🟢 Positive progress
🟠 Limited progress
🔴 Negative progress

Cluster 1

Conserve and sustainably manage oceans and marine ecosystems

Maintaining the quality of life that the ocean provides to humankind while sustaining the integrity of ocean ecosystems, requires changes in how we view, manage, govern, and use ocean resources and coastal areas. The resilience of ecosystems is crucial to their functioning, persistence and viability. Degraded ecosystems – those that have lost biodiversity, ecological functions or structural integrity – are less resilient.

Digital technologies primarily allow humankind to:

a) Locate areas that require protection;

b) Understand the threats and why these areas are endangered; and

c) Take preventative and restorative action.

Organisations have been capitalising on the intersection of science and technology to inform marine technology and marine conservation efforts. Digital technologies provide insight into what sustainable ecosystems look like, and facilitate the first steps towards building them. To support adaptive conservation and resource management, and conserve marine species and habitats, it is necessary to digitally access accurate and up-to-date data and information systems.

However, digital technologies can only support the sustainable management and active pursuit of ocean conservation. True ocean sustainability will be the result of a sustainable ocean governance, which is the integrated product of policies, actions and affairs regarding the world's oceans and the protection of ocean environments, sustainable use of coastal and marine resources as well as conservation of biodiversity. To support ocean governance, there needs to be legal and institutional frameworks, as well as strong mechanisms of implementation. The process of ocean governance will require the participation of governmental institutions, the private sector, NGOs, academics, and scientists, through a system of reciprocal collaboration and coordination.[10]

Cluster attainment by technology table

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Earth management platforms, and data repositories through open data science[11] raise awareness Ocean data platforms deliver an accurate and vivid image of the ocean and seas today, as well as trends and changes throughout the years through visualisation tools.	**Example:** The Ocean Health Index, currently run by Conservation International, combines biological, physical, economic and social data to produce and share reports relevant to the ocean's health and management. Through analytics, the Index is able to produce conclusions regarding the status of the ocean in a given territory.[12] **Example:** REVOcean's Ocean Data Platform, similarly aims to develop a new platform for systemising available data, knowledge and science and making it available to public, policymakers and businesses worldwide.[13]	Digital Access Cloud Cognitive	Importance to SDG **Role of digital technologies** Scalability
Dynamic maps of natural resources measure impact To complement the existence of static information regarding ocean and marine ecosystems, it is essential to make information accessible and understandable to audiences. Through digital technologies, it is possible to build logical and statistical links between the data available and the benefits of conservation.	**Example:** The Nature Conservancy's Mapping Ocean Wealth project has created an AI-powered web application which processes images around the world's oceans, recognises the depicted natural resource, and combines the information with global and local information about the economic impact of nature-based tourism and activities that benefit from the presence of nearby natural resources.[14]	Cloud Cognitive Digital Access	**Importance to SDG** **Role of digital technologies** Scalability

Cluster 2

Improve ocean health and reduce all marine pollution

Marine pollution from human activities has long been a problem, despite ongoing efforts at mitigation, and has an adverse impact on the structure and function of marine ecosystems. Currently, an estimated 12.7 million tonnes of plastic end up in the oceans each year.[15] The use of plastics has increased 20-fold in the past half-century and is expected to double again in the next 20 years.[16] By 2050 there could be more plastic in the ocean than fish by weight.[17]

Digital technologies play a key role in alleviating the already existing marine pollution, mitigating the continuous risks associated with waste from human activity, providing insight into the impact on the ocean ecosystem on which human populations depend, and helping develop the knowledge of the ocean's role in climate change.[18]

This knowledge can only be developed through sustained observation and monitoring of the ocean's climate and ecosystems, activities which in turn are directly enabled by technology. Digital technologies can be used to inform populations about the current status of marine pollution, educate and raise awareness for taking measures against harmful behaviours, ensure the continuous observation and monitoring of the oceans and their marine ecosystems' health, as well as create accountability for harmful activities and reward for sustainable action. Through digital access, IoT, cloud and AI, a vast suite of solutions has been created for the purpose of improving ocean health and protecting oceans from pollution.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Use of social media and on-demand documentaries to inspire further action Through the modern use of social media, and higher visibility given to environmental issues, there has been increased broadcast and sharing of information and knowledge relevant to the oceans. This in return has created a heightened interest by audiences towards preserving planet Earth, and the biosphere within it.	**Example:** According to the Waitrose's annual food and drink report, based on a survey of 2,000 adults who shop across a range of retailers, 88% of those who saw the last episode of BBC's Blue Planet II about the effect of plastics on oceans, have subsequently changed how they use plastic.[19]	Digital Access Cloud Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability
Blockchain-based digital tokens as reward schemes Blockchain has allowed the creation of safe and accessible reward schemes for waste collection. Through digital accessibility, mobile and the exchange of virtual currency, it is possible for audiences to participate in schemes which support ocean conservation causes.	**Example:** In the case of IBM's collaboration with Plastic Bank,[20] collectors of plastic receive payment in the form of a digital token, and Plastic Bank recycles the material into "social plastic," which it then resells at a premium to environmentally aware partner businesses. Similar efforts, include the Clean Water Coin, which is using crowdfunding and blockchain to increase the efficiency of funding clean water projects worldwide.[21]	Cognitive Digital Access Blockchain	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Unmanned vehicles (drone) image analysis can be deployed to support pollution reduction efforts Technological solutions and innovations can be used to identify, measure and reduce the impact of material pollution.	**Example:** Initiatives such as Plastic Tide, recently renamed Ellipsis, aim to use drone-mounted cameras to obtain aerial photos, which will then be used to train AI algorithms to recognise images of plastic trash and distinguish these from marine life forms, creating a map of plastic concentration to support clean up activities.[22]	Cloud Cognitive	Importance to SDG Role of digital technologies Scalability
Connected sensors to monitor oceanic conditions Internet-connected sensors gather real-time continuous data, including temperature, salinity, tide patterns, seismic activity, underwater noise levels and video footage. Sensors can be found in various different forms, and various different locations (on the ocean floor, or even on the heads of seals[23] or in the form of robotic-swans[24]). These sensors gather and provide data to interested stakeholders in aid of decision making, disaster planning and marine conservation efforts.	**Example:** Fujitsu, Microsoft and Digicel under the Institute of Marine Affairs (IMA)'s initiative built IoT-connected sensors, specifically targeted to measure the changes and impact of oil spills in real time. This provides the information and insight to improve response times to local spills, and to attribute accountability for incidents.[25] **Example:** Ocean Networks Canada has deployed its Oceans 2.0 data management software to continuously monitor vital signs of oceans and coastal environments, collecting data through underwater and land based sensors.[26]	Cognitive IoT Cloud	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Autonomous robotic sensors and predictive analytics to understand oceanic health Continuous collection, analysis and monitoring of ocean changes not only through environmental conditions and chemical analysis, but through a real-time understanding of aquatic health.	**Example:** IBM is developing small autonomous AI microscopes, networked in the cloud and deployed around the world, to continually monitor plankton behaviour and in turn, analyse, model and predict environmental changes and responses (Project Microscopic Reality).[27]	IoT Cloud Cognitive	Importance to SDG Role of digital technologies Scalability

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Autonomous clean up service to complement clean up efforts Through the use of IoT, cloud and AI, it is possible to build solutions which can actively complement clean-up efforts in addition to enabling locating pollution and debris.	**Example:** The Ocean Cleanup has launched an independent clean up system in the form of a floating boon, which uses algorithms to specify the optimal deployment locations, after which the system floats autonomously, collects garbage and transmits remotely in real-time data about collection quantities, performance and trajectory of the system.[28]	IoT Cloud Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ■ ■ ■ ■ ■ Higher

Cluster 3

End destructive fishing practices and encourage sustainable fishing

Currently 10-12% of the world's population depends on fisheries and aquaculture for their livelihoods.[29] Over-fishing, illegal, unreported and unregulated fishing, and bad fishing practices have pushed the boundaries of sustainability, jeopardising this critical part of the marine system and this important source of food.

Technology is increasingly being deployed to improve fishing monitoring in all types of fisheries, and to progress to a more unified, sustainable management approach towards fishing. Technologically-enabled monitoring and control practices can be implemented across the value chain, from the point of catch, to fishing operations, to the product supply chain cycle. Through digital technologies, communities and fisheries globally can access know-how, knowledge and information to ensure better fisheries management and more sustainable fishing practices. The collection of data about fish stocks and the continuous observation of fishing vessels actively contributes to maintaining biodiversity levels and preventing illegal activities.

Technology can additionally empower small fisheries and Small Island Developing States to actively participate in the seafood and marine industry by guaranteeing their access to market and to a network of products and services.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Free, digitally accessible advice to empower and educate fishing groups Effective and sustainable fisheries management requires stock assessment based on the best available science to help fishery managers implore appropriate controls.	**Example:** Solutions may range from open-source platforms provided through the internet,[30] digital dashboards[31] or dynamic compilations of data sets (including economic, ecological, governance, and other capacities of a fishery).[32] On an individual level, fishers can access digitally available information on their phones regarding average fish prices and best fishing practices through applications, such as mFish.[33]	Digital Access	Importance to SDG Role of digital technologies Scalability
Creation of a digitally accessible network to reduce food miles Digital access has allowed the creation of new digital marketplaces, which connect small-scale fisheries to nearest communities. Building direct connections and networks on a local scale allows the formulation of more sustainable supply chains.	**Example:** Dock to Dish™ creates a network of local fishermen and local buyers and suppliers to reduce the distance marine products have to travel from one place to another, reducing costs and eliminating the need for carbon-intensive air freight while creating new markets and reliable trade outlets for small communities.[34]	Digital Access Blockchain	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Species tracking to ensure sustainability in supply chains The legal origin of seafood and the conditions associated with their fishing activity can be verified by implementing traceability systems that track seafood along the supply chain. Traceability of fish can be powered through the registration of catches. Control over fish catches (including by catch-and-release) can be delivered through the digital recording of fish caught on deck and sold on shore through mobile applications.	**Example:** Companies are using peer-to-peer networks based on blockchain technologies, to record data across the supply chain journey. Provenance has piloted the "Bait to Plate"[35] approach towards managing fish catches, facilitating the registration of local fishermen and catches through mobile text messages on the blockchain, up to the point of purchase from the consumers, indicating the fish's origin and verifying its sustainability claims through smart stickers and a mobile technology – making all of the information transparent for consumers.[36] **Example:** VeriCatch, comprises two integrated apps: FisheriesApp, which allows the user to self-report catch and biological information, and KnowYour.Fish for creating a traceable supply chain.[37]	Digital Access Blockchain	Importance to SDG Role of digital technologies Scalability
Fishing activity tracking to ensure compliance Activity in ports is a valuable indicator of fishing practices in an area, as the number of ships and catch is measured and documented at port point. Monitoring traffic and vessels in ports is a manual process, often difficult to implement. Through automated monitoring, vessel tracking at the end of a fishing cycle contributes to maintaining a sustainable fishing supply chain.	**Example:** INEX Impact Labs, the City of New Bedford and Dell, have incorporated an interconnected IoT solution to the Port of New Bedford to monitor incoming and outgoing activity. The volume of vessels and fishing cargo is tracked through connected sensors at key entry points of the port. In turn, this increases port security data for fish houses, prevents under-reporting fish catches and supports compliance with catch quotas and port regulations.[38]	Blockchain	Importance to SDG Role of digital technologies Scalability
Vessel tracking to battle illegal fishing Vessels are currently tracked through a diverse set of methods, including vessel tracking via satellite communications (or vessel monitoring system, VMS), Automatic Identification System (AIS) data, infra-red imaging and radar systems. Through digital technologies, data functions can detect illegal fishing by collecting and integrating data from all these sources. These data inputs are run through cloud-based algorithms to ensure the accurate recognition of fishing vessels, rather than cargo ships or sailboats, and allow for additional analysis, e.g. type of gear, vessel size. These fishing activities can be compared to regulations to determine compliance.	**Example:** Studiomapp deploys AI to analyse satellite images of the ocean, in order to identify the number and location of shipping and fishing vessels, as well as port activities. The results can then be cross-referenced with AIS data, a global vessel tracking service which legal vessels should declare themselves on, in order to locate illegal vessels that have not declared their location via AIS. The project won NATO's fourth annual Defence Innovation Challenge.[39] **Example:** Pew Charitable Trusts partnered with the Satellite Applications Catapult for Project Eyes on the Seas, a platform combining satellite monitoring and imagery data with other information, such as fishing vessel databases and oceanographic data, to help authorities detect suspicious fishing activity. With the use of artificial intelligence, the platform can synthesise and analyse multiple layers of data in near real time to monitor and identify suspicious vessels around the globe.[40] The project has now evolved into a full not-for-profit organisation, OceanMind, supporting the enforcement of marine compliance.[41]	Digital Access Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Fishing activity analysis to ensure sustainable fishing practices In order to automate the process of self-reporting and make catch monitoring data in fisheries more verifiable, it is possible to combine easily accessible low-cost cameras (or CCTV) with image analysis. The system is able to determine the activity of a vessel through the use of AI, determine where that activity occurred, accept inputs and comments from the skipper, and record video images of that activity for verification and other purposes.	**Example:** Smart types of electronic monitoring are found in the forms of applications, such as FlyWire Cameras[42] and ShellCatch,[43] or cloud-based software, such as Camio.[44]	Digital Access Cognitive	Importance to SDG Role of digital technologies Scalability

Interactions with other SDGs

Regions with stable and effective governance, and subsequently access to digital technologies and digital infrastructure (SDG 17), tended to perform much better in achieving SDG 14 than regions where corruption, dictatorship, civil strife, war and poverty have been evident.[45] This underscores that improving ocean health will require efforts from all sectors to promote peace and justice (SDG 16), gender equality (SDG 5), socially-responsible business and other aspects of civil health (SDG 9), because progress in those areas makes it much easier for communities and nations to improve the environmental and economic conditions needed to boost ocean health.

In turn, SDG 14 is a critical enabler of poverty alleviation, and environmentally sustainable economic growth, particularly in Small Island Developing States and Least-developed countries, helping the achievement of SDG 1. Sustained incomes and economic benefits from fisheries, aquaculture and tourism sectors depend heavily on the health of oceans and coasts. Similarly, there is a clear correlation between the health of the oceans and their marine ecosystems and the availability of safe, adequate and nutritious food to people (SDG 2), as a significant proportion of the food security of nutritionally vulnerable people comes from fish.[46] On the other hand, designating parts of marine and coastal areas for protection, e.g. establishing marine protected areas, may in some cases constrain opportunities for economic growth and creation of job options, negatively affecting SDG 8.

Sustainable fisheries contribute to sustainable management of natural resources and prevent against food losses along the production chain (SDG 12). On the other hand, sustainable consumption and production, such as sustainable management of natural resources or the reduction of wastes, as defined by SDG 12, are critical for ending overfishing, sustainably managing marine and coastal ecosystems and reducing marine pollution. Appropriate management of chemicals throughout their lifecycle will mitigate, or even prevent, marine pollution from land-based and offshore industries (SDG 12). Additionally, to positively help in addressing ocean sustainability and pollution it is essential to introduce ocean literacy into the curricula of education, as per SDG 4.

Finally, the ocean mitigates the full effect of climate change and supporting SDG 13, absorbing c.26% of the CO2 released by human activities.[47] On the other hand, climate change has severe impacts on the sustainability of oceans. For example, coral reefs are predicted to decline by 70-90% if a global warming of 1.5°C is experienced, and virtually all coral reefs would be lost with 2°C.[48] For this reason, action taken for promoting healthy oceans and coastal systems will also enable or even reinforce the development and integration of climate change measures into policies, planning and management.

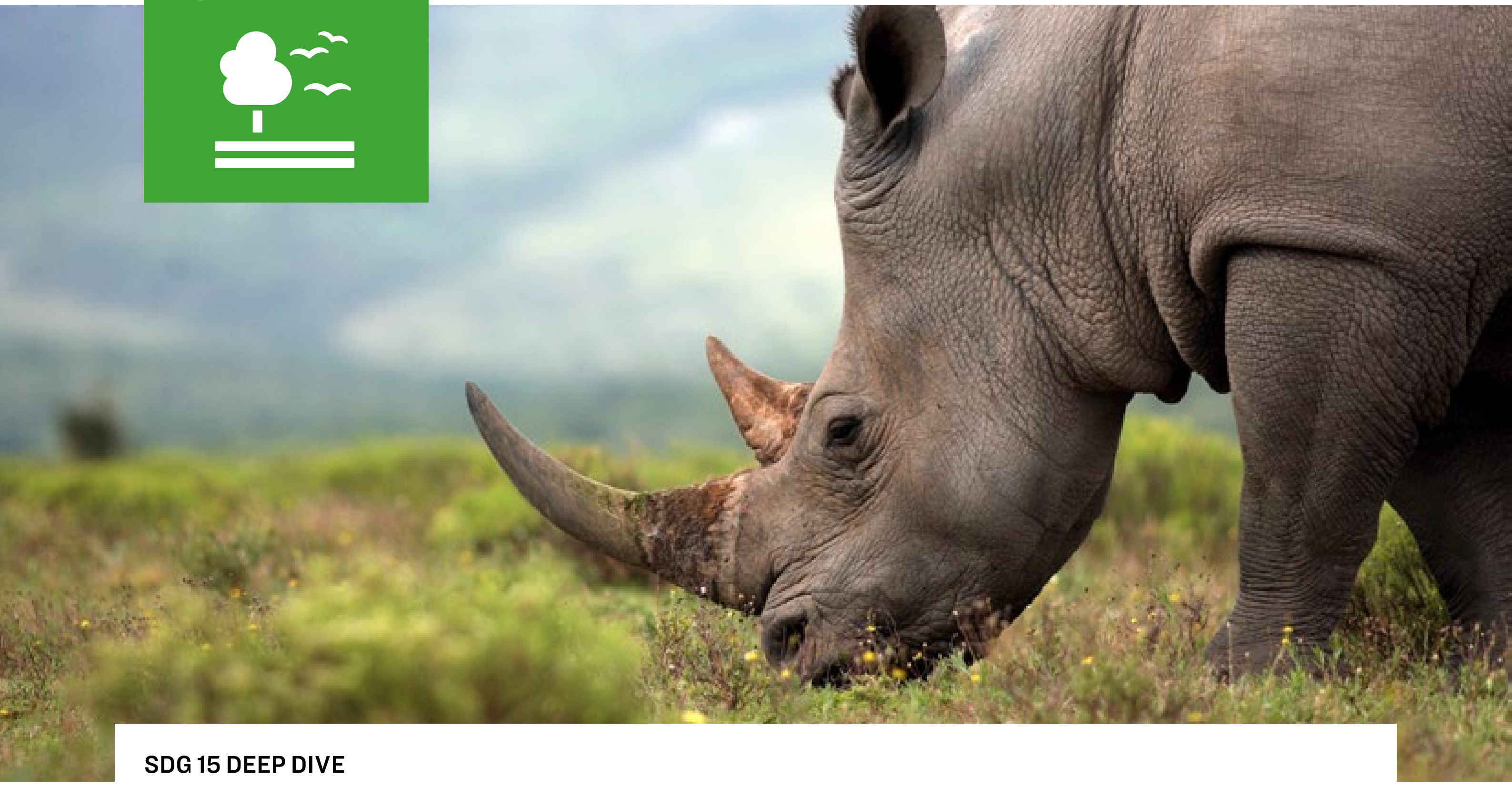
Negative externalities

Negative impacts of using digital technologies to achieve this SDG

Inequality: Access to digital technologies currently used in improving fisheries and aquaculture management, as well as providing access to market and resources for small fisheries and communities may further inequality. Without the use of digital technologies and access to technology, individuals and small communities may have less capacity to improve conditions in their fisheries, and fewer prospects to participate in the supply chain.

E-waste: Monitoring and predicting ocean health and pollution heavily relies on remote sensors, live-streaming video and devices enabling digital access. Intense wear and tear from exposure to salinity and water in the ocean and coastal areas, the short life span of the devices, as well as the lack of appropriate disposal infrastructure in remote communities and traveling vessels, may result in the misplacement of e-waste in marine areas.

Access to information and research knowledge are helping achieve and expedite progress on SDG14 by allowing better collection and use of data to inform ocean and marine conservation efforts.



SDG 15 DEEP DIVE

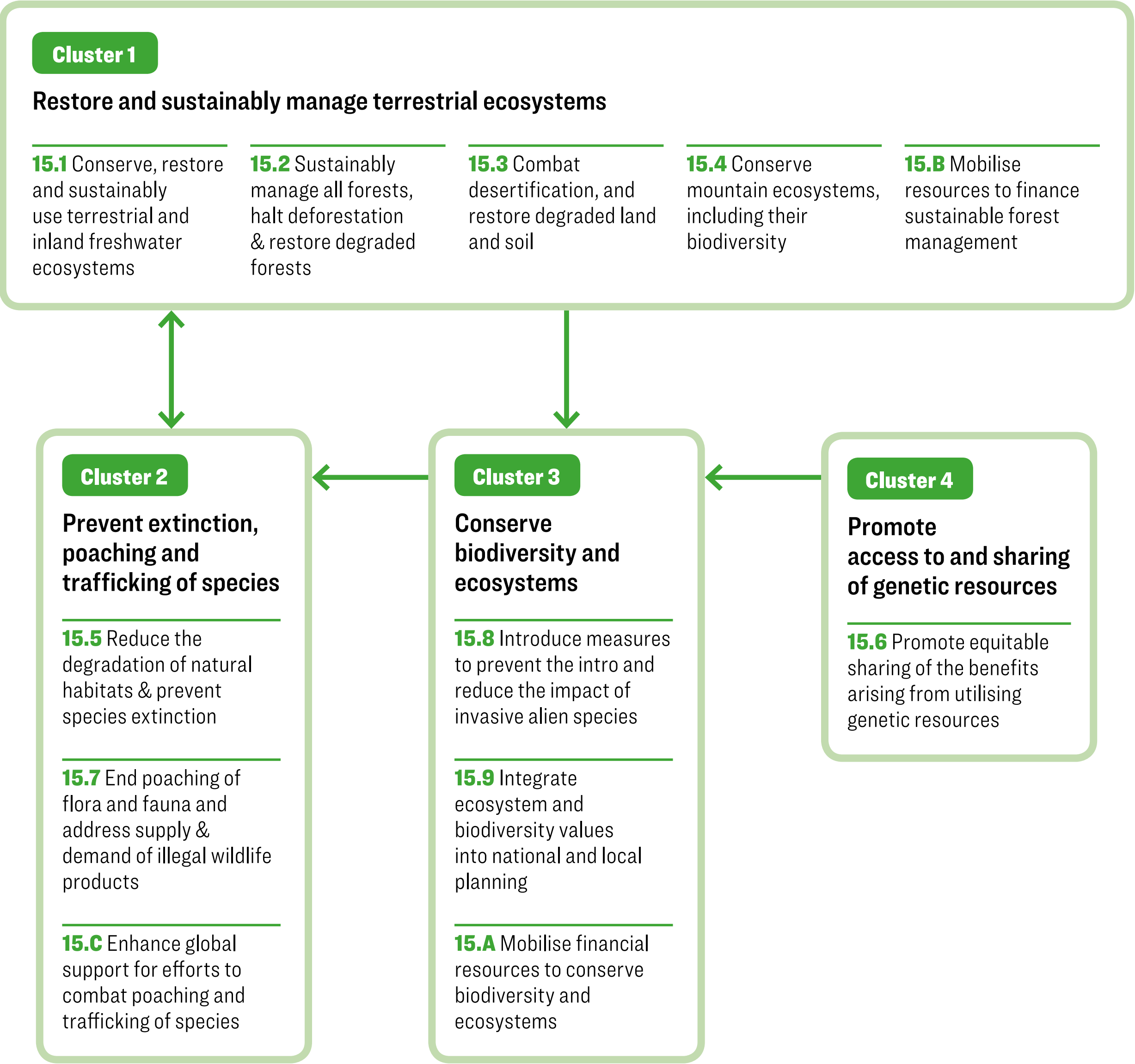
Life on Land

SDG 15 pertains to all types of land-based ecosystems and biodiversity, including urban and rural societies.[1] It promotes the sustainability of terrestrial ecosystems and protects against the depletion of forests, through halting desertification, land degradation and biodiversity loss. In particular, it aims to conserve, restore and sustainably manage terrestrial biomes, prevent extinction, poaching and trafficking of species, and conserve biodiversity.

Cristiana Pasca Palmer, Executive Secretary of the UN's Convention on Biological Diversity (UNCBD) views "healthy biodiversity [as] the essential infrastructure that supports all forms of life on earth, including human life." She adds that it "provides nature-based solutions to many of the most critical environmental, economic, and social challenges that we face as human society, including climate change, sustainable development, health, and water and food security."[2] However, at the time of writing more than 75% of Earth's land areas are substantially degraded, having become deserts, polluted or deforested, undermining the well-being of 3.2 billion people.[3] Furthermore, wildlife populations have declined, on average, by 58% since 1970.[4]

Efforts to protect and restore vital ecosystems and species are improving, as exhibited by the slowing of forest loss which has dropped by 25% since 2005,[5] and the global mean percentage of key biodiversity areas that are under protection, which has increased by 39% since 2000.[6] It is imperative to continue and bolster these efforts if current challenges are to be mitigated.

SDG 15 System



Cluster 1

Restore and sustainably manage terrestrial ecosystems

15.1 Conserve, restore and sustainably use terrestrial and inland freshwater ecosystems

15.2 Sustainably manage all forests, halt deforestation & restore degraded forests

15.3 Combat desertification, and restore degraded land and soil

15.4 Conserve mountain ecosystems, including their biodiversity

15.B Mobilise resources to finance sustainable forest management

Cluster 2

Prevent extinction, poaching and trafficking of species

15.5 Reduce the degradation of natural habitats & prevent species extinction

15.7 End poaching of flora and fauna and address supply & demand of illegal wildlife products

15.C Enhance global support for efforts to combat poaching and trafficking of species

Cluster 3

Conserve biodiversity and ecosystems

15.8 Introduce measures to prevent the intro and reduce the impact of invasive alien species

15.9 Integrate ecosystem and biodiversity values into national and local planning

15.A Mobilise financial resources to conserve biodiversity and ecosystems

Cluster 4

Promote access to and sharing of genetic resources

15.6 Promote equitable sharing of the benefits arising from utilising genetic resources

Restoring and sustainably managing terrestrial ecosystems (Cluster 1) directly supports the battle against wildlife extinction, poaching and trafficking (Cluster 2). Terrestrial, freshwater and mountain ecosystems are home to a multitude of species and the protection of one is essential to safeguarding the other. Restoring and sustainably managing terrestrial ecosystems, additionally, will assist efforts to conserve biodiversity and ecosystems (Cluster 3). Promoting access to and the sharing of genetic resources (Cluster 4) develops understanding of biological organisms and ecosystems, contributing to efforts to conserve biodiversity and ecosystems.

The role of digital technologies in delivering SDG 15

Digital technologies play a significant role in the sustainable use of terrestrial ecosystems and protection of biodiversity. Satellite monitoring and knowledge sharing through web interfaces facilitate the delivery of timely, accurate, and accessible data on critical land issues on a global basis. Digitalisation of data is a foundation to enabling conservation efforts and the path against biodiversity loss, as it influences conservation standards and initiatives. Access to this information can additionally help direct and stimulate interventions, as well as foster participation in education, communication and crowdsourcing activities to further human knowledge and protect the planet's species.

Digital technologies also offer monitoring abilities to track and protect ecosystems. For example, connected sensors and cloud capabilities can be used to deliver updates in real-time, safeguarding against illegal activities and flagging significant events. Big data illustrates short- and long-term biodiversity trends, allowing for mitigation planning in the case of negative trends. In addition, AI and machine learning can be used to recognise and understand species variation and alteration.

The aims of SDG 15 will not be met on current trajectories. Whilst digital technologies can make a significant contribution, transformative changes across economic, social, political and technological spheres are required.[7] Sustainable land management requires cross sector, international and regional participation, as well as policy and legal frameworks, to address desertification and land degradation, the unsustainable use of natural resources, and the consequences of climate change.[8]

Impact projections to 2030

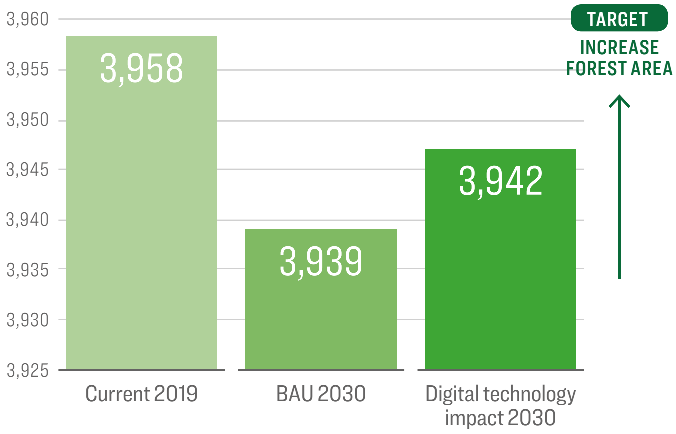
In the decade between 2006 and 2016, global forest area declined 0.4% to around 4,206 million hectares, a loss of around 18 million hectares. This global trend varies by region: Asia and Europe saw growth in forest area over the same period, while Africa, the Americas and Oceania experienced declines that totalled around 53 million hectares. If these global trends continue, current forest area is estimated to be 3,958 million hectares and by 2030, total forest area could fall to 3,939 million hectares (-0.5% on 2019).

Digital technologies have the potential to limit some of this future deforestation. For example, fast internet technology, e.g. 5G, can connect audio monitoring systems that detect illegal deforestation, using AI sound recognition. Additionally, cloud computing could help manage the data amassed by environmental scientists in research. The application of big data stored in the cloud (e.g. taxonomic, biogeographic or ecological information) enables the generation of detailed biological models that provide improved forecasting of events such as the spread of invasive species or the impact of climate change.

The targeted application of these technologies could slow the pace of deforestation so that in 2030, total forest area is around 3,942 million hectares. This represents a reduction of global forest loss of 18% or 3.4 million hectares between now and 2030.

This would have an important impact on the planet's ecosystems but also on carbon abatement. Forests have the potential to offset emissions from other sources. Avoiding 3.4 million hectares of deforestation could translate into an additional 2.3Mt (0.0023Gt) of CO2e removed from the atmosphere.

Global forest area (million hectares)



Importance of digital technology to target attainment

	TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1	**Restore and sustainably manage terrestrial ecosystems**		
🟩	**15.1** Conserve, restore and sustainably use all terrestrial and inland freshwater ecosystems and their services	Digital technologies substantially contribute in monitoring the health of terrestrial ecosystems and communicating this information to the public.	🟢↗
🟧	**15.2** Sustainably manage all forests, halt deforestation and restore degraded forests	Digital technologies play a significant role in raising awareness about deforestation and the key actions required to stop destructive practices. Digital access and accurate sharing of data support the active enhancement of protection efforts.	🟠→
🟧	**15.3** Combat desertification, and restore degraded land and soil	Digital technologies give visibility to the amount and status of degraded land and soil through the comprehensive collection of data and detailed understanding of the extent of damage. However, digital technologies at this stage have limited impact in the pragmatic restoration of degraded land.	NA
🟧	**15.4** Conserve mountain ecosystems, including their biodiversity	The conservation of mountain ecosystems relies on digital technologies for accurate monitoring and appropriate management of collected information by conservationists. However, this information is mainly advisory; further activities need to be undertaken to conserve mountain ecosystems.	🟢↗
⬜	**15.B** Mobilise resources to finance sustainable forest management	Even though digital technologies are essential in shaping sustainable forest management, the most important factors for mobilising financial resources are centred on policy.	NA

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

- 🟩 High impact
- 🟧 Moderate impact
- ⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

- 🟢 Positive progress
- 🟠 Limited progress
- 🔴 Negative progress

2		**Prevent extinction, poaching and trafficking of species**		
	🟧	**15.5** Reduce the degradation of natural habitats and prevent species extinction	Through digital technologies and the collective participation of people with digital access, it is possible to monitor natural habitats, isolate threats, destructive practices and trends, and subsequently mobilise people to safeguard habitats and their species. However, reducing species extinction and the degradation of natural habitats is also dependent on a multitude of macro factors.	🟠 →
	🟩	**15.7** End poaching of flora and fauna and address supply and demand of illegal wildlife products	Digital technologies significantly contribute to ending illegal wildlife trade and poaching as they provide the means to protect endangered species through monitoring protected areas and improving understanding of trafficking trends.	NA
	▨	**15.C** Enhance global support for efforts to combat poaching and trafficking of species	Digital technologies can assist in coordinating responses against illegal trafficking of species. However, local and national initiatives will be the main drivers that provide local communities with sustainable livelihood opportunities.	NA
3		**Conserve biodiversity and ecosystems**		
	▨	**15.8** Introduce measures to prevent the intro and reduce the impact of invasive alien species	In spite of digital technologies substantial impact in informing and empowering conservation efforts, public expenditure policies and initiatives will be central to the achievement of national and local targets relevant to the control of invasive alien species and conservation of biodiversity.	NA
	▨	**15.9** Integrate ecosystem and biodiversity values into national and local planning		NA
	▨	**15.A** Mobilise financial resources to conserve biodiversity and ecosystems	Digital technologies will have little impact, besides facilitating transactions, in mobilising financial resources for conservation. The primary drivers will be local and national policies.	🟢 ↗
4		**Promote access to and sharing of genetic resources**		
	▨	**15.6** Promote equitable sharing of the benefits arising from utilising genetic resources	Digital technologies can support the timely and accurate sharing of genetic resource information. However, commitment to international and cross sector collaboration will be the main driver of progress for this target.	🔴 ↘

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

- 🟩 High impact
- 🟧 Moderate impact
- ▨ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

- 🟢 Positive progress
- 🟠 Limited progress
- 🔴 Negative progress

Cluster 1

Restore and sustainably manage terrestrial ecosystems

Land degradation is a systemic phenomenon affecting all terrestrial ecosystems from forests to wetlands. Amongst unsustainable grazing and agricultural activities, deforestation is the main cause of land degradation. Forests cover nearly 31% of the Earth's surface,[9] and deforestation and desertification, mainly caused by human activities, are endangering both forests and the wider global terrestrial ecosystem. Wetlands are at particular risk, with 87% lost globally in the last 300 years.[10]

Minimising land degradation is essential for human well-being. Forests mitigate climate change induced environmental conditions (including levels of oxygen and humidity in the air) and protect watersheds, which supply 75% of freshwater worldwide.[11] Forests play a significant role in reducing the risk of natural disasters, including floods, droughts and landslides. In addition, forests provide shelter and natural resources to populations, with an estimated 1.6 billion people depending on forests for their livelihood.[12] More specifically, 74% of people in poverty are directly affected by land degradation globally. As land gets degraded, and global population increases, the amount of usable land is decreasing, leading to land shortages and increasing demand of finite land resources.[13]

Technology plays a key role in supporting the conservation and protection of terrestrial ecosystems. Using digital access, remote sensing and the cloud, sustained monitoring of territories provides critical understanding of the current status of ecological biomes, the extent of harm, and the implications of historic trends. Access to crowdsources and scientific data regarding terrestrial ecosystems informs conservation initiatives and raises awareness amongst audiences. Finally, through the cloud and cognitive technologies, the impact on ecosystems and natural resources can be measured, managed and mitigated to reduce land degradation and conserve biodiversity.[14]

Whilst digital technologies have a large role to play, the cross sector nature of land degradation requires the creation of appropriate governance structures, policies and processes. Furthermore, tackling land degradation needs change at a macroeconomic level, with a focus not solely on mitigating damage, but directly addressing the causes of land degradation. The exhaustion of terrestrial ecosystems is the result of an amalgamation of factors and thus requires a co-ordinated use of diverse policy instruments at institutional, community and individual levels.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Open access platforms to encourage scientific cooperation and support conservation research Through the use of cloud and digitally accessible resources, it is possible to gather data relevant to conservation and share approaches. This availability of information encourages scientists, researchers and audiences to explore, test and apply conservation theories, flag sustainability issues and shape conservation standards.	**Example:** EUBrazilOpenBio is a collaborative initiative created with the purpose of making data and tools regarding biodiversity available to the wider audiences. Using the on-demand capabilities of cloud, digital access, and fast internet it aims to provide the hardware, software and data necessary to further understanding of regional and global biodiversity.[15]	Cloud Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Monitor terrestrial changes through collection of data Collecting data using satellite imaging and open source technology has the capacity to give visibility over land changes. Open data platforms deliver an accurate and vivid image of land today, as well as historical trends and changes, through visualisation tools.	**Example:** The FAO, with the support of Google Earth Outreach, developed a land monitoring open source application, named Collect Earth. Collect Earth gathers and analyses data from freely available repositories of satellite imagery, with the purpose of cataloguing and tracking terrestrial changes. The European Space Agency runs a similar initiative focusing on land degradation and desertification.[16] **Example:** Map 4 Environment serves as an interactive repository for spatial data sets and allows audiences to share and manage the data and produce maps online to give greater visibility into changing landscapes.	Cloud Cognitive Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Analyse forest inventory to inform conservation management Through satellite imagery, cloud and machine learning, it is possible to collect information about the sizes, health, and species of trees and other flora included within a forest. This data can be used to analyse changes in the forest as a whole, and inform conservational, ecological and economic choices.	**Example:** Silvia Terra and Microsoft have developed a forest inventory application, which uses machine learning on the cloud to improve forest data analysis, leading to higher quality and more precise insights. Silvia Terra combines data remotely collected with pre-existing field data to create detailed maps of forests to support the creation of sustainable forest management plans.[17] **Example:** Global Forest Watch (GFW) is an online platform providing data and tools for monitoring forests. Through satellite imagery and a mobile application, GFW allows audiences to access near real-time information about where and how forests are changing around the world.[18]	Cloud Cognitive Fast Internet / 5G	Importance to SDG Role of digital technologies Scalability
Remote detection of illegal logging and other harmful activities Connected, portable and weatherproof acoustic sensors are used to monitor wildlife and forests. Through the use of cloud and machine learning, it is possible to aggregate and analyse the data collected to design interventions and collaborate with others.	**Example:** Rainforest Connection and Huawei are using hidden repurposed smartphones, called "Guardian" devices, to continuously monitor the sounds of the rainforest and collect data from threatened areas. The audio data is sent through the local, mobile network and stored and managed in Huawei's big data service.[19] Subsequently through an machine learning framework all auditory data is analysed in real time to detect species, identify dangers, locate logging sounds and initiate alerts when necessary.[20]	Cloud Digital Access IoT	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 2

Prevent extinction, poaching and trafficking of species

Terrestrial biodiversity covers the variety of living organisms found in plants and animals, their genes, ecosystems and ecological processes.[21] Forests, in particular, are the most biologically-diverse ecosystems on land, hosting 80% of the terrestrial species of animals, plants and insects. As of 2019, there are one billion species threatened, including over 50% of assessed plant species and 26% of assessed animal species.[22] Illicit poaching and trafficking of wildlife continues to impede conservation efforts, with nearly 7,000 species of animals and plants reported in illegal trade across 120 countries.[23]

Digital technologies have the capacity to engage the public in conservation realities and initiatives. Through the transmission of relevant information, as well as the wide availability of data and tools necessary to conduct conservation research, audiences are empowered to actively participate in conserving life on land. Additionally, remote sensors and cognitive technologies allow better understanding of the dynamics of protected ecosystems and animal behaviours. Furthermore, digital technologies can improve the process of protecting endangered animals.

As part of national conservation efforts, most countries have put in place legal and institutional frameworks for the sustainable use and conservation of biodiversity as a whole, mainly focusing on ecosystem, landscape and seascape approaches. However, enabling frameworks for the sustainable use and conservation of biodiversity urgently need to be established and strengthened.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Interactive dashboards to increase community awareness and involvement Digitally accessible dashboards and platforms deliver a medium through which conservation awareness can be raised as information becomes available and engagement for ecological issues increases.	**Example:** WILDLABS is an online community operating through a platform where information about conservation and technology is shared. The purpose of the platform is to offer crowdsourced advice and training, as well as a collaborating space to drive innovation relating to conservation.[24]	Cloud Digital Access	Importance to SDG Role of digital technologies Scalability
Encourage active participation in wildlife conservation through AR and VR Virtual, augmented and mixed reality technologies have created new ways of influencing audience behaviours, providing access to information through a different lens and appealing to different audiences. AR in particular allows humans to get exposure to issues which they otherwise would not have access to; a process which creates empathy and inspires further action.	**Example:** Safari Central by Internet of Elephants is an AR application, which creates an augmented reality using threatened animals. It aims to engage users in conservation issues and projects.[25]	Cloud Digital Reality	Importance to SDG Role of digital technologies Scalability
Cryptocurrency to fund conservation initiatives and increase awareness on wildlife animal extinction Cryptocurrencies based on blockchain can help address conservational challenges, such as species extinction, by offering a vehicle to conduct secure transactions. The benefits of each transaction can accrue to an attached conservation objective, for example to raise awareness or collect revenue for conservation activities.	**Example:** Rhinocoin is an emerging cryptocurrency built on Ethereum blockchain and issued against legally obtained rhinoceros horn. Rhinocoin aims to generate revenue required to sustain rhino conservation efforts, promote community-based development projects, and securely monitor transactions attached to rhino horn – without engaging in physical rhino horn trade.[26]	Cloud Blockchain	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Intelligent patrolling and improved monitoring Digitalisation of wildlife data is fundamental to improving conservation efforts. For this reason, digital access and connected devices provide a solution to data collection and storage.	**Example:** M-Stripes (Monitoring System for Tiger-Intensive Protection and Ecological Status), created by the Wildlife Institute of India, aims to address the difficulties of unrecorded data and insights from patrolling protected areas. M-Stripes is a mobile application, relying on digital access, to directly enable field patrols to send data from one device to the other, through an internet connection. M-Stripes improves the reliability and accuracy of information, enabling instant analysis and decision making related to surveillance, monitoring and patrolling.[27] **Example:** Deutsche Telecom has developed a solution which transmits sensor data straight from a beehive to the beekeeper's cell phone. The data is collected by intelligent sensors and transmitted through narrowband IoT technology (NB-IoT). The data transmitted includes temperature, air humidity, air pressure, beehive weight and activity of the bees, and can be used as indicators for bee health.[28]	Digital Access Cognitive	Importance to SDG Role of digital technologies Scalability
Remote sensors to protect against poachers Digital technologies allow the continuous observation and monitoring of humans and their activities. Particularly, IoT and digital access can be used to identify harmful behaviours, illegal activities, and irregularities in protected areas. Similar technologies can be used to track areas with endangered species as a means to ensuring they follow normal migration patterns, and to protect populations against poaching.	**Example:** Cisco partnered with Dimension Data to create a solution that would protect rhinos from poaching. Their project "Connected Surveillance" helps identify suspicious activity, protecting the rhino without disturbing its natural state of being. The solution uses a combination of technologies, WiFi, scanners, CCTV, and sensors, to provide early warnings about intruders. Rangers are then able to act as soon as the perimeter of a protected area is breached.[29] **Example:** Vulcan Earth Ranger is a software platform that collects information on activity in a protected area, monitoring animals, human activities and physical phenomena. Data is collected from a range of sources, from ranger recorded observations to vehicle sensors. Using one real-time visualisation platform, officials and rangers can understand their data more easily and make more informed, faster patrolling decisions.[30]	IoT Cloud	Importance to SDG Role of digital technologies Scalability

Lower ■ ■ ■ ■ ■ Higher

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Cataloguing biological assets to promote sustainable bio-based economic development Gaining visibility over the world's natural assets, processes and ecosystems allows the creation of more sustainable bio-based designs and innovations.	**Example:** The Amazon Third Way initiative is developing the Earth Bank of Codes, an open global digital platform that maps biological functions and biomimetic and biological assets of the Amazon rainforest, whilst codifying the rights and obligations associated to the commercial use of those IP assets.[31]	Digital Access Cognitive	Importance to SDG Role of digital technologies Scalability
Predictive modelling to route patrolling Through the application of machine learning and AI on historical poaching data, it possible to analyse information on previous patrolling and poaching activities in protected areas to predict future incidents.	**Example:** The Protection Assistant for Wildlife Security (PAWS) system developed by University of Southern California and Microsoft, analyses historic poaching data, patrol effect records, and geospatial park data to generate heat maps indicating potential attack areas. Rangers use the information to identify territories in need for increased surveillance, inform their patrolling routes, and allocate their resources.[32]	Cognitive IoT	Importance to SDG Role of digital technologies Scalability
Analyse historic data on species to understand behavioural and extinction patterns Essential to the development of conservation frameworks is the efficient collection and management of wildlife data. Particularly for monitoring species across the world, manual collection and processing of data creates friction, delays and inaccuracies.	**Example:** Wild Me identifies and tracks individual animals using machine learning and computer vision for its project WildBook. Wildbook provides a scalable and collaborative platform for intelligent data storage and management, including advanced consolidated searching. The project analyses collected images to produce a database that records the location and behaviours of animals, as well as the environmental and climate data that affect their decisions.[33] Another example The Natural History Museum in London, for its project PREDICTS (Projecting Responses of Ecological Diversity In Changing Terrestrial Systems), is collecting data from scientists to investigate how terrestrial biodiversity responds to human activity, and ultimately predict future biodiversity changes.[34]	Cloud Cognitive IoT	Importance to SDG Role of digital technologies Scalability
Image recognition to incentivise collection of conservation data Conservation data repositories are very often reliant on citizens to map and share observations of biodiversity across the globe. Given the vast range of biodiversity and ecosystems on the Earth, open data is essential for scientific discovery and conservation research. Through technology and digital access, it is possible to incentivise audiences to participate in ecological research through observation and recording of data.	**Example:** iNaturalist is an online social network of people sharing biodiversity information to help each other learn about nature. Seek by iNaturalist is an app designed to help casual naturalists to learn more about the world around them via real-time ID suggestions powered by computer vision. Users can earn badges by finding new species and they have the option to share their observations to iNaturalist's biodiversity database.[35]	Cloud Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

The aims of SDG 15 will not be met on current trajectories. Whilst digital technologies can make a significant contribution, transformative changes across economic, social, political and technological spheres are required.

Interactions with other SDGs

The restoration and sustainable management of terrestrial ecosystems will contribute significantly in achieving SDGs related to livelihoods and food security (SDGs 1 and 2). In particular, SDG 15 has direct impact on eradicating poverty and hunger, as 40% of rural people in extreme poverty live in forest and savannah areas, receiving a substantial part of their income and food from forests. Sustainable and resilient agriculture practices aligned to ecosystems protection, as instructed by SDG2, can reinforce conservation, restoration and sustainable use of terrestrial ecosystems. On the contrary, intensive agricultural use of land can have a negative impact on SDG 15.[36] Sustainable management of forests, wetlands and grasslands can also assist in allocating land rights equitably, which can promote equal rights amongst genders (SDG 5) and populations (SDG 10).

Additionally, achievement of SDG 15 will improve access to affordable energy (SDG 7). Around 33% of the world's population, roughly 2.4 billion people, use wood to fulfil basic functions such as cooking, boiling water and heating their homes, while 40% of global renewable energy is in the form of wood fuel.[37]

Finally, progress towards the conservation of terrestrial ecosystems can have a positive impact on sustainable water management (SDG 6) and climate change (SDG 13). Forests are integral to the water cycle, providing the drinking water for one-third of the world's largest cities. Additionally, forests strengthen resilience and adaptive capacities to climate-related hazards and natural disasters, for example by moderating the earth's temperature and CO2 levels.

Negative externalities

Impact of widespread use of digital technologies on achievement of SDG 15

Increased demand for land use: High consumption lifestyles in more developed economies, combined with rising consumption in developing and emerging economies, are the dominant factors driving land degradation globally. New economic opportunities and business models enabled by technology result in lower costs for land-based resources for consumers, leading to a rise in demand for land use. Similarly, as there is more demand for the products themselves, and as production lines are becoming more efficient through digital technologies, production capacity and output has increased as well. Coupled with the failure of policies to introduce and enforce sustainable practices and internalise the long-term economic costs of unsustainable production, the exploitation of natural resources has led to greater levels of land degradation.[38] The ultimate result is a cycle of supply and demand of products sourced and produced to the detriment of terrestrial ecosystems.

Impact of using digital technologies to achieve SDG 15

Misuse of information: Digital technologies used for sustainably managing terrestrial ecosystems offer a vast range of new capabilities for monitoring habitats and species. Information on natural assets can be collected with ease and accuracy, and shared digitally to the public. This increases the risk of data misuse, either by parties interested in exploiting land, or potential wildlife traffickers. Consequently, while digital technologies do assist conservation and wildlife protection, open data can expose ecosystems to malicious activity.

Illegal wildlife trade: As endangered animals and protected areas are increasingly monitored and patrolled, it is harder for poachers to gain access to rare species. This could potentially result in a spike in illegal wildlife trade. In spite of intense conservation efforts, and the growing support of digital technologies, the world is facing an unprecedented increase in illegal wildlife trade as endangered species become harder to acquire, and more valuable to trade.[39]

Disruptive hardware and e-waste: Connected monitoring and tracking is, to some extent, disruptive to the natural order of an ecosystem. In order to maintain an accurate understanding of changing conditions and activities in a specific region, the use of connected sensors, either placed directly in the surrounding environment, or on animals, is essential. Sensors created from manmade materials can be intrusive to a habitat, or an animal body. Furthermore, (if there is a widespread proliferation of IoT technology in terrestrial habitats) there is a risk that sensors will create an e-waste problem, as adverse weather conditions and other forms of wear and tear in nature damage them.

16 PEACE, JUSTICE AND STRONG INSTITUTIONS

SDG 16 DEEP DIVE

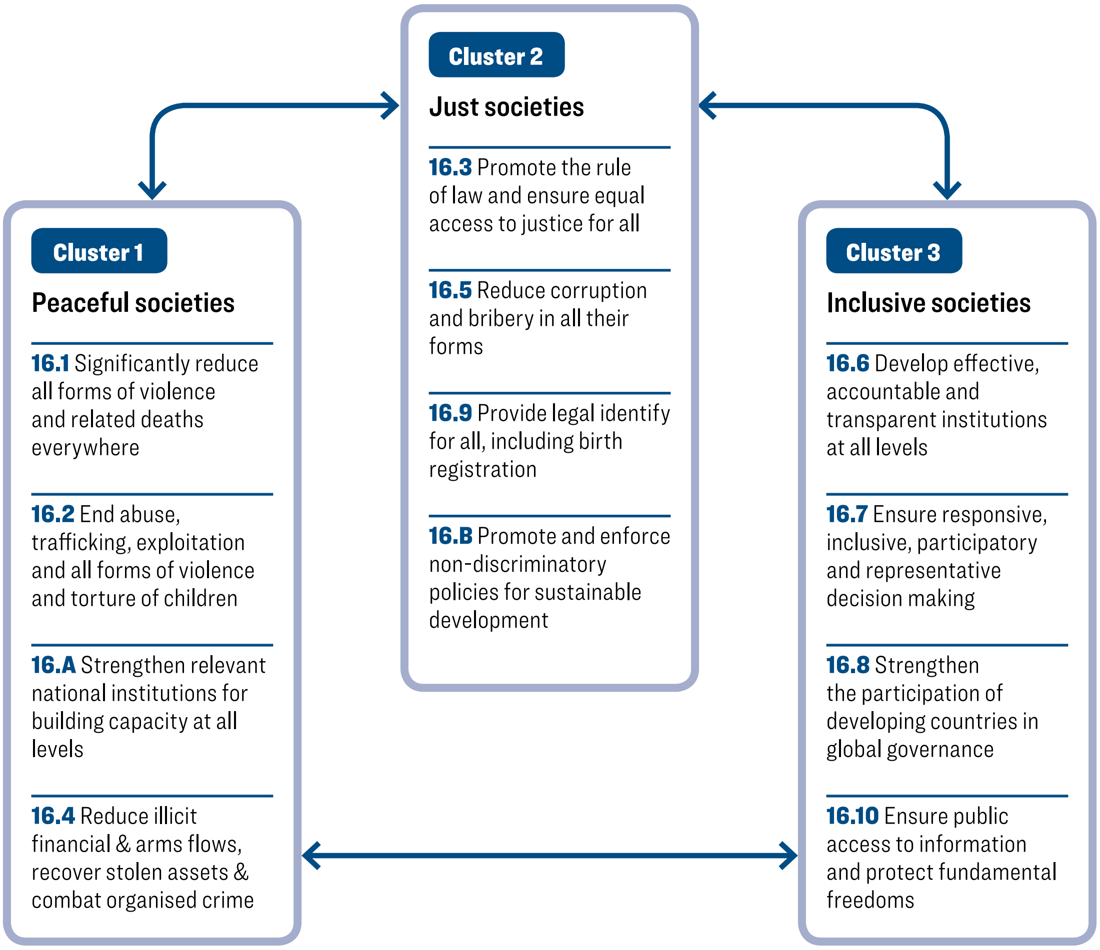
Peace, Justice and Strong Institutions

SDG 16's aim is to "foster peaceful, just and inclusive societies which are free from fear and violence". The SDG Agenda calls out peace as one of the five "areas of critical importance for humanity and the planet", in addition to People, Planet, Prosperity and Partnership, as "there can be no sustainable development without peace and no peace without sustainable development".[1]

Achieving peace, justice and strong institutions by 2030 is an ambitious and visionary goal and the current trajectory to delivering against the targets and indicators, on the data available, is not positive.[2] Reporting on progress against SDG 16 indicators does not necessarily mean reporting against the goal's ambition. For instance, Target 16.3: to promote the rule of law and ensure equal access to justice for all, is only measured by indicators pertaining to criminal justice, despite studies showing that a majority of people's legal issues are civil.[3] This disconnect between targets and goals, coupled with a lack of comparable data available between countries, means that progress on this goal is difficult to measure.

Challenges to achieving SDG 16 are manifold. One that has been a constant since the SDG negotiations is politics. SDG 16 was, and still is, seen as a threat to country sovereignty. Reporting on peace and violence is also complex for governments: fragile states often have weakened statistical capabilities and record keeping in times of conflict is difficult. Finally, a key challenge to achieving SDG 16 is time. Institutional change, resolution of conflicts and the upholding of what is just, fair and moral in accordance with the law all take time and go beyond the 2030 timeline. For instance, fast-moving countries take on average 27 years to bring corruption under reasonable control; while it has been estimated that it would take Haiti 600 years to achieve the institutional quality of Singapore.[4]

SDG 16 System



Cluster 2

Just societies

16.3 Promote the rule of law and ensure equal access to justice for all

16.5 Reduce corruption and bribery in all their forms

16.9 Provide legal identify for all, including birth registration

16.B Promote and enforce non-discriminatory policies for sustainable development

Cluster 1

Peaceful societies

16.1 Significantly reduce all forms of violence and related deaths everywhere

16.2 End abuse, trafficking, exploitation and all forms of violence and torture of children

16.A Strengthen relevant national institutions for building capacity at all levels

16.4 Reduce illicit financial & arms flows, recover stolen assets & combat organised crime

Cluster 3

Inclusive societies

16.6 Develop effective, accountable and transparent institutions at all levels

16.7 Ensure responsive, inclusive, participatory and representative decision making

16.8 Strengthen the participation of developing countries in global governance

16.10 Ensure public access to information and protect fundamental freedoms

The targets within SDG 16 closely interrelate. Societies will only be peaceful (Cluster 1) if they are just (Cluster 2) and inclusive (Cluster 3). Similarly, just and/or inclusive societies will only exist in peaceful and inclusive ones. For instance, peace is threatened in a society that socially excludes some of its citizens or that suffers pervasive corruption. The Gilets Jaunes movement in France is a recent example of a disfranchised tranche of a population who, through the use of social media, connected with each other and organised weekly, sometimes violent, protests for over six months.[5] On balance, France's strong institutions and rule of law prevented the escalation of violence and ensured continuity of social dialogue.

The role of digital technologies in delivering SDG 16

Digital technologies are fast becoming embedded in public institutions and organisations. They are contributing to more peaceful societies by monitoring online forums to identify child abuse and organised crime, and analysing public data to determine crime patterns and prevent future incidents or attacks.

Digital access is also contributing to just societies, by enabling the fast dissemination of information on bribery and corruption, and connecting individuals to low-cost, digitalised public services such as birth registration and legal advice. They also have an important role to play in the identification, collection, sharing, analysis and optimisation of data, which ensures transparency and accountability of societal actors.

Digital technologies are contributing to inclusive societies by ensuring instantaneous public access to information, and by changing the way public representatives and citizens interact, i.e. through social media, online performance rating platforms and online petitions.[6] As governments struggle to keep up with the speed of innovation, the ICT sector acts as a key partner to enable inclusive access to democracy and international cooperation.[7]

In addition to digital technologies, making real progress against SDG 16 will require the strengthening of regional collaboration between stakeholders to monitor and deliver the goal. It also will require companies to foster conditions that promote corporate social responsibility, good governance and transparency.[8]

Impact projections to 2030

By 2030, Target 16.9 aims to provide legal identity for all, including birth registration. The proportion of children under 5 years of age whose births have been registered with a civil authority currently sits at 73% globally. The figure is significantly lower for some developing countries, driven by barriers on both the supply and demand side:[9]

- On the supply side, there are often issues with administrative infrastructure and fragmented government departments across regions.
- On the demand side, there is a lack of awareness of the process, difficulties in getting to the office where the registration takes place, and in many cases parents' experience tells them that birth certificates are not required to access basic services, e.g. healthcare, education. This is backed up by analysis by UNICEF, which shows that rural populations are less likely to achieve universal birth registrations.[10]

In some countries, the proportion of children under 5 years of age with their births registered is still below 30%.[11] Mobile birth registrations could improve this, representing affordable solutions to capture birth registrations in remote, isolated and poor parts of the world. The GSMA reports that in the first six months of a mobile birth registration pilot in Tanzania, the birth registration rate increased from 9% to 30% in the region.[12] If all countries who currently have a birth registration rate of below 30% were to achieve this rate of registrations by 2030, that could mean an additional 11.6 million children have their births registered compared to the status quo.[13]

Importance of digital technology to target attainment

	TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1	**Peaceful Societies**		
🟩	**16.1** Significantly reduce all forms of violence and related death rates everywhere	Digital technologies such as predictive analytics, image recognition solutions and monitoring of communications metadata increase surveillance and targeting of offenders.	🔴 ↘
🟧	**16.2** End abuse, trafficking, exploitation and all forms of violence and torture of children	Digital technologies have created new mechanisms to report issues, enable greater supply chain transparency, as well as identify, monitor and remove illegal internet content and offenders.	🟠 →
🟧	**16.4** Reduce illicit financial & arms flows, recover stolen assets and combat organised crime	Digital technologies significantly increase the capability to detect arms flows through visualisation map tools. Additionally, they can reduce organised crime by providing the means to monitor large amounts of data and predict locations of crime.	N/A
⬜	**16.A** Strengthen relevant national institutions for building capacity at all levels	Whilst digital technologies facilitate greater advocacy for stronger national institutions, it is critically dependent on diplomatic efforts of national governments.	🟢 ↗
2	**Just Societies**		
🟧	**16.3** Promote the rule of law and ensure equal access to justice for all	Digital technologies provide greater access to legal information, legal expertise and representation. They enable remote communities to attend court remotely, identify bias in court decisions, analyse large amounts of jurisprudence and facilitate legal education everywhere in the world.	🟢 ↗
🟧	**16.5** Reduce corruption and bribery in all their forms	Reducing corruption and bribery will be largely enabled by digital technologies, through the identification of patterns and anomalies, biometric identification to prevent fictitious and fraudulent activities and promoting public procurement transparency.	🟠 →
🟩	**16.9** Provide legal identify for all, including birth registration	Digital technologies have a high impact on securing personal identities, for example by increasing birth registration rates and collecting and safely storing citizen's personal data.	N/A
⬜	**16.B** Promote and enforce non-discriminatory laws and policies for sustainable development	Digital technologies have limited scope to impact on policy promotion and enforcement.	N/A
3	**Inclusive Societies**		
🟧	**16.6** Develop effective, accountable and transparent institutions at all levels	Digital technologies enable the development of effective, accountable and transparent institutions by providing widespread access to information and allowing better monitoring of the efficiency of institutions.	🟢 ↗
🟧	**16.7** Ensure responsive, inclusive, participatory and representative decision making at all levels	Digital technologies are key to increasing data availability and accessibility, which in turn enables achievement of responsive, inclusive, participatory and representative decision making.	N/A
⬜	**16.8** Strengthen the participation of developing countries in global governance	Digital technologies are leveraged by developing countries' representatives to remotely participate in the institutions of global governance. However, this is largely an issue of cross-border interaction and collaboration.	🟠 →
🟩	**16.10** Ensure public access to information and protect fundamental freedoms	Public access to information, whilst dependent on institutional transparency, is supported by increased access to the internet. Digital technologies also support protection of fundamental freedoms of vulnerable populations such as human rights defenders and abuse victims.	🟢 ↗ *

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

- 🟩 High impact
- 🟧 Moderate impact
- ⬜ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

- 🟢 Positive progress
- 🟠 Limited progress
- 🔴 Negative progress

*While public access to information has increased, another key indicator for this target, journalist and media killings, has increased.

Cluster 1

Peaceful Societies

Since 2005, there has been a rise in the number and intensity of armed conflicts.[14] Violence in 2018 cost $14.1 trillion in purchasing power terms, or 11.2% of world GDP.[15] Digital technologies help people connect with each other across borders and understand different perspectives, a powerful tool for peacebuilding activities.[16] With increasingly efficient surveillance and tracking capabilities and warfare technologies that remove humans from the battlefield, digital technologies have the potential to help prevent conflicts and lessen their consequences, if used responsibly.

More than 570 different flows involving human trafficking were detected between 2012 and 2014, across all regions; many involving movement from lower-income to higher-income countries.[17] Technology solutions such as visualisation mapping of these flows and tracking solutions of victims and perpetrators assist in reducing instances of trafficking. Blockchain and IoT technologies ensure traceability across a supply chain from sourcing of raw materials, such as lithium, to end product. The exploitation of children and trafficking is identified through the transparent and auditable features of blockchain to ensure that codes of conduct and human rights are respected along the chain.[18]

Children are vulnerable stakeholders and the impact of digital technologies on them should be carefully considered. Children represent one in three internet users globally, with 800 million using social media; and any one of them could become a victim of cyber violence.[19] However, digital technologies can also be employed to combat these challenges, for example, enabling instances of child online sexual abuse to be reported using cyber platforms and tip lines for law enforcement agencies.

To ensure technology solutions help achieve peace-related targets, robust safeguards need to be put in place to ensure data privacy and security. Furthermore, international standards should be created to guide the ideation, design, testing, deployment and implementation of technology solutions. It is also dependent on achievement of just and inclusive targets, without which peace cannot exist or be sustained.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Online training tools raise awareness about the exploitation of people Digital learning tools can be used to raise awareness and educate organisations on human trafficking.	**Example:** Microsoft developed an online training tool in collaboration with End Human Trafficking Now and UN.GIFT. The tool helps organisations understand what human trafficking is, identify incidents of it, and point to actions they are able to take to address this risk.[20]	Cognitive Cognitive	Importance to SDG Role of digital technologies Scalability
Teaching digital literacy can encourage children to connect with society to reduce the chance of radicalisation Access to digital technologies helps prevent social exclusion and radicalisation of youth by connecting people together, creating online communities and a sense of shared purpose.	**Example:** Ericsson partnered with international organisation to provide digital technologies training that helps youth stay connected, share their experiences and actively contribute to society. The programme operates in South Sudan, Uganda and Mexico.[21]	Digital Access	Importance to SDG Role of digital technologies Scalability
Online platforms connect sufferers of human rights violations with support and information Digital technologies such as mobile applications and online platforms create accessible and safe digital platform for victims and citizens to report all forms of violence.	**Example:** A digital platform in Malawi promotes and supports human rights to reduce violence against women and end child marriage. Citizens are able to report human rights violations and abuse using SMS, web and social media and are linked directly with relevant service providers such as lawyers, victim support or community groups. It also provides information on human rights issues including LGBTI and domestic violence to allow users to recognise when rights are being violated.[22]	Digital Access	Importance to SDG Role of digital technologies Scalability
Digital technologies bolster inter-agency collaboration Sharing of knowledge and collaboration between law enforcement agencies has been vastly improved through the use of digital technologies. This has strengthened the fight against child exploitation and abuse.	**Example:** Microsoft has collaborated with a law enforcement agency in a North American country to design a tracking system for investigators to share, search and collaborate on matters of child exploitation.[23]	Digital Access IoT	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Cloud technology and analytics enable tracking of child abuse Digital technologies such as deep analytics and image recognition software are used to collect timelier / better information to make arrests and stop perpetrators of all forms of violence against children online.	**Example:** Microsoft developed a tool using image-matching technology to help find, report and eliminate some of the worst known images of child pornography online. The technology was made freely available to law enforcement to assist child sex abuse investigations. Its integration into a collaborative global law enforcement programme helps law enforcement agencies follow hundreds of suspects at a time and eliminate duplication. This makes it more efficient for the agencies to follow up on leads, collect evidence and build cases against suspected child pornography watchers.[24]	Cloud Cognitive	Importance to SDG Role of digital technologies Scalability
Collecting and analysing crowdsourced data can detect child labour Digital technologies such as smart phone or mobile applications enable interaction and engagement with the local community and workers. This increases understanding of the local context and labour conditions, including whether the exploitation of children is prevalent.	**Example:** Tony Chocolonely's aim is to eradicate slavery and any exploitation of children in its supply chain. It has a platform called BeanTracker that connects farmers and all supply chain actors, who enter data on a weekly basis.[25] Social data is then analysed to understand where child labour is taking place and forms part of the company's efforts for a transparent supply chain from "bean to bar".	Cognitive Blockchain IoT	Importance to SDG Role of digital technologies Scalability
Digital technologies enable the detection and control of counterfeit products Technology solutions are used to identify and track counterfeit goods and products of organised crime. It raises consumers' awareness and supports law enforcement's efforts to tackle the black market by collecting this data.	**Example:** Sproxil developed a mobile product authentication solution that enables consumers to verify that the pharmaceutical product they are buying is genuine. Such technology solutions support law enforcement by mitigating the impact of counterfeit drugs which have led to a significant number of deaths globally.[26]	Digital Access IoT	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AI can predict the future security requirements of communities The optimisation of data collection and analysis coupled with AI capabilities to determine patterns out of unstructured data allows for the identification of future security trends and needs.	**Example:** Elva Community Engagement is a platform that allows organisations to map local needs and advocate change. They can collect data on local conflict trends and security needs, even from the most remote locations, to accurately study trends as they evolve over time. [27]	Digital Access Cognitive	Importance to SDG Role of digital technologies Scalability
Big data analysis can accurately predict incidences of crime Big data can be collected and analysed using AI capabilities to identify patterns and make predictions. This can be used to predict future conflicts, and inform policymaking and community outreach in at-risk areas to reduce instances of violence.	**Example:** Law enforcement agencies in the USA are using big data to identify patterns in data from 911 calls, closed circuit cameras and crime reports to stop crime before it happens.[28]	Cognitive Digital Reality	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Augment & Autonomate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Immersive experiences allow people to empathise with those from different backgrounds to facilitate peacemaking Immersive experiences are designed with the aim to influence the decision making of users by raising awareness about particular issues and causing an emotional response to the experience.	**Example:** A virtual reality portal lets participants immerse themselves in Germany, Afghanistan, Iraq or Mexico to interact with young peacebuilders.[29] The aim of this portal is to connect people from different backgrounds so they can better understand each other and create a peaceful dialogue.	Digital Reality	Importance to SDG Role of digital technologies Scalability
Autonomous surveillance machines can increase safety and security Self-driving autonomous robots can constantly patrol areas otherwise not attended, or attended but with mixed security outcomes. With potential features including recording, movement and heat sensor capabilities, they are more efficient than humans can ever be on their own.	**Example:** Knightscope designed and deployed an autonomous self-driving robot that can patrol areas 24/7. A client who recorded 20 incidents per month before deploying the technology reported one incident in the last 12 months since the robot started patrolling.[30]	Cognitive IoT	Importance to SDG Role of digital technologies Scalability

> **With increasingly efficient surveillance and tracking capabilities, and warfare technologies that remove humans from the battlefield, digital technologies have the potential to help prevent conflicts and lessen their consequences, if used responsibly.**

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 2

Just Societies

An estimated 5.1 billion people worldwide – two thirds of the world's population – continue to live outside the protection of the law. [31] There has been slow progress with respect to the rule of law and access to justice, particularly the ability of judicial systems to efficiently process and try the accused.[32] Since 2003, roughly one third of the world's annual prison population has been held without sentencing. Digital technologies present the opportunity to process and analyse large data sets to help decision making, increase efficiencies of the judicial system and enable legal empowerment.[33]

Bribery and corruption are present in every country in the world and cost approximately $1.5 to $2 trillion per year. [34] Bribery and corruption impede business growth, raise transaction costs and distort the playing field; this in turn creates social instability, fuels mistrust in public officials and institutions, and undermines the rule of law. Digital technologies such as blockchain, data analytics and digital platforms educate people on bribery and corruption and can be deployed to analyse transactions and user interactions to identify red flags suggestive of misconduct.

Birth registration rates are lowest amongst children living in rural areas and highest amongst the richest 20% of the population.[35] Globally, as of 2018, 73% of children under 5 have had their births registered. This number has significantly increased since 2016 when it was only one in four.[36] This is largely as a result of the use of mobile technology to make birth registration accessible to everyone no matter where they live. However, there are still large challenges; the proportion of birth registrations of children in sub-Saharan Africa is 46%, down from 54% in 2016.[37]

Companies have an increasingly important role to play in shaping just societies. However, digital technology solutions designed and used by companies will only work if they are paired with a shift in culture and justice enforcement methods. For example, impunity and lacking investigative resources are clear drivers of corruption and bribery practices. If there is no robust governance at the company level, nor sufficient enforcement at the policy level, the impact of digital technologies will be limited.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Online portals improve access to legal services Digital technologies enable legal service information to be consolidated in one database and made available to the public.	**Example:** Microsoft, Legal Services Corporation and Pro Bono Net have created an online portal to connect low-income people to legal service providers and information on the national justice system. The aim is to simplify the justice process by providing a single, global point of access to assist people needing civil legal assistance.[38]	Digital Access Cloud	Importance to SDG Role of digital technologies Scalability
Mobile birth registration improves reach of birth registration services Mobile phones and apps allow families to register births remotely, saving travel time and making unconnected families aware of the importance of birth registration.	**Example:** UNICEF, the Pakistani government and Telenor developed a mobile app that local authorities and facilitators use to offer birth registrations to rural and remote communities. The app is used in both door-to-door registration drives and by Digital Birth Registration franchises (where local facilitators register children on behalf of families). A pilot of the project increased the rate of birth registration from 30% to 90% in the trial area. By optimising the process of birth registration, the project aims to improve citizen access to government services, increase health awareness through mobile-health (mHealth) services, and facilitate the government manage citizens' data to better plan for social services such as education.[39]	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Digital identity systems secure individuals' rights and provide access to public services As the private and public sector increasingly move into the digital space, individuals need to be able to prove their identity to access essential benefits and services via digital platforms. The design and implementation of a digital identity system can be guided step-by-step and scaled across countries thanks to digital platforms that ensure information remains relevant, up-to-date, available and accessible.	**Example:** The ITU has launched the Digital Identity for Development initiative, which assists member countries in understanding existing practices of digital identity and beginning the process of developing a national digital identification system of their own. As part of this initiative, the ITU has developed a Digital Identity Roadmap guide which provides guidance on developing a digital identity system.[40]	Digital Access Cognitive	Importance to SDG Role of digital technologies Scalability
Digital platforms facilitate cross-organisational collaboration over justice issues Digital platforms provide an effective medium for experts to discuss and advise on major issues.	**Example:** Increased government attention on internet governance and policy because of privacy and civil rights concerns led to the setup of an NGO – Global Network Initiative ('GNI') - with ICT companies as members. When innovative products arrive on the market, their design and use is often unregulated. This panel of experts can help ensure they are created and used responsibly.[41]	Digital Access	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Storage of biometric data will reduce fraud within government organisations Fictitious public services positions cost money to governments. A solution is to integrate biometric data for each employee in the identification system. This minimises the number fictitious public service positons.	**Example:** In Guinea, for the first time since the country gained independence in 1958, a register enrolled all of Guinea's employed civil servants in 2015 by implementing a biometric identification system to conduct a census of civil servants to eliminate fictitious or fraudulent positions and potentially save more than 1.7 million dollars through the discontinuation of salary payments.[42]	Digital Access	Importance to SDG Role of digital technologies Scalability
Blockchain improves voting engagement Blockchain technology can be applied to public services and online voting, providing a secure method of voting online.	**Example:** Voatz is a mobile platform that allows citizens to participate in elections via their mobile phone. The system leverages security and identity verification technology built into the latest smartphones and the immutability of blockchain.[43]	Fast Internet / 5G Blockchain	Importance to SDG Role of digital technologies Scalability
Digital technologies promote transparency and accountability in public procurement Digital technologies secure and optimise processes to reduce corruption and bribery at risk points such as project planning, documentation tender process, contract awards, accounting and auditing. Digital technologies limit the opportunities for deliberate human interaction and intervention.[44]	**Example:** Results from 50 countries' digital procurement technology performance show that the transparency and accountability are the most effective deterrents of corruption in public procurement.[45]	Digital Access IoT Cognitive	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
AI can detect patterns indicative of bribery AI can analyse unstructured data to identify patterns and anomalies, which indicates red flags that are suggestive of bribery and corruption.	**Example:** In Brazil, suspicious patterns of interactions between public service providers and users were uncovered using data analytics. Data was gathered from mobile surveys gleaning patient feedback and combined with administrative data from hospital services. While bribery data collected through mobile phones offered inconclusive results, administrative data was used effectively to identify corruption red flags.[46]	Cognitive	Importance to SDG Role of digital technologies Scalability

Lower 🟦🟦🟦🟦🟦 Higher

Cluster 3

Inclusive Societies

The 2030 Agenda is based on the principle of *leaving no one behind*. Digital technologies are used to achieve greater inclusiveness in societies by, for instance, increasing digital access for the most vulnerable and remotely located citizens. A balanced approach is needed, however, to ensure that the people who remain unconnected are not left behind.

Inclusive societies include achieving protection of the most fundamental freedoms and public access to information. Despite the enactment of freedom of information laws and policies by 125 countries in total, including 31 since 2013, implementation remains a challenge.[47] It is also estimated that at least 1,019 human rights defenders, journalists and trade unionists have been killed in 61 countries since 2015.[48] Used responsibly, digital technologies assist human rights defenders and journalists to share information in real time, shedding light on human rights violations and protecting free expression.[49]

As processes and systems are optimised and automated, human deficiencies can be retained or even amplified. However, with adequate risk controls and ethical safeguards in place, digital technologies have the potential to transcend human bias and dogmas that afflict globalised human interactions.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Online portals provide platforms to connect governments and their citizens Digital technologies such as online portals and mobile applications enable direct engagement between government and citizens. Governments can share data relevant to constituents who are in turn able to provide direct feedback on public services.	**Example:** Since 2008, Armenian citizens have been able to access an online database that contains all government court cases and spending in an easily downloadable, open data format, with a smart search capability. The portal is user friendly with simple language, images and infographics to encourage citizen participation in public services.[50]	Digital Access	Importance to SDG Role of digital technologies Scalability
Public databases allow citizens to engage with constitutional frameworks Digital technologies such as online platforms, mobile applications and smart search databases increase citizens' access to legal information. This means that people are able to easily search for legal information on matters that concern them or their situation and make adequate decisions, or reach out to legal professionals for more guidance as necessary.	**Example:** Constitute is a database established by Google and researchers from multiple universities that offers public online access to the world's constitutions. The project, which is particularly aimed at individuals concerned with constitutional drafting, increases transparency of legal frameworks by enabling users to systematically compare constitutions across a broad set of topics and interact with the world's constitutions in various ways.[51]	Digital Access Cloud	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital technologies can reduce vulnerabilities during humanitarian crises Digital technologies can be deployed in situation of crisis to alleviate particular vulnerabilities such as gender, age and/or refugee status and increase efficiencies of aid relief.	**Example:** Corporates and the United Nations High Commissioner for Refugees partnered to design and deploy a registration system for refugees, many of whom had been stripped of all identification documents. The data gathered was used in the distribution of aid and assisted in searching for and reuniting separated families. It has since been further developed and deployed in several countries in Asia and Africa.[52]	Digital Access	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Big data and AI can improve refugees' living conditions Big data and AI technologies are used to understand refugees' numbers in a country/region and how best to respond to their most pressing needs.	**Example:** Turk Telekom created a big data challenge in 2018. It opened a large dataset of anonymised mobile phone usage to researcher groups to provide better living conditions to Syrian refugees in Turkey. The premise was to understand refugee movements and help authorities provide better conditions to more than 3.5 million Syrian refugees in Turkey. This challenge was aided by AI technology, which processed the huge swathes of data. Turk Telekom partnered with non-profit organisations and governments to guarantee the sustainability of the proposed solutions.	Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Interactions with other SDGs

SDG 16 interacts with other SDGs, namely 1, 4, 5, 8, 10, 11, 13 and 15. For instance, the consequences of climate change, covered by SDG 13, include deaths, forced displacement of population and scarcity of resources available. These consequences increase people's vulnerability to human rights violations and can increase the risk of social exclusion and conflicts.[53]

SDG 16 also acts as an enabler of the other SDGs. Peaceful societies promote inclusivity in society (SDG 10) and the reduction of civil violence will help ensure the equal treatment of women (SDG 5).[54] Tackling violent crime also has knock-on economic benefits, including improving trade and commercial relationships, and protecting workers and their property (SDG 8).[55]

Just societies improve citizens' quality of life and have benefits for the economy and poverty, too. Ending corruption, for instance, is a driver for reducing extreme poverty (SDG 1) and boosting prosperity for the poorest 40% of people in developing countries (SDG 10).[56] This is partly explained by the fact that corruption disproportionately affects the poor and most vulnerable. Generally the poor pay a larger proportion of their income in bribes; in Paraguay, bribery payments represent 12.6% of low-income households' incomes compared to 6.4% for high-income households.[57] Corruption also impacts SDG 8 as it raises the cost of doing business (by 10.9% of transaction value and 34.5% of profits on average), distorts investments (the probability of foreign investment is 15% lower in countries with a strong presence of corruption), and deprives the public sector of revenues (customs related corruption costs $2 billion in revenue each year, and for tax evasion, 30 countries have identified additional potential revenue totalling over €48 billion over the past seven years).[58]

In some countries, the proportion of children under five years of age with their births registered is still below 30%. Mobile birth registrations could improve this, representing affordable solutions to capture birth registrations in remote, isolated, and poor parts of the world.

Negative externalities

Impact of widespread use of digital technologies on achievement of SDG 16

Cyber attacks: Digital technologies are driving and transforming conflict. National security is threatened by cyber attacks that create digital insecurity and cyber vulnerability. In practical terms, the distributed and decentralised nature of the internet means that systemic cyber meltdowns, such as the one that took down Ukraine's power grid from a Russian attack in 2015, can cause violation of the most basic human rights to life, liberty and security of person.[59] In addition, cyber security is a growing issue with state and non-state actors using it to strike others.

Digitally enhanced warfare: Digital technologies have enabled the creation of fully autonomous weapons that are able to select and engage targets without human intervention.[60] These weapons are not yet regulated by international conventions and ethical ramifications of their use has given rise to a global campaign to ban them.[61] Furthermore, any individual now has the ability to produce weapons due to the widespread availability of information on the internet and digitally-enabled technologies such as 3D printing.[62] Finally, through online platforms, extremist organisations and insurgencies are able to recruit and disseminate messages of radicalisation.

Breach of data privacy: Citizens create a large amount of data, which they don't really own or control, through their use of digital applications such as social media, mobile banking, cloud and location-based apps. Unauthorised access to this data may lead to it being used against its 'owner' through illegal surveillance, the publication of 'revenge pornography' and/or tracking partner or ex-partner through GPS or banking applications. Furthermore, digital technologies are being deployed as weapons against data privacy. In China, the rise of cyber repression through mass surveillance, censorship and social monitoring threatens the fundamental rights of its citizens.[63] Data privacy and security are growing concerns and various jurisdictions are enacting regulations to protect citizens' data. The cross-border nature of cyber threats means that greater collaboration across countries is required to adequately respond to data security issues.

Fake news: Digital technologies have enabled unprecedented data accessibility. They have also provided platforms that allow any citizen to become a content creator. This has led to unintended consequences including the dilution of quality information and the expansion of the scale and reach of fictitious content. This has been used to influence decision making during political elections, which undermines democracy.

Systematic bias: Human bias is translating into AI bias, threatening progress towards just and inclusive societies. Bias and discrimination are not novel issues. However, as processes, systems and decision making are optimised and sometimes autonomated, there is a risk that bias and discrimination held by human designers, whether subconsciously or with intention, will be fed into the technology solution.[64]

Impact of using digital technologies to achieve SDG 16

Freedom of speech: Digital technologies have enabled the monitoring of social media platform interactions and content to ensure hate speech and speech that promotes violence are removed. However, this is a potential threat to freedom of speech. People from different cultures and backgrounds will interpret content in various ways, reporting content as offensive depending on the dogmas, e.g. religious and political, that they adhere to.

Sensitive data leaks: Online portals and digital grievance mechanisms bring positive outcomes, e.g. support and protection to victims of violence, human rights defenders, and whistle-blowers. However, this type of data is sensitive and data leaks may lead to serious reprisal against the reporting person. This is particularly true in jurisdictions with weak protection of data privacy, where the government has the right to demand access to this data or where 'backdoors' to the technology were designed for that purpose.

Crossing the public sector boundary: Digital technologies can be used to drive progress against SDG 16. However, companies acting in the realm of SDG 16, e.g. tracking and trying to respond to crime, run the risk of crossing into domains that are the exclusive remit of government. This endangers the line of separation between public and private sectors, which are important for well-functioning democracies and partnerships.[65]

17 PARTNERSHIPS FOR THE GOALS

SDG 17 DEEP DIVE

Partnerships for the Goals

Sustainable Development Goal 17 calls for strengthening the means of implementing Agenda 2030 and in particular to revitalise the global partnership for realising sustainable development all over the world. SDG 17 highlights the need to strengthen partnerships between government, the private sector, and civil society and to increase international cooperation to leverage the interlinkages between SDGs and accelerating progress towards all goals. It additionally requires enhanced coherence between domestic and international policies and initiatives. SDG 17 aims to mobilise both existing and additional resources including technology development, financial resources, capacity building and global trade. Finally, SDG 17 calls for a strong impact measurement system; a system that can be used to quantify progress against the SDGs and that can be used to identify interventions to catalyse further development.

During the formal adoption of the 2030 Agenda, Ban Ki-Moon called for all actors to engage in fulfilling the Agenda He stated: “we must rally businesses and entrepreneurs. We must involve civil society in defining and implementing policies – and give it the space to hold us to account. We must listen to scientists and academia. We will need to embrace a data revolution. Most important, we must set to work – now.”[1] Without the system-level co-ordination called for by SDG 17, the progress of the entire SDG Agenda is stymied.

Clusters within SDG 17 define the enabling conditions for global sustainable development on both an international and domestic level. Access to technology (Cluster 1) will be a necessary input to ensure sustainable progress and innovation. Similarly, providing the finance and resources for sustainable development (Cluster 2), along with capacity building (Cluster 3), will promote the growth and development of all SDGs. Policy coherence (Cluster 4) along with global trade facilitation (Cluster 5) constitute the blocks on which sustainable development can be built. Lastly, the foundations of SDG 17 are multi-stakeholder partnerships (MSPs) and international cooperation (Cluster 6), and the accurate monitoring and appropriate measurement (Cluster 7) of the 2030 Agenda attainment. Cluster 6 and 7 will act as enablers to take action and improve progress for the SDGs.

SDG 17 System

SUSTAINABLE DEVELOPMENT GOALS

Cluster 1

Innovation infrastructure for sustainable development

17.6 Enhance North-South, South-South and triangular cooperation on access to ST&IIs*

17.7 Develop & transfer environmentally sound technologies to developing countries

17.8 Fully operationalise the ST&I capacity building for LDCs*, and improve use of ICT

Cluster 2

Finance for sustainable development

17.1 Improve domestic capacity for tax and other revenue collection

17.2 Developed companies to fully implement their ODA commitments

17.3 Mobilise additional financial resources for developing countries from multiple sources

17.4 Assist developing countries in debt sustainability through co-ordinated policies

17.5 Adopt and implement investment promotion regimes for least-developed countries

Cluster 3

Capacity building for sustainable development

17.9 Enhance international support for targeted capacity building in developing countries

Cluster 4

Enhance policy coherence for sustainable development and economic stability

17.13 Enhance global macroeconomic stability through policy coordination

17.14 Enhance policy coherence for sustainable development

17.5 Respect each country's poverty eradication and sustainable development policies

Cluster 5

Improve global trade and market access

17.10 Promote a universal, rules-based and open trading system under the WTO

17.11 Significantly increase the exports of developing countries, especially LDCs

17.12 Implement duty-free and quota-free market access on a lasting basis for all LDCs

Cluster 6

Promote partnerships for sustainable development

17.16 Enhance global and multi-stakeholder partnerships for sustainable development

17.17 Encourage & promote effective, public, public-private and civil society partnerships

Cluster 7

Enhance data and monitoring of progress to sustainable development

17.18 Support developing countries to increase the availability of high-quality data

17.19 Build on existing initiatives to develop progress measures for sustainable development

The role of digital technologies in delivering SDG 17

Digital technologies enable the achievement of SDG 17. Even though targets within SDG 17 are oriented to policy and financial aid, and require a wide mobilisation of parties and resources for their success, they have much scope for being supported by digital technologies.

Through digital access and the cloud, it is possible to share and exchange knowledge, facilitating the transfer of science, technology and innovation across the world. Digital technologies make tools, approaches, data and information available to a variety of interested stakeholders. Similarly, through digital marketplaces and digital transactions, financial capital and resources can be transferred, monitored and invested with greater ease. Additionally, digital access enables connection and collaboration between stakeholders, and allows the formulation of partnerships and multi-stakeholder engagements previously not possible.

Finally, digital technologies enable the collection, storage and analysis of sustainability related data from both public and private parties. Cloud and analytics can be used to produce valuable insights based on progress indicators against each SDG, and to share each conclusion as a progress identifier, and an actionable next step for improvement.

Importance of digital technology to target attainment

		TARGET PRIORITISATION	INFLUENCE OF DIGITAL TECHNOLOGIES ON THE TARGETS	PROGRESS MARKER
1		**Innovation infrastructure for sustainable development**		
	🟧	**17.6** Enhance North-South, South-South and triangular cooperation on access to science, technology and innovation	Digital technologies and digital access will have great impact facilitating the sharing and exchanging of knowledge and information cross-border, along with governmental and non-governmental cooperation and effective coordination.	↗
	🟧	**17.7** Develop and transfer environmentally sound technologies to developing countries	Digital technologies will be key in developing, transferring, disseminating and diffusing environmentally sound technologies to developing countries by making technologies widely available and equitably accessible, but will need to be supported by international policies.	NA
	🟧	**17.8** Fully operationalise the ST&I capacity building for LDCs, and improve use of ICT	Digital technologies will fundamentally democratise technology access. Universal access to ICT will additionally depend on national and regional cooperation and infrastructure installation.	↗
2		**Finance for sustainable development**		
	🟧	**17.1** Improve domestic capacity for tax and other revenue collection	Digital technologies enable improved tax administration at the national level, improving governmental control over revenue collection.	↗
	⬜	**17.2** Developed companies to fully implement their ODA commitments	Net official development assistance commitments will need to be met fully as instructed by policy with little direct impact from digital technologies.	→
	🟧	**17.3** Mobilise additional financial resources for developing countries from multiple sources	Digital technologies enable the creation of an attractive investing environment to direct investment and facilitate capital flow to and from developing countries.	↗
	⬜	**17.4** Assist developing countries in debt sustainability through co-ordinated policies	Debt management policies will be key in attaining debt sustainability and digital technologies have little direct impact in structuring appropriate policies around debt management and financing.	↘
	⬜	**17.5** Adopt and implement investment promotion regimes for least-developed countries	Improving investment promotion regimes will primarily rely on policy and digital technologies will have little direct role.	NA

3		**Capacity for sustainable development**		
	▨	**17.9** Enhance international support for targeted capacity building in developing countries	Aid and funding will play the most important role in enhancing capacity-building in developing countries; digital technologies contribution is likely to be indirect and limited.	🟠→
4		**Enhance policy coherence for sustainable development & economic stability**		
	▨	**17.13** Enhance global macroeconomic stability through policy coordination	Policy and institutional coherence will be developed systemically through national mechanisms and frameworks, with little input from digital technologies.	NA
	▨	**17.14** Enhance policy coherence for sustainable development		NA
	▨	**17.15** Respect each country's poverty eradication and sustainable development policies		NA
5		**Improve global trade and market access**		
	▨	**17.10** Promote a universal, rules-based and open trading system under the WTO	Even though digital technologies can facilitate to some extent the relationships and transactions existing in a trading system, the creation of a universal, rules-based and open trading system will mostly depend on the uniformity of policies under WTO frameworks.	NA
	▨	**17.11** Significantly increase the exports of developing countries, especially LDCs	Even though digital technologies may to some extent support the creation of a trading network, facilitate financial transactions and monitor supply chains, they will have limited impact in directly increasing the exports of developing countries.	🟢↗
	▨	**17.12** Implement duty-free and quota-free market access on a lasting basis for all LDCs	Regulating tariffs and market access across the world will be mainly realised through trade rules, and digital technologies will have little impact to their establishment.	NA
6		**Promote multi-stakeholder partnerships for sustainable development**		
	🟧	**17.16** Enhance global and multi-stakeholder partnerships for sustainable development	Digital technologies will have an impact in the forging of multi-stakeholder partnerships and in facilitating the sharing of knowledge and expertise through digitally accessible platforms.	NA
	🟧	**17.17** Encourage and promote effective, public, public-private and civil society partnerships	Digital technologies will enable the creation of effective public-private partnerships by building networks and digital marketplaces.	NA
7		**Enhance data and monitoring of progress to sustainable development**		
	🟩	**17.18** Support developing countries to increase the availability of high-quality data	Digital technologies will have a significant impact in facilitating the wide and equitable availability of high-quality data through digital access and cloud technologies.	🟢↗
	🟩	**17.19** Build on existing initiatives to develop progress measures for sustainable development	Digital technologies can catalytically enable the development of progress measurements by supporting monitoring and analytical capabilities.	🟠→

IMPACT OF DIGITAL TECHNOLOGY ON THE TARGET

🟩 High impact
🟧 Moderate impact
▨ Limited impact

PROGRESS OF THE TARGET

The colour of the marker indicates whether positive, limited or negative progress has been made towards the SDG target.

The direction of the arrow indicates the direction of recent trends in relevant SDG target indicator data.

N/A denotes that progress data is either unavailable or not recorded for these targets.

🟢 Positive progress
🟠 Limited progress
🔴 Negative progress

Cluster 1

Innovation infrastructure for sustainable development

As economies become more globally integrated, businesses and countries increasingly trade and interact internationally. Access to technology is critical for supporting local innovation to realise local competitive advantages. Technology transfer provides developing countries the opportunity to adopt the most productive technological advancements, helping to accelerate growth, productivity and welfare.

As of 2018, more than half the world's population had access to the internet, although this varied considerably by geography.[2] Over 80% in developed countries were online in 2018, compared with 45% in developing countries and only 20% in the least-developed countries.[3] In 2016, high-speed fixed broadband penetration reached 6% of the population in developing countries, compared to 24% in developed countries.[4] Limitations in the capacity and speed of connectivity may hinder the full utilisation of the potential benefits for the 2030 Agenda.

Through digital technologies, technological knowledge and innovation practices can be transferred more easily. Through the creation of digital platforms, it is possible to create a comprehensive repository of information and data, existing science, technology and innovation initiatives, to facilitate access to information and experience and facilitate the dissemination of relevant open access scientific research worldwide.[5] Digital technologies also have the capacity to promote synergies and cooperation in the delivery of technology-related technical advice and capacity building, while potentially allowing for the creation of new knowledge and approaches.[6]

However, while digital technologies have the capability to contribute to cooperation and access, effective deployment of digital technologies still relies on many other factors. Governmental and private sector cooperation is required to develop road maps for each individual country's future state, given their current capabilities. Significant consideration needs to be applied to national innovation systems, governance, regulatory environments and the precise value proposition of available technology solutions. Through relationships among key stakeholders, a deep, systemic understanding of the potential wider impacts of each technology and innovation needs to be acquired in order to build market-ready, shareable technology solutions.[7]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digitally accessible information to strengthen technology transfer and access to knowledge Open platforms can connect people and institutions with research, innovation, projects, and studies, empowering access to technology. Through digital access and the cloud, the capability exists to store and access any type of information ranging from books, statistical surveys to genetic information, making research and innovation an accessible reality to interested stakeholders.	**Example** E-lucid is an online marketplace built by University College of London with the purpose of transacting and sharing lower value IP licences. Through the web portal it allows academic technology transfer between universities and other parties, as well as the introduction of new technologies and projects to the wider scientific community.[8]	Digital Access Cloud	Importance to SDG Role of digital technologies Scalability

Lower ▨ ▨ ▨ ▨ ▨ Higher

Cluster 2

Finance for sustainable development

The achievement of the 2030 Agenda relies on a sustainable financial system which will support a global transition toward sustainable development. For this reason, an integrated approach between all financial sector stakeholders is necessary. Financial cohesiveness across public and private financial sector participants will substantially influence the mobilisation of financial resources and direction of national and international initiatives with the purpose of achieving true, global sustainability.[9]

Allocation of financial resources for sustainable development is a key theme for SDG 17. Currently, net ODA[10] flows totalled $149 billion in 2018, down 2.7% in real terms from 2017,[11] with a declining share going to the neediest countries. Similarly, humanitarian aid fell by 8%.[12] In 2012, $1.3 trillion in aid, investment and income from abroad flowed into developing countries, while simultaneously $3.3 trillion, flowed out through interest payments on foreign debt, foreign investment, repatriated income and capital flight.[13] However, notwithstanding recent falls, ODA has increased by 66% in real terms since 2000.[14]

Digital technologies facilitate the increased collection and movement of capital between stakeholders. Through the creation of online platforms for tax collection, governments are able to increase domestic revenues and allow better administrative management of tax affairs. At the same time, technology plays a significant role in motivating investments on a global scale as well as facilitating FDI[15] and M&A activities. The movement of capital across jurisdictions and geographies is increasingly becoming more dependent on digital innovation.

However, in all cases, financing decisions either at the public or private level are influenced by national policy frameworks and the international financial architecture, the effectiveness of global and national financing institutions, and the design and development of instruments to facilitate and help overcome blockers to investment in sustainable development.[16]

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digitalisation of tax systems to create more efficient processes Digital tax records and accessible tax management systems have the capacity to reduce the amount of error on all tax levels, and streamline citizen engagement and subsequently, revenue collection. The creation of a digital tax repository and tax platform makes tax allocation more effective, incentivises citizen compliance, and reduces error.	**Example:** HMRC, the UK's government department in charge of tax collection, aims to become a fully digitally advanced tax administration through its Making Tax Digital initiative. Making Tax Digital requires all tax records to be stored, accessed and edited digitally, while tax requirements (such as VAT returns) to be submitted through software. The new digitalisation of the tax system aims to make tax administration more effective, efficient and easier to use.[17]	Digital Access Cloud	Importance to SDG Role of digital technologies Scalability

Monitor & Track

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Blockchain technology enables faster, cheaper and more secure remittances Migrants' remittances represent one of the most important financial flows for developing countries. As online cross-border credit transfers have risen in the last decade, along with interbank transactions and corporate payments, blockchain technology will transform the payments industry, speeding up transactions and reducing their costs.	**Example:** BitPesa is an African blockchain-based money remittance company, established in Kenya, and currently active in Nigeria, Tanzania, and Uganda. It was able to remove correspondent banks from the transaction chain relying on Bitcoin transfer and digital brokers who deposit the money in the currency of the receiving country. BitPesa's remittances take up to 93% less time, and cost 90% less than traditional method.[18]	Digital Access Blockchain	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Cluster 6

Promote partnerships for sustainable development

The 2030 Agenda signifies a stronger focus on the multi-stakeholder partnership paradigm. The partnership governance model embraces a voluntary rather than legally-binding, and responsibility-based rather than commitment-based, form of partnership approach between public and private sector.[19] This is a shift from a model where public-private partnerships exist solely for harnessing investment,[20] into a format built for inclusiveness, knowledge sharing and development.

MSPs often entail complex governance structures and processes, and are perceived as having a catalytic role in the attainment of the 2030 Agenda.[21] MSPs are a form of institutionalised partnership between public, private and civil society actors with the aim of advancing the principles and action points embodied in the SDGs. In the spirit of SDG 17, these partnerships can be expected to involve international cooperation and coordination. MSPs have a unique position on the 2030 Agenda as they can act where governmental regulation or initiative is missing, widen participation and inclusiveness in collective initiatives, treat issues with increased flexibility and adaptability cutting across regions, sectors, and interest groups, and therefore present an answer to the challenges met by traditional forms of governance hindering SDG progress.[22] MSPs can also be instrumental in mobilising, redirecting, and unlocking the transformative power of private resources to deliver sustainable development.[23]

As Amin J. Mohammed, UN Deputy Secretary-General, highlighted "governments alone cannot achieve the SDGs. [...] Only partnerships can drive inclusive implementation of the Goals".[24] Organisations, such as the UN's Global Compact,[25] bring together the calls to action and the principles behind all SDGs, inspiring stakeholder commitment to implement universal sustainability and take steps to support the SDGs. MSPs can be created to directly support a specific aspect of the biosphere, society and economy. Humanitarian organisations, such as the Committee on World Food Security[26] (reporting to the UN General Assembly and FAO), are supporting the development of prosperous, safe and healthy societies (SDG 1, SDG 2), while others such as the Marrakech Partnership for Global Climate Action,[27] serve environmental purposes advocating against climate change (SDG 13).

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digital platform to connect stakeholders Digital access has made the process of forging new relationships, partnerships and alliances more seamless and more efficient. Digital marketplaces exist to embody a space where all interested parties are able to identify a potential goal they can contribute, the most appropriate partners, and launch a joint venture.	**Example** UN-Business Action Hub has been created as a joint effort of the United Nations Global Compact, Global Hand, a Hong-Kong based non-profit specialising in facilitating private sector and NGO connections, and 20 UN entities, to connect the UN with private businesses. The platform allows businesses to learn more about UN entities, and how they can collaborate to advance solutions and support humanitarian and environmental initiatives. The interactive nature of the platform is aimed to foster collaboration and maximise the impact of each project.[28] **Example:** Samsung are partnering with the UN to support the SDGs through the "Samsung Global Goals' application", an education and donation-based mobile application. The application aims to increase awareness and raise funds for UNDP to support its work. The app will offer suggestions for small actions for people to take to support the issues that matter most to them.	Digital Access	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Monitoring and reporting progress against SDGs is an integral aspect of accelerating action toward the 2030 Agenda. Having a framework for noting periodic progress against the goals is essential to ensure accountability, transparency and improvement.

Cluster 7

Enhance data & monitoring of progress to sustainable development

Within each of the 17 SDGs are a range of targets that provide the basis for a roadmap for action. Progress towards the 169 total targets will be measured through a set of global indicators for monitoring performance. Monitoring and reporting progress against SDGs is an integral aspect of accelerating action toward the 2030 Agenda. Having a framework for noting periodic progress against the goals is essential to ensure accountability, transparency and improvement. Measuring impact for sustainability is enabled both through:

a) the provision of statistics on SDGs, as achieved through the identification of appropriate data sources and methodologies corresponding to SDG indicators; and

b) the active reporting on SDG and target progress at a policy level, such as the report conducted by the UN Secretary General to the High-level Political Forum (HLPF) on Sustainable Development and the voluntary country reviews at HLPF.

National and sub-national monitoring of progress towards SDGs and targets should be the result of close collaboration between statisticians and policymakers. This collaboration ensures that the objectives are measurable and that selected indicators are appropriate for relevant policymakers.

Meaningful statistical analysis can be achieved through digital access, the cloud, ML and new monitoring and reporting tools. Web-based applications, accessible by a multitude of stakeholders, give visibility to data necessary for understanding progress against the SDGs. Advanced analysis and visualisation of conclusions open up the possibility of viewing progress with a critical eye, spotting areas of uncertainty and lack of progress, planning data requirements, and designing action plans.

However, currently specific insight into how companies are performing on the SDGs is lacking.[29]Even if the necessary tools and frameworks for enhancing data analysis and monitoring of progress for sustainable development are in place, there are limitations to the extent that these can be used. Data acquisition and analysis require the existence of the appropriate infrastructure to record and keep track of data on national and regional level, as well as the voluntary sharing of data. For impact measurement to be truly entrenched in the attainment of the SDGs, the technological foundations, a harmonised approach towards sustainability on a global level, and specific framework of measurement are needed.

Assessing impact towards the achievement of the SDGs is a complex task by its nature, both given the multi-faceted character of the indicators – including policy, funding, technology uptake and macroeconomic targets – as well as the challenges attached to collecting and analysing the most relevant data. Technology can be utilised to funnel the vast amount of information available by placing impact assessment at the forefront of the 2030 Agenda.

Cluster attainment by technology table

Connect & Communicate

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Digitally available visualisation and reporting tools to develop deeper understanding of SDG impact The simplest way digital technologies can support impact measurement for the SDGs is by making data around the progress of the SDGs available and accessible to all. Decision makers and policymakers require accurate, timely, sufficiently disaggregated, and relevant data to inform decision making and advocacy. Through the cloud and digital access, it is possible to build comprehensive data repositories, to store and share data ready for analysis.	**Example** The Open SDG Data Hub is the UN's SDG Indicators database, maintained by the United Nations Statistics Division (UNSD) and offering readily available data on each SDG.[30]	Cloud Digital Access	Importance to SDG Role of digital technologies Scalability
Web-based applications to promote the better production and use of statistics Through digital access and web-based applications, it is possible to improve the production, accessibility and use of data for the benefit of the sustainability goals. Digitalisation of statistical infrastructure allows better statistical capacity and data planning to supply the data required for the creation of key policies.	**Example** ADAPT (Advanced Data Planning Tool) by Paris 21 is a free cloud-based tool, currently used by many National Statistical Offices (NSOs) for the development of statistical capacity and promotion of evidence in policy design and monitoring. ADAPT produces reports to be integrated to SDG related discussions, visualises where essential data is missing and plans future data collection activities.[31]	Cloud Digital Access	Importance to SDG Role of digital technologies Scalability

Analyse, Optimise & Predict

SPECIFIC DRIVER / USE CASE	USE CASE EXAMPLE	TECH	IMPACT
Comparative tools to provide actionable input in measuring SDG impact To advance reporting and impact measurement on the SDGs, it is essential both to contextualise insights and to attribute statistical results to actionable conclusions. Through data analytics and digital access, research and insights drawn from statistical analysis can be translated to useful, available, and ready-to-use recommendations on how performance against sustainability issues can be improved.	**Example** World Benchmarking Alliance (WBA), launched by Aviva, the Index Initiative and the UN Foundation, aims to increase the private sector's impact towards a sustainable future. WBA will develop a range of corporate benchmarks by 2023 to comprehensively assess the progress of 2,000 companies across major areas of transformation required to achieve the SDGs. WBA will subsequently make all information available to inspire further positive action.[32] **Example:** SoPact[33] is an impact measurement platform developed to be used across sectors and public/private organisations for collecting, managing and assessing data around social impact.	Digital Access Cloud Cognitive	Importance to SDG Role of digital technologies Scalability
Measurement of corporate impact on sustainability to drive capital allocation Quantitative analysis powered by ML and digital access allows the identification of the negative and positive impact of a company's products and services on the 17 SDGs. The quantifiable measurement of corporate impact, as opposed to qualitative discussions, enables the specific allocation of capital and formulation of investment portfolios with the highest yield of positive sustainability results.	**Example:** Util conducts company assessment and analysis using big data and ML. It aims to discover and aggregate quantified, comparable company data to allow responsible investors to screen, monitor and report based not only on financial but also on environmental, and social returns on investment.[34]	Digital Access Cloud Cognitive	Importance to SDG Role of digital technologies Scalability

Lower ▨▨▨▨▨ Higher

Appendix

Methodology

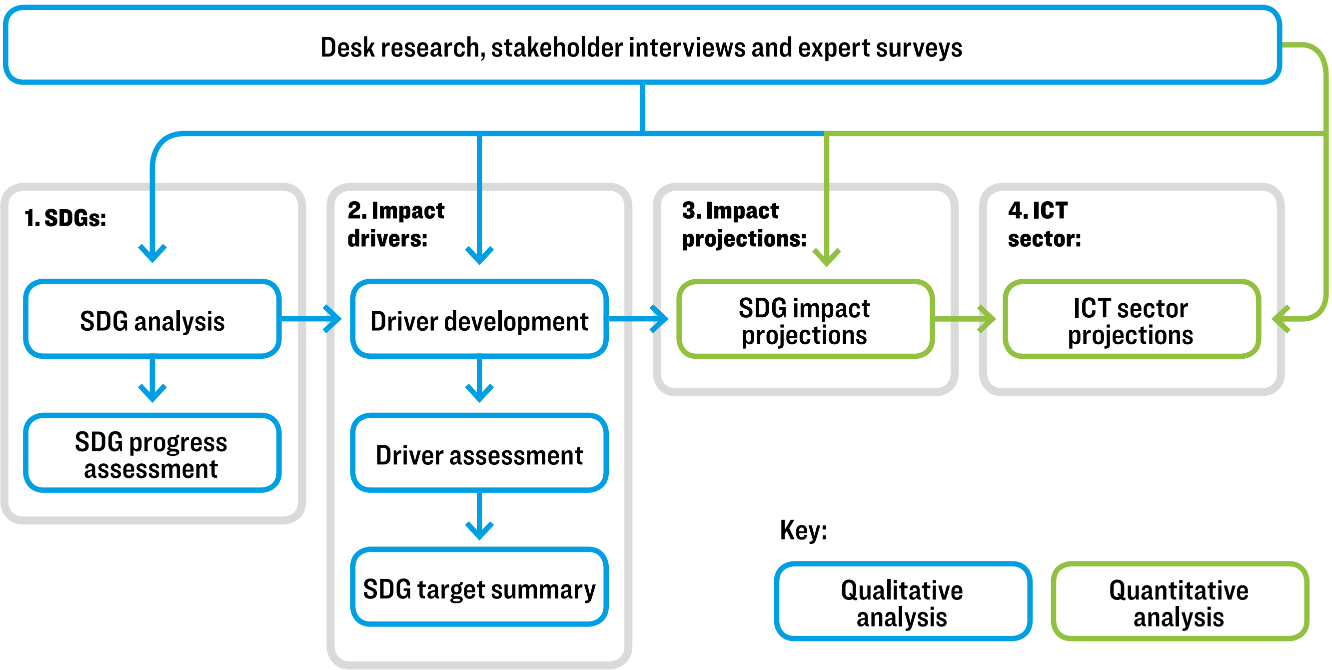
The purpose of this report is to build on previous GeSI analyses to explore a causal relationship between the deployment of digital technology and the achievement of the Sustainable Development Goals (SDGs), and to further consider the footprint of the ICT sector.

To achieve this, qualitative tools have been used to explore the role of digital technologies in achieving the SDGs, and quantitative analysis has been deployed to establish the impact of the ICT sector and the potential impacts of various digital technology use cases.

Analysis has been built upon extensive desk research, drawing on previous GeSI reports, other relevant publications and data sources (listed in the endnotes and highlighted in the Bibliography). Further information has been gathered through engagement with GeSI stakeholders, including representatives of over 40 GeSI member organisations and the 'expert panel' convened for this report. Finally, a wider body of experts were surveyed through a crowdsourcing platform, to validate estimates in the literature on the future adoption of digital technology and potential impact of selected use cases on the SDG target indicators.

The methodology is broken down into four interrelated clusters, which are examined in turn in this chapter:

1. **SDGs:** an analysis of the 17 SDGs as clusters of targets and their reliance on the deployment of digital technology;
2. **Impact drivers:** an assessment of how the deployment of digital technology drives progress against each SDG cluster – drawing on a range of use case examples, categorised through the impact functions framework (see Digital Technologies chapter);
3. **Impact projections:** quantitative research to project the future benefit of high-impact applications of digital technology against selected SDG targets; and
4. **ICT sector footprint:** quantitative research to project the future economic and environmental impact of the ICT sector.



1 SDGs

SDG analysis

SDGs as a system

The 2030 Agenda for Sustainable Development sets out 17 Goals, comprised of 169 targets and aligned to 232 indicators. Each target and accompanying indicator(s) is set out in the 2019 edition of the 'Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development'.[1]

In the 17 SDG appendices to this report, each of the Goals have been framed as a system, built upon clusters of targets that interrelate in driving towards the achievement of the Goal. Each target has been summarised into a short phrase to capture its core intent. The targets have been grouped into clusters that represent key thematic aspects of the overall Goal. The clusters are then positioned visually to indicate their inter-relationship.

Alongside the relationships between targets within a particular Goal, there are also many relationships between targets across different Goals. These relationships have been captured in a high level in a short description towards the end of each of the 17 SDG appendices. For more on this topic, please see the wider literature:

- *Nilsson, M. (2016). Understanding and mapping important interactions among SDGs*[2]
- International Council for Science. *(2017). A guide to SDG interactions: From science to implementation.* [3]

SDG targets and the deployment of digital technology

Of the 169 targets that comprise the SDGs, not all rely directly on the development and deployment of digital technology for their completion. Through analysis conducted for this report, 46 targets were identified as reliant primarily on policy decision making and 16 were identified as primarily reliant on financing for aid or other types of development funding.

This left 107 targets that are not primarily reliant on policy decision making or aid/development financing, which were then considered to assess the relevance of the development and deployment of digital technology for their fulfilment. This assessment was conducted through a review of the literature against each SDG Goal and the relative weight of evidence to indicate the relevance of digital technology on the fulfilment of the target. This analysis is laid out in each of the 17 SDG deep dive chapters, in the section entitled 'The importance of digital technology to target attainment'.

Of the 107 targets, 56 targets that have some reliance on digital technology for their achievement are indicated in yellow. The 47 targets that directly rely on the development and deployment of digital technology for their achievement are indicated in green. It is these targets that have formed the focus for the subsequent qualitative and quantitative analysis in this report through the framework of clusters. Finally there are 4 targets which had a low reliance on digital technology, but were not primarily reliant on financing for aid or other types of development funding. These 4 targets, alongside the 62 targets which are primarily reliant on policy or financing, rather than digital technologies, are indicated in grey, totalling 66 targets.

Target Filtering

1 NO POVERTY	2 ZERO HUNGER	3 GOOD HEALTH AND WELL-BEING	4 QUALITY EDUCATION	5 GENDER EQUALITY	6 CLEAN WATER AND SANITATION	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	10 REDUCED INEQUALITIES	11 SUSTAINABLE CITIES AND COMMUNITIES	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION	14 LIFE BELOW WATER	15 LIFE ON LAND	16 PEACE, JUSTICE AND STRONG INSTITUTIONS	17 PARTNERSHIPS FOR THE GOALS

169 TARGETS

Deprioritise policy or aid focused targets

1 NO POVERTY	2 ZERO HUNGER	3 GOOD HEALTH AND WELL-BEING	4 QUALITY EDUCATION	5 GENDER EQUALITY	6 CLEAN WATER AND SANITATION	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	10 REDUCED INEQUALITIES	11 SUSTAINABLE CITIES AND COMMUNITIES	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION	14 LIFE BELOW WATER	15 LIFE ON LAND	16 PEACE, JUSTICE AND STRONG INSTITUTIONS	17 PARTNERSHIPS FOR THE GOALS
57%	63%	85%	90%	78%	75%	60%	67%	75%	40%	60%	45%	60%	60%	50%	75%	47%

% TARGETS REMAINING

62 TARGETS DEPRIORITISED
107 TARGETS REMAINING

Deprioritise targets where ICT is of low importance

1 NO POVERTY	2 ZERO HUNGER	3 GOOD HEALTH AND WELL-BEING	4 QUALITY EDUCATION	5 GENDER EQUALITY	6 CLEAN WATER AND SANITATION	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	10 REDUCED INEQUALITIES	11 SUSTAINABLE CITIES AND COMMUNITIES	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION	14 LIFE BELOW WATER	15 LIFE ON LAND	16 PEACE, JUSTICE AND STRONG INSTITUTIONS	17 PARTNERSHIPS FOR THE GOALS
57%	63%	85%	80%	67%	63%	60%	67%	75%	30%	50%	45%	60%	60%	50%	75%	47%

% TARGETS REMAINING

4 TARGETS DEPRIORITISED
103 TARGETS REMAINING

SDG progress assessment

Alongside the assessment of the relevance of digital technology, each target has further been assessed in terms of progress towards the 2030 target date. This assessment has been conducted with exclusive reference to established UN sources – notably:

- *UN Statistics Division*[4]
- *The SDG Tracker*[5]
- *UN Sustainable Development Goals Knowledge Platform*[6]

The trend is represented by an arrow where the direction of the arrow indicates the direction of the quantifiable aspect of the target, and the colour represents whether the trend is positive (green), negative (red) or neutral (orange).

2 Impact drivers

2.1 Driver development

A literature review was performed for each set of prioritised SDG targets to identify use case examples (i.e. real world instances where organisations are employing digital technologies to drive progress against an aspect of the SDGs) that addressed key challenges set by the target clusters and the individual targets.

Use case examples were then reviewed and genericised to formulate drivers of impact, which summarised the way groups of use case examples could further progress against an SDG. At this stage, the drivers of impact were tested with industry experts, stakeholder groups and further desk research, in order to determine whether there were any areas that had been overlooked. Through a number of iterations of this process, a list of drivers that matched each prioritised SDG target was created.

To illustrate the principal means by which digital technologies support achievement of the SDGs, drivers were categorised into four impact functions. The impact function framework was developed through desk research and discussions with technology experts. Within each impact function, drivers were categorised again, into a sub-function, which represent the main categories of drivers found in the literature reviews across all SDGs.

Impact functions	**CONNECT & COMMUNICATE**	**MONITOR & TRACK**	**ANALYSE, OPTIMISE & PREDICT**	**AUGMENT & AUTONOMATE**
Impact functions definitions	Connecting people to one another, to information, and to marketplaces and digital resources	Monitoring and tracking of things, people and systems increasingly in real time and at scale	Processing of large volumes of data to reach conclusions, optimise processes and predict outcomes	Simulation of physical world, augmentation of human activity, creation of autonomous systems
Impact sub-functions	Public awareness messages Targeted content Digital marketplaces and business models Digital payments and finance	The environment Populations, people and activities Organisations and supply chains Individual assets and rights	Process optimisation Socio-ecological analysis and targeting Rapid data analysis for innovation Future state prediction	Immersive experiences to aid decision making Augmented humans Autonomous processes and machines

2.2 Driver assessment

To determine the relative significance of each driver to an SDG, a comparative impact assessment was conducted. This was a qualitative scoring exercise across three dimensions that were each rated on a 1-5 scale: the current importance of the driver to the SDG, the current importance of the ICT sector's role in delivering the driver and the scalability of the driver towards 2030.

The current importance of the driver to the SDG: where 5 indicates a significant role for the driver in delivering or enabling the achievement of the SDG and 1 indicates some role in delivering or the enabling of a target within the SDG.

The current importance of the ICT sector's role: where 5 indicates the sector has a critical role, and no other sector or institution would be able to achieve the driver at a comparable speed or cost. A score of 1 indicates the ICT sector could not have a distinctive role in delivering the driver, and its contribution would be the same as any other sector.

Finally, the scalability of the driver was considered, through two lenses, which were aggregated into one scalability score:

- The maturity of the application of the digital technology, and its current level of deployment. Maturity was measured on a 1-5 scale, where 5 indicates the technology within the driver is widely deployed e.g. mHealth, and 1 indicates the technology within the driver is yet to be deployed.
- The financing challenge of the digital technology underpinning the driver, and whether there is a commercial benefit to the intended user. The financing challenge was measured on a 1-5 scale, where a 5 represents a compelling commercial benefit and 1 represents a driver with no obvious commercial benefit.

2.3 SDG target summary

Finally, at the SDG target level, the report offers a qualitative indication of where the relative weight of use-case examples and drivers lies against the four generic impact functions. A score of 1 indicates where most use case examples and drivers were found per target, and a 4 represents the least. In some instances, limited use case examples could be readily identified. A suggestion of where the future focus of digital technology is expected per target is also offered, based on findings from literature reviews, and discussions with stakeholder groups.

3 Impact projections: Quantitative methodology

3.1 Introduction

The quantitative analysis aims to illustrate the impact of the ICT sector, and the potential impact that digital technology could have on the SDGs. The quantitative analysis comes in two parts:

- **Impact projections on the SDGs.** The impact projections model how selected digital technology use cases could support achievement of some of the SDG targets, based on expected future adoption and impacts sourced from a literature review and expert survey.
- **ICT sector footprint.** This part of the analysis estimates the current and potential future size of GVA, emissions, and e-waste generated by the ICT sector, considering the benefits and challenges of increased adoption of digital technology.

This section provides an overview of the quantitative impact methodology, including citation of data sources used in the analysis, a description of the impact estimation approach, and discussion on the approach to estimating the ICT footprint.

The approach intends to provide a realistic view of the expected impact of currently observable digital technology on the SDGs; however the following constraints should be noted:

→ **Projection time frame:** Any analysis of the impacts of technology over a ten-year time frame is necessarily speculative. There are a range of other factors that will affect final outcomes and the actual realised impacts of digital technologies will, in reality, include use cases that have not yet been developed and hence cannot be measured. The estimates here provide a guide to the potential impacts of digital technology, based on:

- Reasonable expectations for the increased adoption of existing use cases;
- Outcomes experienced where those use cases have already been deployed (where possible, assessing trends across multiple randomised trials); and
- Testing and extending those adoption rates and impact coefficients in the existing literature with expert insight from diverse specialist panels.

→ **Future innovations:** As referenced in the previous point, the analysis does not take account of the impact of future use cases that will be the result of ongoing R&D innovation, and as such have not been developed and deployed.

→ **Data availability:** The variables on which impacts are measured have been chosen based on the following factors:

- Importance of digital technology in having an impact
- Relation to the SDG target (i.e. preference is always given to an official indicator, subject to other constraints being satisfied)
- Country coverage
- Availability of a business-as-usual trend (i.e. is there a third party projection available, or has the variable been consistently measured for a number of years so as to demonstrate a steady historic trend)

→ **Targeted adoption:** The estimated potential impacts of digital technology are subject to appropriate targeting of the use cases to the areas that require them. If adoption rose, but in areas where the use cases were not helpful, this would not drive the same impacts.

→ **Role of non-ICT factors:** The analysis between the business-as-usual and digital technology scenarios is based on an increase in the adoption of ICT. It does not model the impact of any other significant changes in policy or infrastructure that could occur between now and 2030 that go beyond the status quo.

→ **Economic footprint of the ICT sector:** As is noted in the ICT Sector Footprint chapter, the measure of the economic footprint (GVA) does not necessarily capture the full economic impact of ICT. For example, it does not include some intangibles that are not recorded in national accounts, such as user generated content, and other elements that are challenging for statistics authorities to measure. More detail is provided in the ICT Sector chapter.

Where these constraints are particularly relevant to the estimated impact, this is called out in the text.

The following two sections discuss the methodology for the impact projections on the SDGs and the ICT sector footprint.

3.2 Impact projections on the SDGs

3.2.1 Overview of impact projection methodology

The output of the impact analysis framework is a potential value of the indicator or indicator proxy in 2030 under a business-as-usual scenario and a digital technology scenario. The **business-as-usual scenario** illustrates what the future would look like if we were to continue with the same levels of technology adoption and sophistication. This scenario is estimated using either historic trends or third party projections, on the assumption that there are no significant changes from the status quo. That is, under the business-as-usual projections there are no notable deviations from the current paths of technology, policy or infrastructure that would lead the variable to shift away from its current path.

Comparatively, the **digital technology scenario** assumes that digital technology adoption increases to above current levels, targeted in the places where gains can be made, such that it is able to have a material impact on the SDG Target.

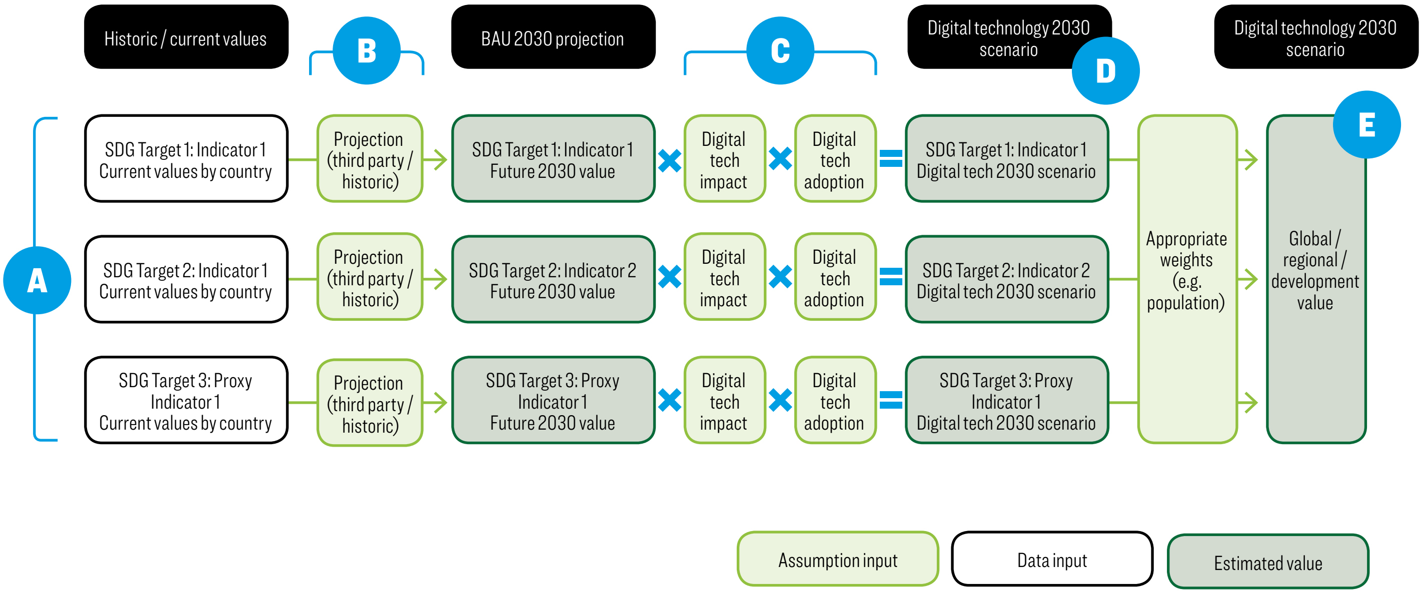
Where data allows, the baseline data uses an official SDI. However in many cases, a proxy is used to more robustly demonstrate the potential impact on an SDG target. Further, with limited exception, the analysis has been performed at a country level and appropriately aggregated (i.e. using relevant weights) to report at global, regional or development level.

The approach to estimate the impacts of digital technology on the SDGs consists of 5 steps:

- **A** **Identify variables to model.** Impacts are modelled where sufficient data is available, impact and adoption rates can be robustly defined, and findings from the qualitative research identify a critical driver where digital technology can be deployed to enable achievement of the selected SDG targets.
- **B** **Project data to obtain the business-as-usual (BAU) 2030 scenario.** An estimate of the indicator or indicator proxy is established using a third-party projection, or historic trends where a future projection is unavailable.
- **C** **Establish rates of impact and adoption**. An analytical hierarchy is applied to establish impact rates: in the first instance, a meta-analysis of control trials is considered. If this is not possible, a literature review validated by an external expert panel is used, and if this is not possible the impacts are informed by an expert survey. Rates of adoption come from first a literature review and second an expert panel.
- **D** **Apply impacts and adoption to BAU to obtain Digital Technology 2030 scenario.** The potential impact on the 2030 BAU scenario is estimated using the established rates of impact and adoption.
- **E** **Regional aggregation.** Global, regional and development level impact results are calculated using appropriately weighted averages (e.g. by population, agricultural production, land area).

A high level overview of this framework is presented in Figure 1, where the letters in the figure relate to each of the 5 steps.

Figure 1: Steps in the quantitative impact analysis



3.2.2 Steps to the impact analysis

This section goes through the 5 impact analysis steps in more detail, with a worked example on the skilled birth attendance indicator, relevant to Target 3.1.

A Identify variables to model

Step description

The variables on which to model the impact of digital technology have been determined on the basis of:

Qualitative research: For each SDG, the qualitative research establishes the importance of digital technology in achieving a Goal

Data availability: It is preference to use an official SDI in the analysis, though this is not always possible due to data limitations. In some cases, an SDI proxy is used on the basis of higher country coverage and availability of business-as-usual trend.

Impact evidence availability: This is primarily driven by how established a use case is and the extent of real-world evidence available for estimation.

Example

For SDG 3, Target 3.1 is identified as relevant for impact modelling:

Role of digital technology	✓	The qualitative research concludes that the application of digital technologies is critical to the attainment of this goal; for instance in achieving improvements in skilled delivery care and increasing accessibility to this form of care in order to reduce common drivers of maternal mortality.
Baseline data availability	✓	Data on one of the official indicators (births attended by skilled health staff, % of total) available for 184 countries, with the most common year available being relatively recent (2017).
2030 projection	✓	A robust third-party projection to 2030 is available from the Global Burden of Disease Study 2017.
Impact rate availability	✓	The role of mHealth in increasing birth attendance by skilled health professional is relatively well established, with a reasonable number of randomised control trials available to determine a country-level impact.

B Project the business-as-usual (BAU) scenario

Step description

The business-as-usual scenario projects the variable to 2030 on the assumption that there are no significant changes from the status quo; for example, there are no significant deviations from the current levels of technology, policy or infrastructure.

In the first instance, the BAU projection to 2030 is obtained from a third-party. Where this is not available, a projection is made using the historical trend, on the assumption that this best represents the status quo.

Example

Projected growth rates as estimated by the Global Burden of Disease Study 2017 are applied to the baseline data to obtain BAU values for 2030.

C

Establish rates of impact and adoption

Step description

An analytical hierarchy is used to establish the potential impact of digital technology. This is outlined in the figure.

1

Meta-analysis of controlled trials. The relationship between the impact of a digital technology intervention observed in randomised control trials in the academic literature and the relevant indicator/indicator proxy is estimated using a simple regression analysis (Ordinary Least Squares). The impact for each country can then be estimated by applying the obtained coefficients to the country-level indicator/indicator proxy.

2

Literature review with expert survey validation. Desk research is conducted to obtain a collection of observed impacts from the use case, albeit where the impacts have not been tested in a controlled setting. These observed impacts, typically making the distinction between developed or developing countries, are tested against an expert survey panel.

3

Expert survey opinion. The panel of experts are tested on their expectation of the size of an impact, and the impact applied in the analysis is a simple average of these values. On the assumption that the experts surveyed represent a random sample of the population, the expert sample average should reasonably approximate the expert population average.

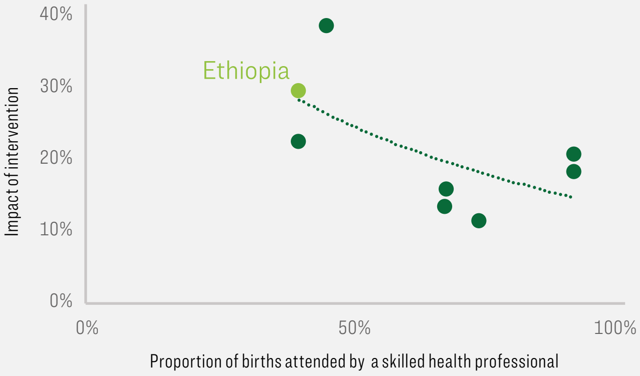
The impact is obtained on the assumption of 100% adoption of the digital technology. Therefore, this impact is scaled down with an assumption on **adoption rates**, i.e. what proportion of the relevant population will be using this technology in 2030 compared with today.

Assumptions regarding the adoption rates are obtained using approaches 2 and 3 outlined above, or in the event that a reputable international organisation provides an estimate, this value is used.

Example

A meta-analysis of the available RCTs is conducted, covering studies such as:

- **Atnafu et al., 2017:** The role of mHealth intervention on maternal and child health service delivery: findings from a randomised controlled field trial in rural Ethiopia[7]
- **Hackett et al., 2018:** Impact of smartphone-assisted prenatal home visits on women's use of facility delivery: Results from a cluster-randomised trial in rural Tanzania[8]



Using the results of these studies and the known proportion of births attended by a skilled health professional for the respective countries, a line of best fit is estimated. The slope (beta) of this line is applied to the proportion of births attended by a skilled health professional for each country to obtain a country-specific potential impact.

This approach assumes decreasing returns to the mHealth intervention for countries with a high proportion of births attended by a skilled health professional.

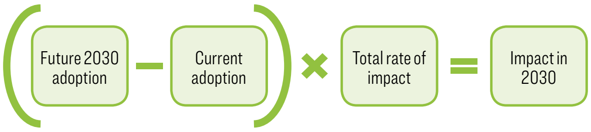
The mHealth adoption rates by World Bank-defined income level are obtained from a World Health Organisation study.

D Apply impacts and adoption to BAU

Step description

The impacts obtained in step C can be interpreted as a *total* impact rate, that is, 'the impact of digital technology with 100% adoption'. Therefore, the impact needs to be scaled for the expected change in the rate of adoption in 2030.

The difference between the current and future adoption, multiplied by the total impact rate, gives the impact rate that is applied to the variable to give the difference between the BAU and digital technology scenarios.



The digital technology scenario assumes that digital technology adoption increases above current levels, in the places where the most gains are to be made in achieving the goals, such that it is able to have a material impact on the SDG indicator or proxy indicator.

Example

The country-level total impact percentages determined in step C are adjusted downwards for expected adoption rates.

E Regional aggregation

Step description

Global and regional level figures are appropriately aggregated. Depending on the variable, population (or other) weightings will be used to obtain an average, or the variable will be summed across countries to obtain an average.

Example

The figure of proportion of births attended by a skilled health professional for each country is associated with a total number of births. The total number of crude births, as estimated and projected to 2030 by the UN, is used to estimate global and regional weighted averages.

3.3 SDG Progress: acceleration and mitigation

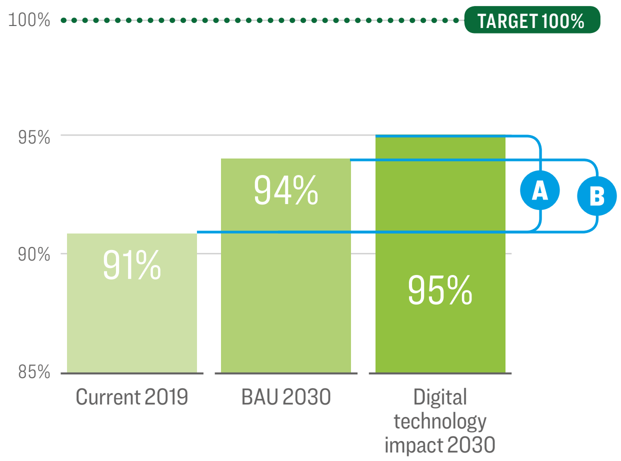
The analysis has shown how digital technology has the potential to both accelerate global achievement of the SDGs and mitigate future deterioration in their progress. Using SDG 6 as an example, acceleration and mitigation are estimated for 22 impacts as follows:

→ **Accelerate:** The additional progress in the indicator that could be achieved with expected levels of ICT adoption. Estimated as *(a – b) / a.* The total accelerate figure is a simple average across 14 impacts observed to be deteriorating.

→ **Mitigate:** The extent that deterioration in the indicator could be mitigated with expected levels of ICT adoption. Estimated as: *(d – c) / d.* The total mitigate figure is a simple average across 8 impacts observed to be deteriorating.

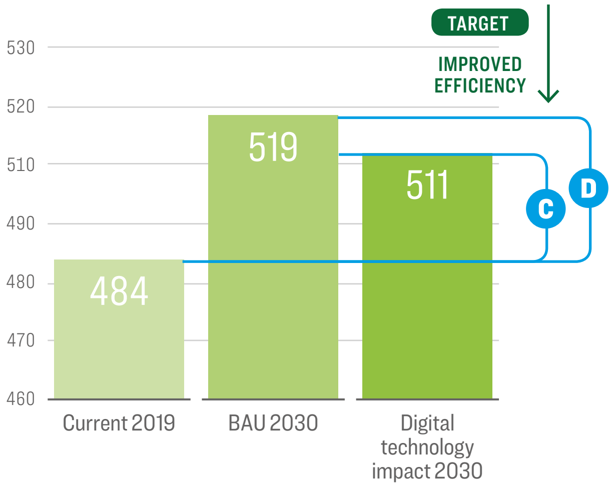
Accelerate: Proportion of the population using at least basic drinking-water services

Proportion of the population using at least basic drinking-water services



Mitigate: Municipal water withdrawals

Municipal water withdrawals (10^9 m3 per year)



For a further 3 indicators (in agriculture), digital technology has the potential to change a pattern of deterioration to pattern of improvement.

Table 1: Current and future indicator estimates, and extent of digital technology acceleration and mitigation

IMPACT NAME	ESTIMATED 2019 VALUE	BUSINESS-AS-USUAL SCENARIO, 2030	DIGITAL TECHNOLOGY SCENARIO, 2030	ACCELERATION	MITIGATION
2.3: Agricultural productivity – smallholder farms	1,957	2,370	2,512	25%	
2.3: Agricultural productivity – medium large farms	4,072	4,938	5,131	18%	
2.4: Nitrogen fertiliser	111	117	110		
2.4: Enteric fermentation	2.1	2.3	2.2		-61%
3.A: Smoking prevalence	19%	18%	17%	50%	
3.1: Skilled birth attendance	84%	89%	92%	32%	
4.6: Youth literacy	92%	94%	95%	38%	
5.6: Reproductive rights	76%	81%	84%	41%	
6.4: Water use – agricultural withdrawals	2,862	2,899	2,712		
6.4: Water use – municipal withdrawals	484	519	511		-22%
6.1: Clean drinking water	91%	94%	95%	24%	
7.1: Access to electricity	90%	92%	92%	21%	
7.3: Energy efficiency	4.6	3.4	3.4	3%	
7.3: Energy efficiency – emissions	31.5	36.3	35.9		-8%
7.2: Renewable energy consumption	18%	22%	23%	7%	
9.2: Manufacturing value add	1,818	2,526	2,732	22%	
9.4: Manufacturing emissions	8,727	6,951	6,622	19%	
9: Domestic material consumption	38	50	47		-20%
10.C: Remittance costs	24%	61%	64%	9%	
11.6: Vehicle emissions in cities	16	21	21		-7%
11.6: Mean levels of PM2.5	46	51	49		-40%
12.3: Food loss in the supply chain	62	65	61		
14.4: Sustainable fish stocks	64%	57%	57%		-10%
15.2: Global forest area	3,958	3,939	3,942		-21%
15.2: Net emissions from forests	1.5	1.7	1.7	1%	
			Average	**22%**	**-23%**

3.3.1 Impact analysis sources

Given the breadth of the impacts estimated in this report, there is a wide range of sources called upon. All variables have been sourced from international agencies, and the assumptions on impact and adoption rates come from either academic literature or public data sources, some of which are also validated by a survey of experts.

Across the variables, the most recent available year will vary dependent on the data custodian and frequency of measurement. Therefore, for consistency and ease of use the report presents the 2019 BAU estimate, which is part of the BAU projection, as the ‘current’ value for each variable. It should also be noted that UN classifications and country definitions are used throughout.

This section presents all sources used in the SDG impact analysis, and comes in two parts:

- SDG impacts excluding emissions abatement
- Emissions abatement impacts

SDG Impacts excluding emissions abatement

Biosphere

SDG TARGET AND IMPACT MEASURED	DATA AND SOURCE	NUMBER OF COUNTRIES COVERED	MOST RECENT AVAILABLE YEAR	BAU APPROACH AND SOURCE	IMPACT
6.4: Water use – agricultural withdrawals	Agriculture water withdrawal (10^9 m3/ year), FAO Aquastat	200	2013-17	Apply projected agricultural production growth rates (FAO-OECD Agricultural Outlook) on the basis of analysis that shows strong relationship between agricultural production growth and growth in agricultural water withdrawals	Literature review validated by agriculture expert survey, split by developed and developing
6.4: Water use – municipal withdrawals	Municipal water withdrawal (10^9 m3/ year), FAO Aquastat	200	2013-17	Apply projected population growth rates (UN World Population Prospects) on the basis of analysis that shows strong relationship between population growth and growth in municipal water withdrawals	Literature review validated by smart city expert survey, split by developed and developing
6.1: Clean drinking water	Population using at least basic drinking-water services (%), WHO	194	2015	Historic trends	Literature review validated by smart city expert survey
14.4: Sustainable fish stocks	Proportion of fish stocks within biologically sustainability levels (%), FAO	Estimated at global level	2015	Historic trend validated by expert survey	Environment conservation survey, split by developed and developing
15.2: Global forest area	Forest land area (1000 ha), FAO. Accessed July 2019.	216	2016	Historic trend validated by expert survey	Environment conservation survey, split by developed and developing

Society

SDG TARGET AND IMPACT MEASURED	DATA AND SOURCE	NUMBER OF COUNTRIES COVERED	MOST RECENT AVAILABLE YEAR	BAU APPROACH AND SOURCE	IMPACT	CURRENT AND FUTURE ADOPTION / OTHER
2.3: Agricultural productivity	Cereals (total production, area harvested and yield), FAO. Production associated with smallholder farms estimated from 'An open-access dataset of crop production by farm size from agricultural censuses and surveys'[9], with regional weighted averages used where country not available	184	2017	Data limitations require assumption that growth rates for smallholder and larger farms are the same. Projections use forecasts published in OECD-FAO Agricultural Outlook	Literature review validated by agricultural expert survey, split by developed and developing	n/a
2.4: Nitrogen fertiliser	Nutrient nitrogen, agricultural use (tonnes), FAO	161	2016	Tests on historic growth in nitrogen-based fertilisers and crop production show statistical significance. Assume this relation holds to 2030 and project growth in nitrogen-based fertilisers using forecasts on crop production published in OECD-FAO Agricultural Outlook	Literature review validated by agricultural expert survey, split by developed and developing	n/a
2.4: Enteric fermentation	Enteric fermentation CO2e, livestock count and emissions per head, FAO	212	2017	Assume constant emissions per livestock head to 2030 and project growth in emissions using forecasts on livestock production published in OECD-FAO Agricultural Outlook	Literature review validated by agricultural expert survey, split by developed and developing	n/a
3.1: Skilled birth attendance	Births attended by skilled health staff (% of total), UN Statistics Division	184	Range 2012-17, mode year 2017	Annual future growth rates as projected by the Global Burden of Disease Study 2017, Institute for Health Metrics Evaluation (Used with permission. All rights reserved.)	Meta-analysis of randomised control trials	World Health Organisation[10]
3.A: Smoking prevalence	Prevalence of smoking any tobacco product among persons aged >= 15 years, WHO	124	Includes forecasts to 2025	Directly from data, missing years projected using forecast trend	Meta-analysis of randomised control trials	World Health Organisation[11]
4.6: Youth literacy	Literacy rate, youth total (% of people ages 15-24), World Bank	139	Range 2012-18, mode year 2016	Historic trend	Meta-analysis of randomised control trials	UNESCO Institute for Statistics; for analysis purposes, future adoption assumed to reach 100%

SDG TARGET AND IMPACT MEASURED	DATA AND SOURCE	NUMBER OF COUNTRIES COVERED	MOST RECENT AVAILABLE YEAR	BAU APPROACH AND SOURCE	IMPACT	CURRENT AND FUTURE ADOPTION / OTHER
7.1: Access to electricity	Proportion of population with access to electricity, by urban/ rural (%), World Bank. Impact analysis performed only on rural areas of developing countries.	215	2016	IEA Energy Access Outlook 2017[12]	Literature review validated by energy expert survey, split by developed and developing	n/a
7.2: Renewable energy consumption	Renewable energy share in the total final energy consumption (%), UN Statistics Division	227	2016	Historic trends	Literature review validated by energy expert survey, split by developed and developing	n/a
11.6: Mean levels of PM2.5	PM air pollution, mean annual exposure (micrograms per cubic metre), World Bank	192	2017	Annual future growth rates as projected by the Global Burden of Disease Study 2017, Institute for Health Metrics Evaluation (Used with permission. All rights reserved.)	Literature review validated by smart city expert survey, split by developed and developing	n/a
5.6: Reproductive rights	Proportion of women of reproductive age (aged 15-49 years) who have their need for family planning satisfied with modern methods, UN Statistics Division. Due to data availability, the impact of digital technologies on gender equality is measured on target 3.7.1, proportion of women of reproductive age (aged 15-49 years) who have their need for family planning satisfied with modern methods which serves as a reasonable proxy to Target 5.6 Ensure universal access to sexual and reproductive health and reproductive rights.	128	Range 2012-19, mode year 2014	Annual future growth rates as projected by the Global Burden of Disease Study 2017, Institute for Health Metrics Evaluation (Used with permission. All rights reserved.)	Meta-analysis of randomised control trials	World Health Organisation[13]
16.9: Birth registration	Proportion of children under 5 years of age whose births have been registered with a civil authority, UN Statistics Division	173	Range 2006-18, mode year 2014	n/a	Hypothetical scenario based on report by GSMA. Assumes that intervention is targeted in areas of 11 countries where the current proportion of children under 5 years of age with their births registered is less than 30% (Angola, Chad, Democratic Republic of the Congo, Bangladesh, Ethiopia, Guinea-Bissau, Somalia, Liberia, Malawi, United Republic of Tanzania, Zambia), and as a result the proportion increases to 30% by 2030.	

Economy

SDG TARGET AND IMPACT MEASURED	DATA AND SOURCE	NUMBER OF COUNTRIES COVERED	MOST RECENT AVAILABLE YEAR	BAU APPROACH AND SOURCE	IMPACT	CURRENT AND FUTURE ADOPTION / OTHER
8.10: Financial inclusion	GSMA Global Mobile Money Dataset; Mobile cellular subscriptions per 100 people	97	2016	Average mobile money account uptake per mobile cellular subscription uptake	n/a	Additional people 'banked' based on projected uptake of mobile money services, which is based on historical trends.
10.C: Remittance costs	World Bank Remittance Prices Worldwide database	351 remittance corridors	2019	Split remittance services between mobile and non-mobile and estimate average cost for each using respective historic trends	n/a	Estimate a 'within corridor' discount factor on cost for mobile relative to non-mobile services. For corridors where there are currently no mobile service, include a 'hypothetical' new mobile service (which has a discounted cost) and estimate the new average cost.
9.2: Manufacturing value add	Manufacturing value added per capita (constant 2010 United States dollars), UN Statistics Division	205	2018	Historic trends	Literature review validated by manufacturing expert survey, split by developed, developing and least-developed	n/a
9: Domestic material consumption	Domestic material consumption (tonnes), UN Statistics Division	186	2017	Historic trends	Literature review validated by manufacturing expert survey, split by developed, developing and least-developed	n/a
12.3: Food loss in the supply chain	Losses during storage and transportation, FAO Food Balance Sheets	166	2013	Assume constant food loss-to-production ratio to 2030, project growth in losses using forecasts published in OECD-FAO Agricultural Outlook for foods with highest losses.	Literature review validated by agricultural expert survey, split by developed and developing	n/a

Emissions abatement impacts

For the use cases studied in this report, the next table summarises the approaches in estimating the abatement potential of digital technology.

SDG TARGET AND IMPACT MEASURED	DATA AND SOURCE(S)	NUMBER OF COUNTRIES COVERED	MOST RECENT AVAILABLE YEAR	APPROACH
7.2: Renewable energy share of consumption	• Renewable energy share in the total final energy consumption (%), UN Statistics Division • IEA Headline Global Energy Data (2018 edition)	Estimated at global level	2016	BAU based on IEA World Energy Outlook. Rates of impact and adoption informed by literature review validated by energy expert survey. Proportion of renewable energy consumption as share of total increased, and respective decrease in energy from non-renewable sources used to obtain emissions estimate.
7.3: Energy efficiency	• Energy intensity level of primary energy (megajoules per constant 2011 purchasing power parity GDP), UN Statistics Division • CO2 emissions per TPES (Total Primary Energy Supply), IEA CO2 Emissions from Fuel Combustion Highlights 2018 • GDP, PPP (constant 2011 international $), World Bank	191	2016	BAU estimated used historic trends. Rates of impact and adoption informed by literature review validated by energy expert survey.
2.4: Nitrogen fertiliser – emissions	Emissions from synthetic nitrogen fertilisers, FAO	161	2015	Emissions per tonne of nitrogen nutrient applied to the reduction in tonnes of nitrogen nutrient used, as estimated for SDG 2.
2.04: Enteric fermentation	See SDG impact table			
12.3: Emissions from food loss	FAO: Food waste and climate change[14]	Estimated at global level	Estimates published by FAO in 2015	Food loss in the supply chain (tonnes) as estimated for SDG 12. Emissions per tonne of food loss are then applied to this figure using results from the FAO 'Food waste and climate change' report, taking into account the stage of the supply chain at which food is wasted.
11.6: Vehicle emissions in cities	• Cities Community Wide Emission Data (CDP)[15] • UN Population at Mid-Year by Country, historic and projections • CO2 emissions per person, IEA CO2 Emissions from Fuel Combustion Highlights	48 countries included in CDP dataset, extrapolated to global on basis of urban populations	2017	Urban emissions per capita estimated using CDP dataset. This is extrapolated to a global level using UN estimates of urban populations. The BAU takes account of changing emissions per person (declining, apply historic trend) and population growth (increasing, apply UN trends). The impact and adoption rates are informed by a literature review validated by smart city expert survey.

15.2: Net emissions from forests	Net emissions/removal (CO2eq) from forest land, FAO	156	2016	Assume constant net CO2eq emissions per hectare of forest area by country between now and 2030. Apply net emissions/removal per hectare factor to change in forest area by country as a result of limited deforestation from digital technology (see SDG impacts table)
9.4: Manufacturing emissions	Manufacturing emissions (Mt CO2): Available for some countries from IEA (Scope 2), supplemented by World Bank construction and industry (Scope 1) dataset. The World Bank data is adjusted to capture Scope 2 emissions based on IEA data then adjusted downward using known manufacturing : construction and industry ratios.	140	Majority 2014, 21 countries up to 2017	Literature review validated by manufacturing expert survey, split by developed, developing and least-developed

3.3.2 Expert survey

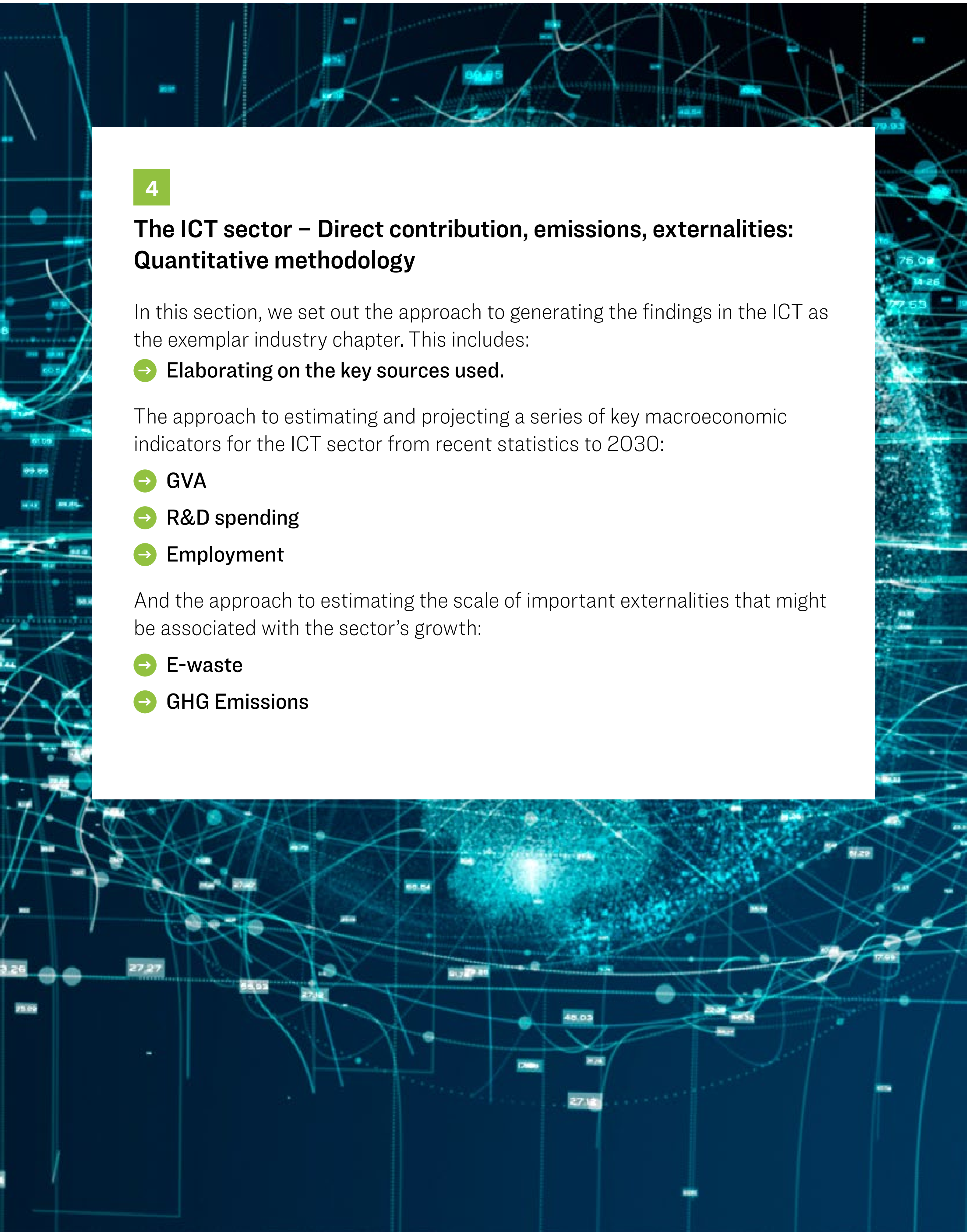
To inform and validate the modelling assumptions, surveys were conducted with subject matter experts across the world in agriculture, energy, smart cities, manufacturing and environment conservation. These surveys were used to ascertain:

1. Existing and potential adoption of digital technology in developed and developing countries.
2. The potential impact of digital technology on a certain variable in developed and developing countries.
3. The amount of this impact that could be attributed to digital technology in developed and developing countries.

Note that the manufacturing questions were asked for developed, developing and least-developed countries.

Most importantly, the surveys were an important way of validating use cases for which impacts had been observed, but had not been extensively implemented or tested. The questions also helped to provide a more in-depth understanding of the opportunities of digital technology, and the extent to which there are barriers to achieving these opportunities.

SURVEY	COLLECTIVE YEARS' EXPERIENCE	SUMMARY OF POSITIONS HELD BY RESPONDENTS	COUNTRIES OF RESPONDENTS
Agriculture	184	Standards Manager (Smart Agriculture techniques), Software Architect, Smart Agriculture Business Developer, COO	Australia, Brazil, France, Netherlands, Spain, Sri Lanka, United Kingdom
Energy	239	Project Manager specialised in offshore wind development, Scientist for research on biomass and solar cells, Project Manager specialised in the microgrid market, Project Manager specialised in renewable energies	Australia, Denmark, France, Germany, India, Singapore, Spain, Taiwan, United States of America
Smart cities	167	Sofware developer, IoT Entrepreneur, Business developer specialised in new digital/IoT business services, Electronics and computer programming expert, Architect specialised in sustainable city construction, Intelligent Transport System expert	Finland, Germany, Indonesia, Italy, Norway, Portugal, United Kingdom, United States
Manufacturing	207	Industrial engineering and digital transformation expert, Business developer specialised in the Indusrty 4.0 B2B market, BtB Sales Manager of IT solutions within manufacturing, Big data analysis specialist, Architect specialised in Industry 4.0 and IoT solution scenarios	Austria, Belgium, Denmark, Egypt, Germany, Italy, Netherlands, Turkey, United Kingdom
Environment conservation	179	Environment Manager, Professional technical expert and Manager specialised in environmental sustainability, Project Manager specialised in chemicals and pharmaceuticals, Expert in health management and environmental regualtions, Project Manager specialised in renewable energies, climate change and environment, Expert in sustainable consumption, Ambassador for sustainable development	Belgium, France, Ghana, India, Indonesia, Singapore, Spain, United Kingdom, United States of America



4

The ICT sector – Direct contribution, emissions, externalities: Quantitative methodology

In this section, we set out the approach to generating the findings in the ICT as the exemplar industry chapter. This includes:

- **Elaborating on the key sources used.**

The approach to estimating and projecting a series of key macroeconomic indicators for the ICT sector from recent statistics to 2030:

- GVA
- R&D spending
- Employment

And the approach to estimating the scale of important externalities that might be associated with the sector's growth:

- E-waste
- GHG Emissions

4.1.1 Key sources

There are a range of key sources that were used in the production of the estimates in the footprint chapter. However, please note that the organisations providing this data have in no way reviewed or endorsed the findings in this report.

DATA TYPE	PROVIDER NAME	DESCRIPTION
GVA, R&D spending, employment	PREDICT	This is a database produced by the European Commission Joint Research Centre. It covers the EU Member States plus key economies for the global digital technology sector, providing estimates for the scale of the sector on various economic metrics.[16]
Emissions intensity of manufacturing, energy; energy consumption of data centres and networks	IEA	Estimates for energy consumption in IT services (data centres and networks in 2014/15 and 2020/21) are provided in a report, Digitalization and Energy 2017.[17] The CO2 highlights[18] provide high-level statistics on emissions by country and Energy Efficiency statistics provide the emissions intensity of manufacturing.[19]
E-waste volumes	Global E-waste Monitor	These reports are a product of a consortium including the ITU and provide estimates of e-waste by country in 2014 and 2016.

4.1.2 GVA

The estimate for Gross Value Added (GVA) uses data gathered in the European Commission PREDICT project to establish a global trend. PREDICT provides an analysis of the economic scale of the ICT sector in the EU Member States and major economies which are competitive in the sector.

The statistical definition of the sector often varies: the definition used in PREDICT includes TVs, for example, but not e-commerce. It distinguishes between ICT services and ICT manufacturing, which exhibit quite different growth rates. Crucially, this dataset provides a time series which allows for a high-level projection based on the observed historic trend growth rate in the sector.

This report aggregates the data and adjusts the services component to reflect countries not included. This adjustment is not performed for manufacturing, as manufacturing activity is more concentrated in those countries assessed in PREDICT. The result is manufacturing growing by around 2% a year above inflation and services by around 5% a year above inflation. These trends have been broadly stable since 2005 outside of a boom in the dotcom era, after which growth corrected to trend.

The steps to estimate GVA include:

1. Add up the PREDICT estimates for ICT manufacturing and ICT services GVA from 1995 to 2015 and fill any missing values for specific countries with linear projections.
2. The countries included in the PREDICT database account for around 81% of global GDP. In the case of ICT services, which appears to be distributed in line with GDP, those missing countries are accounted for by dividing by that share of global GDP. In the case of ICT manufacturing, which is more concentrated and less correlated to GDP, the results are not scaled and PREDICT is assumed to account for 100% of global value added.
3. Extrapolate to 2030 based on the trend rate of growth from 1995 to 2015 as the trend growth rate is stable and other data points support the potential for continued growth.

4.1.3 R&D spending

R&D spending represents an economic impact of the ICT sector through its beneficial spillovers and supports the development of new use cases that can, in turn, contribute to meeting the SDG targets. The approach to estimating R&D spending here is very similar to GVA.

1. Add up the PREDICT estimates and fill in missing values based on linear projection or removing a small number of countries where the data is weak throughout the period (e.g. Switzerland). We do not scale in this case as R&D is relatively concentrated (although there are some significant research centres, e.g. Israel, outside the coverage of the PREDICT database there is not the same link to a high-level macroeconomic indicator such as GDP).
2. Extrapolate to 2030 based on the trend rate of growth from 2005 to 2015. 2005 is used as the start date as the data is weaker in earlier years and the dotcom boom is particularly distortive of the data for R&D.

4.1.4 Employment

The ICT sector is a significant employer in many countries. The approach here is again very similar to GVA:

1. Add up the PREDICT estimates, fill in missing values with linear projections, and, in the case of services, scale up in line with the share of global GDP accounted for by countries in the PREDICT database.
2. Extrapolate to 2030 based on the trend rate of growth from 2000 to 2015, reflecting data availability.

4.1.5 E-waste

While e-waste is only one facet of the impact of ICT manufacturing through its use of natural resources, it provides a unit of measurement (tonnes of e-waste) that can help in understanding trends in the scale at which devices are being disposed of without recycling. This section uses data from the Global E-waste Monitor reports, which are a product of a consortium including the ITU and provide estimates of e-waste by country in 2014 and 2016. The steps to forecast from 2016 to 2030 are:

1. Add up the Global Monitor estimates in 2014 and 2016 and account for the missing countries (in this case, the difference is more modest than the scaling of ICT services GVA in PREDICT, with 98-99% of global GDP included) by dividing by the share of global GDP covered.
2. Divide those values for 2014 and 2016 by estimates for ICT manufacturing GVA to estimate an e-waste intensity of ICT manufacturing (tonnes of e-waste per €m in ICT manufacturing GVA).
3. Estimate the trend growth rate from 2014 to 2016 in the emissions intensity of ICT manufacturing GVA.
4. Project forward based on that trend growth rate in emissions intensity and the expected value of ICT manufacturing value added to generate estimates for the total volume of e-waste in each year to 2030.

4.1.6 GHG Emissions

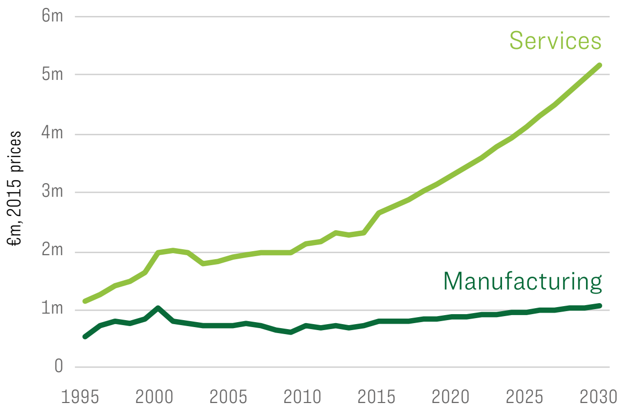
In order to understand the environmental impact of the ICT sector, and draw comparisons to emissions abated through the use of digital technologies, we need to model its contribution to GHG emissions. In particular, we need to estimate how emissions are likely to grow to 2030. The objective is then to compare this growth to potential abatement impacts of digital technology use cases, the approach to which was set out in the earlier section in this appendix, and the increase in their adoption expected over the same period from 2019 to 2030. ICT is too interwoven with modern life to realistically isolate its entire contribution to decarbonisation, so for example, the analysis will not test a counterfactual in which the letter has not been replaced by email and then instant messaging, and the comparison should therefore not be to the entire footprint.

Components to an ICT footprint projection

Any emissions projection or analysis for the ICT sector is necessarily uncertain, given the challenges in defining its boundary and the limitations on current emissions reporting data by sector. However, they generally include three elements:

1. *An understanding of the baseline.* For example, Malmodin and Lunden estimate that in 2015 the ICT sector contributed 730 Mt CO2e or 1,150 Mt CO2e including TV.[20]
2. *An understanding of the sector growth trend.* In Andrae and Edler, this is provided by the growth in micro variables such as data volumes and device numbers. In this study, the trend growth in sector GVA is used instead.[21] This takes advantage of the stability of the trend (see graph below) and reflects a common approach elsewhere in the climate literature, often known as the Kaya Identity (CO2 = GDP * (Energy / GDP) * (CO2 / Energy)).[22]
3. *An understanding of the efficiency trend.* The approach taken by existing studies varies depending on the indicator concerned, but Malmodin and Lunden find that overall emissions have been broadly flat over the 2010-2015 period, despite the growth of the sector, which illustrates the importance of the efficiency trend. IEA research expects this to continue in data centres, at least in the short run.[23] This report develops an efficiency trend from data points from different sources:
    a. For services, existing IEA estimates for data centres and networks are used.[24]
    b. For manufacturing, analysis of trends in the wider manufacturing sector (based on IEA Energy Efficiency indicators)[25] and device-by-device data provided by certain manufacturers.

ICT GVA Contribution Projection



Approach

At the corporate level, GHG emissions are often divided into Scopes:[26]

- **Scope 1:** Direct GHG emissions – these occur from sources owned and controlled by the company, e.g. a diesel generator it owns.
- **Scope 2:** Electricity indirect emissions – these result from the generation of energy purchased by the company and their quantification is often described as "market based" (i.e. based on the mix of sources in the energy that the company actually buys) or "location based" (i.e. based on the typical energy mix in the locations that the company buys energy, on the logic that if a company buys renewable energy it will not directly change the renewable component in the overall energy mix).
- **Scope 3:** Other Indirect GHG Emissions – these are emissions that are consequences of the activities of the company, but which do not directly result from its activities or its purchases of electricity. This includes both the use of devices (in the case of manufacturing) and the supply chain.

Scope 4 is sometimes used to refer to the effects of the use of ICT goods and services beyond their immediate power consumption and would include the use cases modelled in other parts of this report.

It is important to note, however, that the Scope classification is intended for use in corporate reporting and is therefore not ideally suited to estimating emissions at a sector level. In estimating the GHG emissions footprint of the sector, we consider three components, which are included in this measurement of the total ICT GHG footprint:

- **Manufacturing** – the emissions generated in the production of ICT devices.
- **Use** – the emissions generated by those using ICT devices, particularly through the electricity used to power them.
- **Services** – the emissions generated due to the power consumption of ICT services, of which the two most important components are data centres and networks.

Manufacturing

IEA Energy Efficiency statistics present emissions by end use,[27] that is, their eventual use (e.g. residential, industrial, etc.). This source does not single out the ICT sector and therefore the key assumption is that ICT manufacturing energy intensity is broadly typical of the wider manufacturing sector. While some parts of the ICT manufacturing sector are energy intensive (e.g. particularly the manufacturing of components), it seems reasonable that, across the sector, it is broadly in line with wider manufacturing norms (which also include a mix of lighter industry and energy intensive sectors such as cement or aluminium). With that assumption aside, this data should provide a good estimate for the overall effort involved in manufacturing.

In this report, manufacturing emissions intensities for all the countries in the PREDICT dataset are estimated by filling in for countries not included in the IEA energy efficiency dataset with those that exhibit a similar overall emissions intensity of energy. The average is then weighted for where ICT manufacturing specifically takes place. This is done in order to reflect that, while ICT manufacturing may not be exceptional compared to other manufacturing, its contribution to GHG emissions will be dictated by the emissions intensity of the energy it consumes (reflecting factors such as the extent to which electricity generation in the countries where ICT manufacturing takes place is dependent upon coal power, versus gas or renewable energy).

This provides estimates for emissions intensity over time from which we can develop a trend, which reflects rising efficiency in each country and the changing geographical distribution of the sector. The results show around a 3% a year improvement in energy efficiency overall.

Use

There is a general finding that smaller devices tend to have a smaller share of their overall emissions resulting from use versus manufacturing. On the other hand, devices used in businesses (at an extreme, the servers in data centres) tend to be used more intensively and therefore have a higher use share versus manufacturing. Device use in data centres and transmissions networks will be captured under ICT services sector modelling (see services section below), but consumer devices need to be modelled separately.

Andrae and Edler provide estimates for the numbers of devices by category, which provides estimates for the overall shares out to 2030 (including TVs and their accessories). From these estimates, the assumption for DVD and Blu-Ray players is adjusted to trend towards zero. Those estimates are used to weight estimates for use case emissions provided by Dell[28] and Apple,[29] where we found this comparison reported by device. TVs and their accessories were assumed to have the same use-to-manufacturing ratio as monitors, and ordinary mobiles were assumed to have the same use-to-manufacturing ratio as smartphones (pre-empting a convergence in the two categories). These are necessarily approximations but should provide a reasonable guide. Usage is found to be around 30% of manufacturing emissions, with the ratio declining slowly over time.

Services

Malmodin and Lunden note that their estimate for data centres is very similar (and in part based on) estimates published by the IEA. We therefore adopt the same IEA reported estimates for data centres and networks, which are provided for in 2014/15 and 2020/21. This provides both baseline power consumption and data points which can be compared to the growth in services GVA to establish an emissions intensity of ICT services trend. The volumes of energy consumption in data centres needed to deliver €1 million of GVA is falling by around 6% a year (reflecting significant efficiency improvements), while network power consumption intensity is rising at around 5% a year (reflecting the shift from fixed line to mobile and rising data transmission volumes).

While it seems plausible that this might be too optimistic for data centres, or too pessimistic for networks, the result is grounded in the existing literature and those upside and downside risks could be broadly balanced.

Volume of energy consumption is converted to emissions based on an average emissions intensity for coal and gas power generation,[30] weighted by their share in fossil fuel energy generation, and multiplied by the fossil fuel share in overall electricity generation for 2015 and 2030 under the central New Policies Scenario in the IEA World Energy Outlook.[31] Non-fossil fuel electricity generation is assumed to contribute zero emissions (those sources do generate some emissions, but not material for these purposes). This gives an overall emissions intensity of electricity generation which can be used as a multiplier for services power consumption.

Services supply chain

There is limited data on the supply chain for the ICT sector, with marked inconsistencies in reporting even among large businesses, and the supply chain (particularly services) is not modelled specifically for this report. However, a review of corporate reporting gives a sense of the scale, and a sample of those businesses that report Scope 3 emissions collected by Arabesque shows a ratio of 2.57:1 for Scope 3 to Scope 1 and 2 emissions among those companies.

This ratio would need to be adjusted for the share of ICT output (Scope 1 and 2) in the intermediate consumption of the ICT sector (and therefore its Scope 3 emissions). To put this more simply, Scope 1 or 2 emissions for an equipment manufacturer might be Scope 3 emissions for a telecommunications business. Analysis of US Supply and Use tables suggests that around 40% of intermediate consumption in the ICT sector is of its own output. Subtracting this proportion from the total, the ratio from Scope 1 and 2 to Scope 3 emissions would be 1:1.62. However, reflecting that the reporting of Scope 3 emissions is nascent and many categories are often not included, the multiplier could be adjusted up to an assumption of 1:2, i.e. the supply chain impact triples the estimate for services emissions.

Glossary

This provides definitions for key terms and acronyms used extensively through the report.

AI | Artificial intelligence: computer systems able to perform and even improve the efficiency of tasks normally requiring human intelligence, such as visual perception, speech recognition, decision making, and translation between languages.

AR | Augmented Reality: a technology that overlays computer-generated contextual information onto physical environments for users to see.

Autonomate | A portmanteau of autonomous and automate. Refers to integrating computers with the physical environment, creating entities that do not rely on human guidance or intervention. An autonomous system can learn and adapt to its environment, interact with humans and other objects and evolve as the environment around it changes.

Big data | Structured or unstructured data from diverse sources, in volumes too large for traditional technologies to capture, manage and process in a timely manner.

Blockchain | A digital distributed ledger technology, allowing for the secure management of shared ledgers where transactions are verified and stored on a network without a governing central authority.

Business-as-usual | For the quantified impact projections on the SDGs, the impact of digital technology refers to the difference between a business-as-usual scenario in 2030 and a scenario with higher digital technology adoption in 2030. The business-as-usual scenario projects the indicator to 2030 using either historic trends or third party projections, on the assumption that there are no significant changes from the status quo. That is, under the business-as-usual projections there are no notable deviations from the current paths of technology, policy, or infrastructure that would lead the variable away from its current path.

Capex | Capital expenditure: Money spent by a business or organisation on acquiring or maintaining fixed assets, such as land, equipment and hardware.

Cloud | The provision of highly scalable, advanced IT capabilities as hosted services. Typically on-demand and pay-as-you-go and including an ever widening breadth of capabilities including infrastructure, network, storage, computing power, applications and data.

Cognitive | The application of advanced analytics, machine learning and artificial intelligence (AI) approaches to datasets to develop humanlike insights.

CO2e | Carbon dioxide equivalent: a metric used to compare the emissions from various greenhouse gas emissions. It converts amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential.

Digital access | Connectivity between people and of people to the internet and / or each other via telecommunications infrastructure (fixed or mobile), devices (handheld devices and computers) and software.

Digital technology scenario | For the quantified impact projections on the SDGs, the digital technology scenario assumes that digital technology adoption increases above current levels, in the places where the most gains are to be made in achieving the goals, such that it is able to have a material impact on the SDG indicator or proxy indicator. The increase in adoption is in accordance with estimates in literature and validated by a survey of independent experts.

Digital twin | A digital replica of potential and actual physical assets (physical twin), processes, people, places, systems and devices.

Digital reality | A way of describing a wide spectrum of technologies and experiences that digitally simulate reality in one way or another across most of the senses. Includes virtual digital worlds or systems (Virtual Reality), or mixed virtual and physical worlds (Augmented Reality).

Economies of agglomeration | Benefits and resource sharing efficiencies arising resulting from the close proximity of people, housing and businesses and the associated economies of scale and network effects.

Ed Tech | Educational technology: The use of physical hardware, software, and educational theory to facilitate and improve learning.

Energy efficiency | For the purposes of this report, the UN interpretation of energy efficiency has been used, which relates to energy intensity levels; i.e. the amount of energy required to produce one unit of economic output.

Extreme poverty | The World Bank defines extreme poverty as living on less than $1.90 (USD) per person per day.

FAO | Food and Agriculture Organization of the United Nations

Fast internet | Next generation connectivity that provides speed, capacity and reliability at fundamentally higher levels including high-speed fixed broadband, 4G and 5G.

FGM | Female Genital Mutilation: a procedure where the female genitals are deliberately cut, injured or changed. There is no medical reason for this to be done.

GDP | Gross Domestic Product: The standard measure of value added through the production of goods and services in a country during a certain period.

GDP per capita | Total value of goods and services produced in a country during a certain period, divided by the total population of the country.

GHG | Greenhouse gases: Gases that absorb and emit radiant energy within the thermal infrared range. Primary greenhouse gases in Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide and ozone.

Gt / Mt | Gigatonnes / megatonnes: units that equate to billions and millions of metric tonnes (1000kg). In this report these are the typical metrics used for the measurement of GHG emissions.

GVA | Gross Value Added: Total output produced (which is typically equal to total revenues) less intermediate consumption, where intermediate consumption is the cost of goods and services used up in the process of production. GVA represents the sum of the wages, taxes and profits a sector supports.

ICT | Information and Communication Technologies

Industry 4.0 | Industry 4.0 is often used to describe data-driven, AI-powered, networked smart factories and supply chains as the harbingers of the fourth industrial revolution.

IoT | The Internet of Things: The suite of technologies enabling the connection of physical objects to the internet, and enabling communication from, and to, the object about the object's condition, position and surroundings.

IP | Intellectual Property: Intangible property that is the result of creativity, such as patents or trademarks.

ITU | International Telecommunication Union

LDCs | Least-developed countries: A group of countries that have been classified by the UN as "least developed" in terms of their low gross national income (GNI), their weak human assets and their high degree of economic vulnerability.

mHealth | The Global Observatory for eHealth defines mHealth or mobile health as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants and other wireless devices.

Machine learning | An application of AI that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it to learn for themselves.

Mobile money (mMoney) | The use of a mobile phone to transfer funds between banks or accounts, deposit or withdraw funds, or pay bills. This term is also used for the broader realm of electronic commerce, i.e. the use of a mobile device to purchase items. Mobile money removes the reliance on a traditional bank account and need for paper money.

NEET | Not in Education, Employed or in Training: Applies to those not considered to be in any form of education and training (e.g. educational classes or apprenticeships) or employment, which includes the unemployed but also those who are economically inactive, i.e. not looking for or available to work.

PM2.5 | Tiny particles in the air measuring less than 2.5 microns in diameter that reduce visibility and cause the air to appear hazy when levels are elevated. By nature of the size of these particles, in large quantities they can become embedded in human airways and bloodstream, placing a burden on public health.

R&D | Research and Development

Scope 1 emissions | The direct GHG emissions that occur from sources that are owned or controlled by a company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.

Scope 2 emissions | Accounts for GHG emissions from the generation of purchased electricity consumed by a company. Scope 2 emissions physically occur at the facility where electricity is generated.

Scope 3 emissions | Incorporates all indirect emissions that occur in a company's value chain (excluding those under scope 2). They are a consequence of the activities of a company, but are outside of the company's ownership and control. Examples of scope 3 activities are extraction and production of purchased materials, and transportation of purchased fuels.

SDG | Sustainable Development Goal

SDG target | Each SDG is made up of a set of specific targets

SDG indicator | Each SDG target is made up of one or more indicators: suggested measures of target progress

SMARTer 2030 | Refers to GeSI's aspiration to realise its vision of a sustainable world through responsible, ICT-enabled transformation.

UNCDF | United Nations Capital Development Fund

UNDP | United Nations Development Programme

UNFCCC | United Nations Framework Convention on Climate Change

UNIDO | United Nations Industrial Development Organization

USAID | United States Agency for International Development

VR | Virtual Reality: a simulated experience that immerses users in artificial surroundings, replacing the users' real world environment.

WEF | World Economic Forum

WFP | World Food Programme

WHO | World Health Organization

Bibliography

A large number of sources are referenced throughout this report, often relating to specific topics or SDGs. However, a selection of key papers were drawn upon to guide the overarching research and production of the report. These are listed below.

Addressing sustainable development

Arneth, A., Barbosa, H. et al. (2019), *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.* IPCC. https://www.ipcc.ch/report/srccl/

International Council for Science (2017), *A guide to SDG interactions: From science to implementation.* https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf

Nilsson, M. (2016), *Understanding and mapping important interactions among SDGs.* https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf

Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G. (2019), *Sustainable Development Report 2019*. New York: Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN). https://s3.amazonaws.com/sustainabledevelopment.report/2019/2019_sustainable_development_report.pdf

Stockholm Resilience Centre and BI Norwegian Business School (2018), *Transformation is feasible: How to achieve the sustainable development goals within Planetary Boundaries*. https://www.stockholmresilience.org/download/18.51d83659166367a9a16353/1539675518425/Report_Achieving%20the%20Sustainable%20Development%20Goals_WEB.pdf

World Inequality Lab (2018), *World Inequality Report.* https://wir2018.wid.world/

The impact of digital technologies on the SDGs

Andrae, A.S.G., Edler, T. (2015), 'On Global Electricity Usage of Communication Technology: Trends to 2030'. *Challenges, 6*, 117-157. https://www.mdpi.com/2078-1547/6/1/117

Arizona State University, & Dell (2017), *The feasibility of mapping ICT initiatives to the UN sustainable development goals*. https://static.sustainability.asu.edu/giosMS-uploads/sites/15/2017/04/SDG-ICT-Final_Report_FINAL.pdf

Baldé, C.P., Forti V., Gray, V., Kuehr, R., Stegmann,P. (2017) *The Global E-waste Monitor – 2017*, United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna. https://www.itu.int/en/ITU-D/Climate-Change/Pages/Global-E-waste-Monitor-2017.aspx#FullReport

Chui, M., Chung, R. and van Heteren, A. (2019), *Using AI to help achieve Sustainable Development Goals*. https://www.undp.org/content/undp/en/home/blog/2019/Using_AI_to_help_achieve_Sustainable_Development_Goals.html

Deloitte Netherlands (2015), *Smart Cities: How rapid advances in technology are reshaping our economy and society*. https://www2.deloitte.com/content/dam/Deloitte/tr/Documents/public-sector/deloitte-nl-ps-smart-cities-report.pdf

Ericsson and The Earth Institute, Columbia University (2015), *ICT & SDGs: How information and communication technology can accelerate action on the SDGs*. https://www.ericsson.com/assets/local/about-ericsson/sustainability-and-corporate-responsibility/documents/ict-sdg.pdf

GeSI and Accenture Strategy (2015), *SMARTer 2030: ICT Solutions for 21st Century Challenges*. http://smarter2030.gesi.org/downloads/Full_report.pdf

GeSI and Accenture Strategy (2016), *#SystemTransformation – How Digital Solutions Will Drive Progress Towards the Sustainable Development Goals.* http://systemtransformation-sdg.gesi.org/160608_GeSI_SystemTransformation.pdf

GSMA (2018), *2018 Mobile Industry Impact Report: Sustainable Development Goals.* https://www.gsma.com/betterfuture/2018sdgimpactreport/

Huawei (2017), *ICT Sustainable Development Goals Benchmark.* http://www-file.huawei.com/-/media/CORPORATE/PDF/Sustainability/2017-ICT-sustainable-development-goals-benchmark-final-en.pdf

Huawei (2018), *Accelerating SDGs through ICT.* https://www.huawei.com/minisite/gci/assets/files/Huawei_2018_SDG_report_en.pdf

IEA (2017), *Digitalization & Energy.* https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf

International Development Research Centre (2017), *Unpacking the disruptive potential of blockchain technology for human development*. https://idl-bnc-idrc.dspacedirect.org/handle/10625/56662

ITU (2017), *Fast-forward progress: Leveraging tech to achieve the global goals.* https://www.itu.int/en/sustainable-world/Pages/report-hlpf-2017.aspx

ITU and Cisco (2016), *Harnessing the Internet of Things for global development.* https://www.itu.int/en/action/broadband/Documents/Harnessing-IoT-Global-Development.pdf

Malmodin, J., Lundén, D., (2018), 'The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010–2015'. *Sustainability 10*, 3027. https://www.mdpi.com/2071-1050/10/9/3027

Mas, M., Fernández De Guevara, J., Robledo, J.C., Righi, R., Cardona, M., Samoili, S., López Cobo, M. and De Prato, G. (2019) *The 2019 PREDICT Key Facts Report. An Analysis of ICT R&D in the EU and Beyond*. https://ec.europa.eu/jrc/en/publication/2019-predict-key-facts-report

Rocamora, A. R. and Aryanie A. (2018), *Blockchain applications and the sustainable development goals: Analysis of blockchain technology's potential in creating a sustainable future. https://www.researchgate.net/publication/327338538_Blockchain_Applications_and_the_Sustainable_Development_Goals_-_Analysis_of_blockchain_technology's_potential_in_creating_a_sustainable_future*

Sorgner, A, Bode, E, Krieger-Boden, C. (2017), *The effects of digitalization on gender equality in the G20 economies.* https://www.ifw-kiel.de/publications/policy-papers/the-effects-of-digitalization-on-gender-equality-in-the-g20-economies-5134/

The World in 2050 (2018), *Transformations to Achieve the Sustainable Development Goals*. http://pure.iiasa.ac.at/15347

World Bank (2016), *World Development Report 2016: Digital Dividend.* https://www.worldbank.org/en/publication/wdr2016

World Energy Council (2018), *The role of ICT in energy efficiency management.* https://www.worldenergy.org/wp-content/uploads/2018/06/20180420_TF_paper_final.pdf

References

Key Messages

1. https://sustainabledevelopment.un.org/
2. Defined in this report as digital access, fast internet, cloud, IoT, cognitive, digital reality, and blockchain
3. The SR15 Report, IPCC, 2018

Executive Summary

1. This follows the Stockholm Resilience Centre's groupings of the SDGs https://www.stockholmresilience.org/
2. The SR15 Report, IPCC, 2018

Introduction

1. https://sustainabledevelopment.un.org/post2015/transformingourworld
2. https://www.socialprogress.org/assets/downloads/resources/2018/Progress-Against-the-SDGs.pdf
3. See GeSI and Accenture Strategy (2015) "SMARTer 2030: ICT Solutions for 21st Century Challenges", GeSI and BCG (2012) "GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future" and GeSI and The Climate Group (2008) "SMART2020: Enabling the Low Carbon Economy in the Information Age"
4. See GeSI and Accenture Strategy (2018) "Enabling the Global Goals: Evidence of digital solutions' impact on achieving the Sustainable Development Goals (SDGs) and GeSI and Accenture Strategy (2016) "#SystemTransformation – How Digital Solutions Will Drive Progress Towards the Sustainable Development Goals"
5. This follows the Stockholm Resilience Centre's groupings of the SDGs https://www.stockholmresilience.org/
6. Additional detail on the methodology employed can be found in the Appendix.

1 Digital Technologies

1. https://www.un.org/sg/en/content/sg/speeches/2018-09-25/address-73rd-general-assembly
2. https://www2.deloitte.com/insights/us/en/focus/internet-of-things/technical-primer.html
3. https://www2.deloitte.com/insights/us/en/focus/cognitive-technologies/what-is-cognitive-technology.html
4. https://www2.deloitte.com/insights/us/en/focus/big-data.html
5. https://www2.deloitte.com/insights/us/en/topics/emerging-technologies/digital-reality-technical-primer.html
6. https://www2.deloitte.com/insights/us/en/focus/signals-for-strategists/trends-blockchain-bitcoin-security-transparency.html
7. https://www.itu.int/ITU-D/ict/dai/
8. http://digitalaccessindex-sdg.gesi.org/digital-access-index/
9. https://www.itu.int/en/mediacentre/Pages/2018-PR40.aspx
10. https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx
11. http://digitalaccessindex-sdg.gesi.org/digital-access-index/
12. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2019/07/GSMA-State-of-Mobile-Internet-Connectivity-Report-2019.pdf
13. http://uis.unesco.org/en/blog/global-framework-measure-digital-literacy
14. https://www.oecd.org/site/schoolingfortomorrowknowledgebase/themes/ict/bridgingthedigitaldivide.htm
15. http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/573884/EPRS_BRI(2015)573884_EN.pdf
16. https://worldin2019.economist.com/digitaldivide
17. https://www.itu.int/en/mediacentre/backgrounders/Pages/5G-fifth-generation-of-mobile-technologies.aspx
18. https://www.ericsson.com/en/mobility-report/population-coverage
19. https://www.itu.int/en/mediacentre/backgrounders/Pages/5G-fifth-generation-of-mobile-technologies.aspx
20. https://www2.deloitte.com/content/dam/Deloitte/br/Documents/technology/DI_TechTrends2019.pdf
21. https://www.gsma.com/newsroom/press-release/new-gsma-study-5g-to-account-for-15-of-global-mobile-industry-by-2025/
22. https://www.itu.int/en/mediacentre/backgrounders/Pages/5G-fifth-generation-of-mobile-technologies.aspx
23. https://www2.deloitte.com/insights/us/en/industry/retail-distribution/potential-of-cloud-technology-adoption-consumer-products.html
24. https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/technology/deloitte-uk-tech-trends-2019-chapter1-macrotech.pdf
25. https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Technology/gx-tech-cloud-myths-report.pdf
26. Deloitte analysis
27. https://www2.deloitte.com/content/dam/insights/us/articles/iot-primer-iot-technologies-applications/DUP_1102_InsideTheInternetOfThings.pdf ; https://medium.com/iotforall/iot-connectivity-101-3f6fcee49a17
28. https://www2.deloitte.com/content/dam/insights/us/articles/iot-primer-iot-technologies-applications/DUP_1102_InsideTheInternetOfThings.pdf
29. https://www2.deloitte.com/content/dam/insights/us/articles/4420_IoT-primer/DI_IoT-Primer.pdf
30. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/digital-industrial-transformation-industrial-internet-of-things.html
31. Deloitte, 2015. "Smart Cities: How rapid advancements in technology are reshaping our economy and society". Gov Lab, Version 1.
32. https://www2.deloitte.com/content/dam/insights/us/articles/4420_IoT-primer/DI_IoT-Primer.pdf
33. https://www.forbes.com/sites/louiscolumbus/2018/12/13/2018-roundup-of-internet-of-things-forecasts-and-market-estimates/#2d7cba4b7d83
34. https://www2.deloitte.com/content/dam/insights/us/articles/4420_IoT-primer/DI_IoT-Primer.pdf
35. https://www2.deloitte.com/us/en/pages/technology-media-and-telecommunications/articles/cyber-risk-in-an-internet-of-things-world-emerging-trends.html
36. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/digital-industrial-transformation-industrial-internet-of-things.html
37. https://www2.deloitte.com/insights/us/en/focus/cognitive-technologies/what-is-cognitive-technology.html
38. https://www2.deloitte.com/insights/us/en/focus/big-data.html
39. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/regulatory/us-director-advisory-real-deal-with-big-data-013015.pdf
40. https://www2.deloitte.com/insights/us/en/focus/cognitive-technologies/technical-primer.html
41. https://www2.deloitte.com/insights/us/en/focus/cognitive-technologies/technical-primer.html
42. https://www2.deloitte.com/nl/nl/pages/deloitte-analytics/articles/part-1-artificial-intelligence-defined.html
43. https://www2.deloitte.com/content/dam/Deloitte/in/Documents/strategy/in-strategy-innovation-artificial-intelligence-next-bold-play-noexp.pdf
44. Gartner Hype Cycle for Artificial Intelligence 2019
45. https://www2.deloitte.com/insights/us/en/focus/cognitive-technologies/technical-primer.html#endnote-sup-7
46. https://www2.deloitte.com/insights/us/en/topics/emerging-technologies/digital-reality-technical-primer.html
47. https://www.statista.com/statistics/591181/global-augmented-virtual-reality-market-size/
48. Gartner Top 10 Strategic Technology Trends for 2019: Immersive Experience
49. https://www2.deloitte.com/insights/us/en/focus/tech-trends/2018/immersive-technologies-digital-reality.html
50. https://www2.deloitte.com/insights/us/en/topics/emerging-technologies/blockchain-technical-primer.html
51. Blockchain for social impact – Stanford University report
52. https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/Innovation/deloitte-uk-what-is-blockchain-2016.pdf
53. https://www2.deloitte.com/content/dam/insights/us/articles/trends-blockchain-bitcoin-security-transparency/DUP_1381_Beyond-bitcoin_SFS_vFINAL.pdf
54. https://www.ibm.com/blogs/blockchain/2017/05/the-difference-between-public-and-private-blockchain/
55. https://www2.deloitte.com/content/dam/insights/us/articles/trends-blockchain-bitcoin-security-transparency/DUP_1381_Beyond-bitcoin_SFS_vFINAL.pdf
56. Gartner Blockchain Status 2018: Market Adoption Reality
57. https://www.gsb.stanford.edu/faculty-research/publications/blockchain-social-impact
58. https://www2.deloitte.com/content/dam/Deloitte/se/Documents/risk/DI_2019-global-blockchain-survey.pdf
59. https://media.consensys.net/gartner-blockchain-will-deliver-3-1-trillion-dollars-in-value-by-2030-d32b79c4c560
60. https://www.pwc.com/gx/en/issues/blockchain/blockchain-in-business.html
61. https://www.theverge.com/2019/7/4/20682109/bitcoin-energy-consumption-annual-calculation-cambridge-index-cbeci-country-comparison
62. Deloitte, 2015. "Smart Cities: How rapid advancements in technology are reshaping our economy and society". Gov Lab, Version 1.
63. mMoney: Mobile Money; eEducation: E-education
64. https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/technology/deloitte-uk-tech-trends-2019-chapter1-macrotech.pdf
65. Deloitte, 2015. "Smart Cities: How rapid advancements in technology are reshaping our economy and society". Gov Lab, Version 1.
66. https://www2.deloitte.com/content/dam/Deloitte/hu/Documents/process-and-operations/gx-fsi-automation-here-to-stay.pdf

2.1 Biosphere

1. https://www.nationalgeographic.org/encyclopedia/biosphere/
2. https://sustainabledevelopment.un.org/post2015/transformingourworld
3. https://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/the-nine-planetary-boundaries.html
4. https://www.stockholmresilience.org/research/planetary-boundaries.html
5. Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist
6. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf
7. https://www.scientificamerican.com/article/co2-emissions-reached-an-all-time-high-in-2018/ https://www.iea.org/statistics/co2emissions/
8. https://www.noaa.gov/news/2018-was-4th-hottest-year-on-record-for-globe
9. https://azure.microsoft.com/en-gb/blog/using-ai-and-iot-for-disaster-management/
10. https://www.nytimes.com/2018/09/09/world/asia/green-climate-fund-global-warming.html
11. https://www.unwater.org/publication_categories/sdg-6-synthesis-report-2018-on-water-and-sanitation/
12. https://www.un.org/sustainabledevelopment/water-and-sanitation/
13. https://sustainabledevelopment.un.org/sdg6
14. https://www.unwater.org/publication_categories/sdg-6-synthesis-report-2018-on-water-and-sanitation/
15. https://sustainabledevelopment.un.org/sdg14
16. https://sustainabledevelopment.un.org/sdg14
17. https://sustainabledevelopment.un.org/sdg14
18. https://sustainabledevelopment.un.org/sdg14
19. https://www.ipbes.net/system/tdf/spm_3bi_ldr_digital.pdf?file=1&type=node&id=28335
20. https://sustainabledevelopment.un.org/sdg15
21. https://sustainabledevelopment.un.org/sdg15
22. These abatement figures are the result of impacts estimated for SDG 7 (renewable energy), SDG 2 (smart agriculture), SDG 12 (smart solutions to reduce food waste in the supply chain), SDG 11 (intelligent transport systems in cities), SDG 15 (detection of illegal logging and cloud enabled data analysis), and SDG 9 (Industry 4.0). Further detail on the estimation of each of these impacts can be found in the appendix. Note that any differences are due to rounding.
23. This estimate uses data from the FAO Aquastat dataset, FAO OECD Agricultural Outlook and UN population forecasts. The rates of impact and adoption are based on a review of the literature, validated by a survey of experts. See the [technical appendix] for more detail.
24. This estimate uses data from the World Health Organisation, and the rates of impact and adoption are based on a review of the literature, validated by a survey of experts. See the [technical appendix] for more detail.
25. https://www.weforum.org/agenda/2018/07/fish-stocks-are-used-up-fisheries-subsidies-must-stop/
26. This estimate uses data from the FAO, and the rates of impact and adoption are based on a survey of experts. See the [technical appendix] for more detail.
27. https://www.woodlandtrust.org.uk/mediafile/100523043/RR-WT-060315-economic-benefits-woodland.pdf
28. This estimate uses data from the FAO, and the rates of impact and adoption are based on a survey of experts. See the [technical appendix] for more detail.
29. https://waitrose.pressarea.com/pressrelease/details/78/NEWS_13/10259 (also: 80m people in China watched Blue Planet II https://www.bbc.co.uk/mediacentre/worldwide/2017/blue-planet-2-tencent-china)
30. https://www.peta.org/blog/peta-using-emerging-technology-cultivate-empathy-animals/
31. https://www.huffingtonpost.co.uk/entry/how-virtual-reality-tech-will-help-the-environment_uk_59a7f038e4b010ca289a8578?guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAH7F4qJLeFjE3ILcZd39gJRqyCnq7EQaZyG7apwCy30UYtE-uRc4VcCgKbkZpIqfnVt3Z05wyl1eY9UG9o2695ulD9vnVZ_DYaFZRRQlG3IhB8CcjleYNipg9X3dxKGXej5Sp9vChSJ1k2Iuh3iaRlwTYZk5qwZF0ftst39Vdbvr&guccounter=2
32. https://www.internetofelephants.com/wildeverse
33. https://aftershock.wateraid.org/
34. WASH stands for Water Supply, Sanitation and Hygiene. The aims for a basic WASH system, outlined by UNICEF prior to the inception of the SDGs were: 1) no one practices open defecation; 2) everyone has safe water, sanitation and hygiene at home; 3) all schools and health centres have water, sanitation and hygiene; and 4) water, sanitation and hygiene are sustainable and inequalities have been progressively eliminated. https://www.unicef.org/wash/files/1_WSSCC_JMP_Fact_Sheets_1_UK_LoRes.pdf
35. http://fortune.com/2017/11/21/virtual-reality-charities-donations/
36. https://www.ciria.org/News/CIRIA_news2/New_working_with_wildlife_app.aspx https://www.nature.org/en-us/what-we-do/our-priorities/provide-food-and-water-sustainably/food-and-water-stories/fishpath/
37. https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2018-26/nhess-2018-26.pdf https://www.preparecenter.org/topics/social-media-disasters https://www.ifrc.org/en/what-we-do/beneficiary-communications/tera/ https://www.ifrc.org/Global/ifrc.org/news/TERA%20Product%20Description%20Final.pdf
38. https://www.scienceforconservation.org/science-in-action/fishpath
39. https://gesi.org/report/detail/gesi-smarter2020-the-role-of-ict-in-driving-a-sustainable-future
40. https://www.goldstandard.org/sites/default/files/documents/cli_report_dec18.pdf
41. https://www.carbonx.ca/#goodcoins
42. https://www.t-systems.com/de/en/solutions/collaboration/collaboration-solutions/ucc/unified-communication-and-collaboration-147388
43. https://www.dezeen.com/2019/05/03/doconomy-climate-change-credit-card/
44. https://www.wri.org/blog/2017/02/pay-you-go-solar-could-electrify-rural-africa https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2018/08/Key-trends-in-mobile-enabled-water-services-What%E2%80%99s-working-and-what%E2%80%99s-next.pdf
45. https://thewaterproject.org/why-water/poverty
46. https://www.ewaterpay.com/
47. https://www.gsma.com/iot/wp-content/uploads/2016/10/Cost-Effective-Care-for-the-Environment-1.pdf https://www.dutchwatersector.com/news/indymo-underwater-drone-collects-water-quality-data-in-niger-river-mali
48. https://newsroom.ibm.com/2019-02-08-State-of-California-Tackles-Drought-with-IoT-Blockchain https://www.wired.com/story/how-blockchain-could-protect-californias-aquifer/
49. https://www.seafoodsource.com/news/environment-sustainability/trinidad-and-tobago-fishers-hope-water-monitoring-buoy-will-ease-oil-spill-fears
50. https://www.provenance.org/tracking-tuna-on-the-blockchain#pilot-phase-1https://gcn.com/articles/2019/01/10/ai-disaster-response.aspx
51. https://www.provenance.org/tracking-tuna-on-the-blockchain#pilot-phase-1 https://www.worldwildlife.org/pages/bait-to-plate
52. http://www.oneworld.net/updates/news/artificial-intelligence-linked-success-sdgs
53. https://www.unitedutilities.com/corporate/newsroom/latest-news/united-utilities-signs-ai-deal-in-uk-first/
54. http://sitn.hms.harvard.edu/flash/2017/artificial-intelligence-will-revolutionize-energy-industry/
55. https://www.smartgrid.gov/files/The_Smart_Grid_Estimation_Energy_CO2_Benefits_201011.pdf
56. https://www.esa.int/ESA
57. https://www.microsoft.com/en-us/ai/ai-for-earth-projects?activetab=pivot1:primaryr3
58. https://hub.packtpub.com/ai-rescue-5-ways-machine-learning-can-assist-emergency-situations/
59. https://ellipsis-environmental.com/
60. http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf
61. http://forocilac.org/wp-content/uploads/2018/10/PolicyPapersCILAC2018-AmazonNobre.pdf
62. https://www.earthbankofcodes.org/
63. http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf
64. https://hub.packtpub.com/ai-rescue-5-ways-machine-learning-can-assist-emergency-situations/
65. http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf
66. https://theoceancleanup.com and https://permaculturenews.org/2017/04/17/pollution-eating-robots-help-protect-planet/
67. http://urbanriv.org/
68. https://www.hydropoint.com/resources/research-studies
69. https://muru-d.com/news/skygrows-blue-sky-vision-using-tree-planting-robots-to-fight-climate-change/
70. https://www.telekom.com/en/media/media-information/archive/deutsche-telekom-connects-street-lighting-479470
71. https://www.t-systems.com/de/en/industries/digitizing-ttl/solutions/public-transport/smart-solutions-for-public-transport-252574
72. https://theoceancleanup.com/about/
73. https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(17)30028-1/fulltext
74. https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(17)30028-1/fulltext
75. https://www.stockholmresilience.org/research/research-news/2015-01-15-planetary-boundaries---an-update.html https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf
76. https://www.vodafone.com/content/index/about/sustainability/energy-innovation/energy-innovation-in-our-operations.html
77. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018GL078202
78. https://e360.yale.edu/features/can-artificial-intelligence-help-build-better-smarter-climate-models https://pubs.giss.nasa.gov/abs/mo01100t.html https://blogs.ei.columbia.edu/2018/06/05/artificial-intelligence-climate-environment/
79. https://www.un.org/sustainabledevelopment/water-and-sanitation/
80. https://www.un.org/sustainabledevelopment/water-and-sanitation/
81. http://www.oxwater.uk/about.html
82. https://www.unicef.org/esa/sites/unicef.org.esa/files/2018-09/UNICEF-Somalia-2015-FN-Mobile.pdf
83. https://www.gsma.com/iot/wp-content/uploads/2016/10/Cost-Effective-Care-for-the-Environment-1.pdf
84. https://medium.com/descarteslabs-team/global-scale-water-monitoring-in-the-cloud-c38cb4e9fe56
85. https://www.suez.com/en/news/press-releases/on-connect-coach
86. https://www.oceanicinstitute.org/aboutoceans/aquafacts.html
87. https://www.weforum.org/agenda/2018/07/fish-stocks-are-used-up-fisheries-subsidies-must-stop/
88. https://planning.gov.tt/content/planning-ministry-collaborating-microsoft-fujitsu-digicel-and-fishing-community-curb-water
89. http://www.oceannetworks.ca/
90. https://oceanwealth.org/
91. https://www.oceanmind.global/
92. https://www.nature.org/en-us/what-we-do/our-priorities/provide-food-and-water-sustainably/food-and-water-stories/fishpath/
93. https://docktodish.com/
94. https://www.ipbes.net/system/tdf/spm_3bi_ldr_digital.pdf?file=1&type=node&id=28335
95. https://collect.earth/
96. https://www.silviaterra.com/bark/index.html

97. http://www.esa.int/Our_Activities/Observing_the_Earth/Space_for_our_climate/Satellite_data_instrumental_in_combating_desertification
98. http://www.eubrazilopenbio.eu/Pages/Home.aspx
99. https://rfcx.org/
100. http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf
101. https://www.nature.com/articles/s41559-018-0490-x
102. https://science.sciencemag.org/content/349/6250/827
103. https://www.thehindu.com/sci-tech/energy-and-environment/india-stares-at-pile-of-solar-e-waste/article26809672.ece
104. https://www.un.org/press/en/2019/ga12131.doc.htm

2.2 Society

1. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
2. https://sustainabledevelopment.un.org/post2015/transformingourworld
3. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
4. https://sustainabledevelopment.un.org/post2015/transformingourworld
5. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
6. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
7. https://sustainabledevelopment.un.org/post2015/transformingourworld
8. https://sustainabledevelopment.un.org/post2015/transformingourworld
9. https://sustainabledevelopment.un.org/sdg1
10. https://globalfindex.worldbank.org/
11. http://www.worldbank.org/en/news/feature/2016/10/14/promoting-land-rights-to-empower-rural-women-and-end-poverty
12. https://sustainabledevelopment.un.org/sdg1
13. https://sdg-tracker.org/zero-hunger
14. https://sustainabledevelopment.un.org/sdg2
15. http://www.winners-project.org/
16. http://www.fao.org/3/I9900EN/i9900en.pdf
17. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
18. https://sdg-tracker.org/good-health
19. https://sustainabledevelopment.un.org/sdg3
20. https://undocs.org/E/2019/68
21. https://sustainabledevelopment.un.org/sdg4
22. https://sustainabledevelopment.un.org/sdg4
23. http://uis.unesco.org/en/blog/tracking-literacy-increasingly-digital-world-0
24. https://sustainabledevelopment.un.org/sdg4
25. https://sustainabledevelopment.un.org/sdg7
26. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/2019-Tracking-SDG7-Report.pdf
27. https://sustainabledevelopment.un.org/sdg7
28. https://sustainabledevelopment.un.org/sdg11
29. https://sustainabledevelopment.un.org/sdg11
30. https://sustainabledevelopment.un.org/sdg11
31. https://sustainabledevelopment.un.org/sdg5
32. https://sustainabledevelopment.un.org/sdg5
33. https://sustainabledevelopment.un.org/sdg5
34. https://sustainabledevelopment.un.org/sdg16
35. https://sustainabledevelopment.un.org/sdg16
    https://sdg-tracker.org/peace-justice
36. https://worldjusticeproject.org/sites/default/files/documents/WJP%20Access%20to%20Justice-Online%20Version%20%281%29.pdf
37. Analysis of FAO Food Balance Sheets
38. This estimate uses data on production, yields and harvest area from the FAO and the FAO-OECD Agricultural Outlook. The rates of impact and adoption are based on a review of the literature, validated by a survey of experts. See the Methodology appendix for more detail.
39. https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9827.pdf
40. Global Burden of Disease Study 2017, Institute for Health Metrics Evaluation. Used with permission. All rights reserved.
41. This estimate uses data from the World Bank and Global Burden of Disease Study 2017, Institute for Health Metrics Evaluation (used with permission. All rights reserved). The rates of adoption are based on research by the WHO, and impacts are based on a meta-analysis of randomised control trials published in academic literature. See the Methodology appendix for more detail.
42. http://disde.minedu.gob.pe/bitstream/handle/123456789/4336/The%20Impact%20of%20Literacy%2c%20Numeracy%20and%20Computer%20Skills%20on%20Earnings%20and%20Employment%20Outcomes.pdf?sequence=1&isAllowed=y
43. This estimate uses data from the World Bank. The rates of adoption are based on research by UNESCO, and impacts are based on a meta-analysis of randomised control trials published in academic literature. See the Methodology appendix for more detail.
44. This estimate uses data from the World Bank. The rates of impact and adoption are based on a literature review, validated by a survey of experts. See the Methodology appendix for more detail.
45. https://www.un.org/en/development/desa/population/publications/database/index.asp
46. http://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf
47. This estimate uses data from the World Bank. The rates of impact and adoption are based on a literature review, validated by a survey of experts. See the Methodology appendix for more detail.
48. Due to data availability, the impact of digital technologies on gender equality is measured on target 3.7.1, proportion of women of reproductive age (aged 15-49 years) who have their need for family planning satisfied with modern methods which serves as a reasonable proxy to Target 5.6 Ensure universal access to sexual and reproductive health and reproductive rights.
49. This estimate uses data from the UN Global SDG Database and Global Burden of Disease Study 2017, Institute for Health Metrics Evaluation (used with permission. All rights reserved). The rates of adoption are based on research by the WHO, and impacts are based on a meta-analysis of randomised control trials published in academic literature. See the Methodology appendix for more detail.
50. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2017/01/Innovations-in-Mobile-Birth-Registration_Insights-from-Tigo-Tanzania-and-Telenor-Pakistan.pdf
51. Angola, Chad, Democratic Republic of the Congo, Bangladesh, Ethiopia, Guinea-Bissau, Somalia, Liberia, Malawi, United Republic of Tanzania, Zambia.
52. https://www.youtube.com/watch?v=cUChmbMiAeE
53. This hypothetical scenario assumes that the proportion of children under 5 years of age whose births have been registered with a civil authority could increase to 30.3% by 2030 through the targeted adoption of mobile birth registration. The status quo uses the current proportion of children with births registered. The dataset is sourced from the UN Statistics Division.
54. https://www.unodc.org/centralasia/en/news/over-10-000-people-participated-in-the-100-days-against-trafficking-in-persons-campaign-in-kyrgyzstan.html
55. https://eeas.europa.eu/delegations/kyrgyz-republic_en/57230/Kyrgyzstan%20youth%20movement%20steps%20up%20to%20say%20no%20to%20human%20trafficking
56. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
57. https://eit.europa.eu/news-events/news/eit-climate-kic-supported-winners-secures-over-eu15-million-funding
58. https://www.climathttps://www.climate-kic.org/success-stories/winners/e-kic.org/success-stories/winners/
59. https://www.climathttps://www.climate-kic.org/success-stories/winners/e-kic.org/success-stories/winners/
60. http://www.cgap.org/blog/m-pawa-1-year-mobile-banking-perceptions-use-tanzania
61. https://enterprise.verizon.com/resources/whitepapers/transforming-public-safety-with-safe-cities-technologies.pdf
62. https://www.researchgate.net/publication/327338538_Blockchain_Applications_and_the_Sustainable_Development_Goals_-_Analysis_of_Blockchain_technology's_potential_in_creating_a_sustainable_future
63. https://academic.oup.com/heapol/article/33/2/155/4616250
64. https://www.worldbank.org/en/news/feature/2017/09/20/in-pakistan-and-beyond-land-records-get-a-digital-upgrade
65. Interview with Deutsche Telekom, July 2019.
66. https://arxiv.org/abs/1807.00523
67. https://www.cytoreason.com/
68. https://www.civitaslearning.com/outcomes/
69. www.bbc.com/future/story/20140516-i-operate-on-people-400km-a
70. https://www.eonreality.com/portfolio-items/virtual-disaster-preparedness/
71. https://www.telekom.com/en/media/media-information/enterprise-solutions/farm-2-0-intelligent-pasture-fences-and-autonomous-machinery-362202
72. https://www.cr-report.telekom.com/site19/customers-products/sustainable-products-and-services#atn-15804-15812,atn-15804-16131
73. https://sustainabledevelopment.un.org/sdg1
74. Based on UN projections of the world population in 2030
75. https://juntosglobal.com/texting-people-out-of-poverty/
76. http://aon.mediaroom.com/news-releases?item=137772
77. https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf
78. https://sustainabledevelopment.un.org/sdg2
79. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
80. https://www.theguardian.com/environment/2015/dec/02/arable-land-soil-food-security-shortage
81. https://innovation.wfp.org/project/building-blocks
82. https://news.microsoft.com/en-in/features/child-growth-monitor-malnutrition-india-microsoft-ai/
83. https://grameenfoundation.org/what-we-do/agriculture/connect-farmers-finance
84. https://www.business.att.com/content/dam/attbusiness/reports/iot-precision-king-case-study.pdf
85. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
86. https://www.un.org/sustainabledevelopment/health/
87. https://www.un.org/sustainabledevelopment/health/
88. https://japantoday.com/category/features/health/ai-used-to-detect-fetal-heart-problems
89. https://broadbandcommission.org/Documents/publications/EpidemicPreparednessReport2018.pdf
90. https://www.healthtechevent.com/health-tech/new-medical-sensors-improve-health-outcomes-ebola-patients/
91. https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_574717/lang--en/index.htm
92. https://unesdoc.unesco.org/ark:/48223/pf0000246124
93. https://www.gov.uk/government/publications/essential-digital-skills-framework
94. https://education.microsoft.com/skype-in-the-classroom/overview
95. https://www.eduncle.com/
96. https://betterlesson.com/professional-learning/our-impact/
97. https://www.skillshare.com/about
98. https://www.swisscom.ch/dam/swisscom/en/about/media/publications/documents/cr-report-2011.pdf
99. https://www.pearson.com/corporate/sustainability/sustainability-stories/tomorrows-markets-incubator.html
100. https://lsi.ku.edu/project/virtual-reality-opportunities-to-integrate-social-skills-voiss
101. https://sustainabledevelopment.un.org/?page=view&nr=1473&type=230&menu=2059

102. https://acumen.org/wp-content/uploads/2017/07/Lean-Data-Report-Evdience-Review-On-Affordability.pdf
103. https://www.technologyreview.com/s/604227/blockchain-is-helping-to-build-a-new-kind-of-energy-grid/
104. https://www.sms-plc.com/insights/blogs-news/smart-meters-inspire-86-of-people-to-take-energy-saving-actions/
105. https://www.smartenergygb.org/en/resources/press-centre/press-releases-folder/smart-meter-usage-october-2017?tab=1&docspage=1
106. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
107. https://www.un.org/sustainabledevelopment/cities/
108. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-11.pdf
109. https://sustainabledevelopment.un.org/content/documents/197282018_background_notes_SDG_11_v3.pdf
110. http://www.interactivearchitecture.org/lab-projects/palimpsest
111. https://enterprise.verizon.com/en-gb/products/internet-of-things/smart-cities-and-communities/intelligent-traffic-management/
112. https://www.raconteur.net/technology/smart-city-data-management
113. http://www.fujitsu.com/au/about/resources/news/press-releases/2018/innovative-smart-drains-solution-reduces-risk-of-flooding.html
114. https://www.un.org/sustainabledevelopment/gender-equality/
115. https://sdg.iisd.org/news/global-index-finds-no-country-is-gender-equal/
116. https://www.un.org/sustainabledevelopment/gender-equality/
117. https://undocs.org/E/2019/68
118. https://www.reuters.com/article/us-moldova-trafficking-technology-blockc/scan-on-exit-can-Blockchain-save-moldovas-children-from-traffickers-idUSKBN1JF00J
119. http://www.npwj.org/content/Using-SMS-spread-message-FGM-illegal.html
120. www.cherieblairfoundation.org/business-women-mobile-service-in-nigeria/
121. https://www.sciencedirect.com/science/article/abs/pii/S0010782416301639
122. http://www.oecd.org/dac/accountable-effective-institutions/Achieving%20the%20Impossible%20can%20we%20be%20SDG16%20believers.pdf
123. https://www.worldbank.org/en/topic/governance/brief/anti-corruption
124. https://www.knightscope.com/knightscope-k5
125. http://www.businessfor2030.org/goal-16-promote-justice-1
126. https://www.unglobalcompact.org/docs/issues_doc/rule_of_law/B4ROL_Framework_Business_Examples.pdf
127. https://core.ac.uk/download/pdf/11049357.pdf
128. https://www.worldbank.org/en/topic/governance/brief/anti-corruption
129. https://goexplorer.org/birth-registration-using-smartphones/
130. https://www.constituteproject.org/
131. https://voatz.com/faq.html
132. https://www.ohchr.org/EN/NewsEvents/Pages/HumanRightsDefenders.aspx
133. https://www.un.org/sustainabledevelopment/progress-report/
134. https://sdg.iisd.org/news/global-index-finds-no-country-is-gender-equal/
135. https://www.sciencedaily.com/releases/2017/11/171130090041.htm
136. https://www2.deloitte.com/content/dam/Deloitte/tr/Documents/public-sector/deloitte-nl-ps-smart-cities-report.pdf
137. https://www.forbes.com/sites/forbestechcouncil/2017/06/19/the-problems-with-smart-cities/#f03a1216067f

2.3 Economy

1. https://www.collinsdictionary.com/dictionary/english/economy
2. https://sdg.guide/chapter-1-getting-to-know-the-sustainable-development-goals-e05b9d17801
3. https://sustainabledevelopment.un.org/content/documents/2754713_July_PM_2._Leaving_no_one_behind_Summary_from_UN_Committee_for_Development_Policy.pdf
4. https://sustainabledevelopment.un.org/sdg9
5. https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html
6. http://wedocs.unep.org/bitstream/handle/20.500.11822/25764/SDG12_Brief.pdf?sequence=1&isAllowed=y
7. https://www.ellenmacarthurfoundation.org/assets/downloads/Circular-Consumer-Electronics-FV.pdf
8. https://www.stockholmresilience.org/publications/artiklar/2018-10-17-transformation-is-feasible---how-to-achieve-the-sustainable--development-goals-within-planetary-boundaries.html
9. https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS
10. https://www.ilo.org/asia/media-centre/news/WCMS_627585/lang--en/index.htm
11. https://sustainabledevelopment.un.org/sdg8
12. https://sustainabledevelopment.un.org/sdg10
13. With data taken from China, Europe and the US
14. https://wir2018.wid.world/files/download/wir2018-full-report-english.pdf
15. https://www.weforum.org/agenda/2018/06/migrants-remittance-global-economic-force/
16. https://sustainabledevelopment.un.org/sdg10
17. https://sustainabledevelopment.un.org/sdg9
18. https://sustainabledevelopment.un.org/sdg9
19. https://sustainabledevelopment.un.org/sdg9
20. https://sustainabledevelopment.un.org/sdg12
21. https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management
22. https://sustainabledevelopment.un.org/sdg12
23. This estimate is based on analysis of the GSMA Global Mobile Money Dataset and Mobile cellular subscriptions (per 100 people) obtained from the World Bank. See the Methodology appendix for more detail.
24. http://remittanceprices.worldbank.org
25. This estimate uses data from the World Bank Remittance Prices Worldwide database. The analysis is based on a hypothetical scenario, which assumes corridors with no mobile services adopt mobile services; more detail is provided in the Methodology appendix.
26. https://www.un.org/en/events/family-remittances-day/un-action.shtml
27. This estimate uses data on manufacturing productivity from the UN Global SDG Database, plus an impact assessment based on impacts cited in the literature validated by a survey of experts. The impacts are estimated at the developed, developing and least-developed country level. See the Methodology appendix for more detail.
28. This estimate uses data on manufacturing productivity from the UN Global SDG Database, plus an impact assessment based on impacts cited in the literature validated by a survey of experts. The impacts are estimated at the developed, developing and least-developed country level. See the Methodology appendix for more detail.
29. http://www.fao.org/food-loss-and-food-waste/en/
30. This estimate uses data from the FAO Food Balance Sheets and the OECD-FAO Agricultural Outlook, plus an impact assessment at the developed and developing country level based on the observed impacts of the use cases and rates of adoption cited in the literature validated by a survey of experts. See the Methodology appendix for more detail.
31. http://www.fao.org/faostat/en/#data/FBS
32. https://creatoracademy.youtube.com/page/lesson/edu-channel-start
33. http://www.sdg.org/#about
34. https://www.change.org/p/tesco-ban-the-sales-of-eggs-from-caged-and-barn-kept-hens
35. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2015/06/DigitalLiteracy_v6_WEB_Singles.pdf
36. https://www.iom.int/migapp
37. https://gikibadges.com/
38. https://www.liberianobserver.com/news/mpw-mobile-app-for-citizens-report-infrastructure-issues/
39. https://www.tele2.com/media/news/sho-helping-newly-arrived-immigrants-and-swedish
40. https://labs.telstra.com/
41. https://www.unglobalcompact.org/library/5241
42. https://deloitte.wsj.com/cio/2018/06/15/how-cloud-can-boost-innovation-2/
43. https://www.nebengers.com/
44. https://olioex.com/about/our-impact/
45. https://www.bi.team/wp-content/uploads/2019/01/Annual-update-report-BIT-2017-2018.pdf
46. http://www.gigwalk.com/gigwalkers/
47. https://www.forbes.com/sites/juliewalmsley/2019/03/26/daimler-backed-ride-hail-app-beat-adds-service-in-colombia-and-peru/#7b456a3d6721
48. https://thebeatperu.zendesk.com/hc/en-us/articles/360019830373-New-Beat-Lite-service
49. https://www.vodafone.com/content/index/media/vodafone-group-releases/2017/m-pesa-10.html#
50. https://www.telegraph.co.uk/business/business-club/finance/mobile-finance-for-smes/
51. https://www.researchgate.net/publication/327338538_Blockchain_Applications_and_the_Sustainable_Development_Goals_-_Analysis_of_Blockchain_technology's_potential_in_creating_a_sustainable_future
52. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
53. https://www-file.huawei.com/-/media/corporate/pdf/sustainability/2017-huawei-sustainability-report-en.pdf?la=en-gb
54. https://www.vice.com/en_us/article/3daak3/how-iot-can-help-monitor-and-rebuild-aging-infrastructure
55. https://www.enevo.com/
56. https://www.fujitsu.com/au/solutions/business-technology/sustainability/smart-ewaste-bins/
57. https://www.researchgate.net/publication/328657407_A_Blockchain-Based_Decentralized_System_for_Proper_Handling_of_Temporary_Employment_Contracts
58. https://www.glassdoor.com/about-us/
59. https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/technology/lu-blockchain-internet-things-supply-chain-traceability.pdf
60. https://about.att.com/ecms/dam/csr/otherpdfs/ATT-Connected-Pallets-Case-Study-2017.pdf
61. https://www.wesustain.com/en/esg-portfolio-management-en/
62. https://cointelegraph.com/news/china-shenzhen-special-economic-zone-to-use-blockchain-for-electronic-tax-invoices
63. www.uport.me
64. https://www.unhcr.org/blogs/unhcr-accepting-proposals-digital-identity/
65. https://forrestbrown.co.uk/news/blockchain-technology-beyond-bitcoin/
66. www.uport.me
67. https://www2.deloitte.com/content/dam/Deloitte/es/Documents/tecnologia/Deloitte_ES_tecnologia_economic-and-social-impacts-of-google-cloud.pdf
68. https://www.pressroom.ups.com/pressroom/ContentDetailsViewer.page?ConceptType=Factsheets&id=1426321616277-282
69. https://cdn2.hubspot.net/hubfs/650776/AI%20Guide/AI%20Guide_2.pdf
70. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
71. https://www.datamaran.com/
72. https://www.wasteless.co/case-studies
73. https://www.sciencedirect.com/science/article/pii/S0924271618300479
74. https://www.sciencedirect.com/science/article/pii/S0924271618300479
75. https://www.newscientist.com/article/2138163-volunteers-teach-ai-to-spot-slavery-sites-from-satellite-images/
76. http://breakthrough.unglobalcompact.org/site/assets/files/1454/hhw-16-0017-d_c_artificial_intelligence.pdf
77. https://www.cio.com/article/3309058/5-ways-industrial-ai-is-revolutionizing-manufacturing.html

78. https://ai.google/research/teams/brain/
79. https://ai.google/research/pubs/pub48231
80. https://www.cio.com/article/3309058/5-ways-industrial-ai-is-revolutionizing-manufacturing.html
81. https://hbr.org/2017/03/augmented-reality-is-already-improving-worker-performance
82. https://www.spssanalyticspartner.com/case-study-santos
83. http://www.bce.ca/responsibility/corporate-responsibility/2018-cr-report/2018-csr-report.pdf
84. https://news.ewmfg.com/blog/the-future-of-virtual-reality-vr-in-manufacturing
85. https://hbr.org/2017/03/augmented-reality-is-already-improving-worker-performance
86. https://about.att.com/story/2018/aira_added_to_retail_stores.html
87. https://nomad-vr.com/
88. http://www.open.ac.uk/research/news/groundbreaking-new-ou-project-tackle-hate-
89. https://sgwdesignworks.com/virtual-reality-prototyping/
90. https://www.arup.com/perspectives/virtual-and-augmented-reality-changing-the-way-we-design-and-build-infrastructure
91. https://www2.deloitte.com/content/dam/insights/us/articles/4780_State-of-AI-in-the-enterprise/DI_State-of-AI-in-the-enterprise-2nd-ed.pdf
92. https://www.recyclingtoday.com/article/wasteexpo-2018-robots-ai-mrf/
93. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/smart-factory-connected-manufacturing.html?icid=dcom_promo_featured|il;en
94. https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/consultancy/deloitte-uk-the-robots-are-waiting.pdf
95. https://www.finextra.com/pressarticle/73218/simbapay-chatbot-powers-international-remittance-payments
96. https://migranet.io
97. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/smart-factory-connected-manufacturing.html?icid=dcom_promo_featured|il;en
98. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/smart-factory-connected-manufacturing.html?icid=dcom_promo_featured|il;en
99. https://goexplorer.org/
100. https://hbr.org/2017/03/augmented-reality-is-already-improving-worker-performance
101. This target has an important sustainability aspect, but due to its breadth, this is more properly captured in SDG 13.
102. https://www2.deloitte.com/content/dam/Deloitte/es/Documents/tecnologia/Deloitte_ES_tecnologia_economic-and-social-impacts-of-google-cloud.pdf
103. https://www.wamda.com/2016/10/home-cooked-food-finally-gets-taste-delivery-services-jordan
http://blogs.worldbank.org/developmenttalk/gig-economy-growth-pains
104. https://www.bi.team/wp-content/uploads/2019/01/Annual-update-report-BIT-2017-2018.pdf
105. https://www.reuters.com/article/us-Blockchain-coca-cola-labor/coca-cola-u-s-state-dept-to-use-Blockchain-to-combat-forced-labor-idUSKCN1GS2PY
106. https://hbr.org/2017/03/augmented-reality-is-already-improving-worker-performance
107. https://www.amdocs.com/mobile-financial-services
108. https://sustainabledevelopment.un.org/content/documents/2754713_July_PM_2._Leaving_no_one_behind_Summary_from_UN_Committee_for_Development_Policy.pdf
109. https://www-file.huawei.com/-/media/corporate/pdf/sustainability/2017-huawei-sustainability-report-en.pdf?la=en-gb
110. https://www.tele2.com/media/news/sho-helping-newly-arrived-immigrants-and-swedish
111. https://www.iom.int/migapp
112. https://www.finextra.com/pressarticle/73218/simbapay-chatbot-powers-international-remittance-payments
113. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-9.pdf
114. https://www.un.org/sustainabledevelopment/infrastructure-industrialization/
115. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
116. https://sdg.iisd.org/commentary/policy-briefs/how-can-progress-on-infrastructure-industry-and-innovation-contribute-to-achieving-the-sdgs/
117. https://www.bloomberg.com/news/articles/2019-05-20/google-glass-finds-a-new-home-at-the-factory
118. https://www.dgap.de/dgap/News/corporate/bewhere-holdings-inc-and-trakit-launch-miot-devices-and-solutions-bells-ltem-network/?newsID=1104307
119. https://climathon.climate-kic.org/en/
120. https://www.raconteur.net/technology/smart-city-data-management
121. https://www.bitbond.com/
122. https://www-file.huawei.com/-/media/corporate/pdf/sustainability/2018/2018-csr-report-en.pdf?la=en
123. https://www.getaround.com/
124. https://www.wasteless.co/case-studies
125. https://www.fujitsu.com/au/solutions/business-technology/sustainability/smart-ewaste-bins/
126. http://www.sdg.org/#about
127. For example, in alcohol: https://news.utexas.edu/2015/03/25/alcohol-advertising-has-little-effect-on-overall-consumption/
128. https://www.umweltbundesamt.de/publikationen/einfluss-der-nutzungsdauer-von-produkten-auf-ihre
129. https://www.bbc.co.uk/news/business-47691078
130. Of course, the flip side to this is the potential of new job creation through automation. Deloitte research in the UK, for example, has found that over "800,000 jobs have been lost but nearly 3.5 million new ones have been created".
131. https://www2.deloitte.com/uk/en/pages/risk/articles/winning-the-cyber-war.html
132. https://www.forgerock.com/resources/view/92170441/industry-brief/us-consumer-data-breach-report.pdf
133. https://www2.deloitte.com/us/en/pages/about-deloitte/articles/press-releases/deloitte-announces-new-cyber-threat-study-on-criminal-operational-cost.html

3 Sectors

1. Sectors were determined and distilled with reference several official sector designations, primarily the ILO's official Industries and Sectors designation and the MSCI's GUCS Industry Standard. The final list of the above 8 was created by combing sector designations on the basis of grouping industries that could potentially have a large impact against the SDGs using digital technologies, and who could work together in synergy to achieve such an impact.
2. https://www.humanium.org/en/identity/
3. https://blogs.worldbank.org/voices/global-identification-challenge-who-are-1-billion-people-without-proof-identity
4. https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_604882.pdf
5. http://www.fao.org/3/y4307e/y4307e04.htm
6. http://www.worldbank.org/en/news/feature/2016/10/14/promoting-land-rights-to-empower-rural-women-and-end-poverty
7. https://www.ifad.org/documents/38714170/39148759/Land+tenure+security+and+poverty+reduction.pdf/c9d0982d-40e4-4e1e-b490-17ea8fef0775
8. https://www.worldbank.org/en/news/feature/2016/10/14/promoting-land-rights-to-empower-rural-women-and-end-poverty
9. https://hms.harvard.edu/news/high-cost-preventable-deaths
10. https://www.un.org/en/development/desa/population/migration/publications/migrationreport/docs/MigrationReport2017_Highlights.pdf
11. https://www.unhcr.org/uk/figures-at-a-glance.html
12. http://uis.unesco.org/en/topic/out-school-children-and-youth
13. https://worldjusticeproject.org/sites/default/files/documents/Measuring%20the%20Justice%20Gap_WJP%20Update_Feb2019_Final-updated_0.pdf
14. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
15. https://unhabitat.org/sdg-11-synthesis-report/
16. https://unhabitat.org/sdg-11-synthesis-report/
17. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
18. https://azure.microsoft.com/en-gb/blog/using-ai-and-iot-for-disaster-management/
19. file:///K:/Corporate%20Finance/London/Chargeable%20Engagements/G/GeSI/B.%20Research/SDGs/SDG%2013/Disaster%20Relief/Disruptive-Technologies-Use-Disaster-Risk-Reduction-Mgmt.pdf
20. https://unctad.org/en/Pages/MeetingDetails.aspx?meetingid=1551
21. http://www.fao.org/3/I9900EN/i9900en.pdf
22. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
23. https://www.un.org/sustainabledevelopment/hunger/
24. https://www.weforum.org/agenda/2018/07/fish-stocks-are-used-up-fisheries-subsidies-must-stop/
25. https://sustainabledevelopment.un.org/sdg14
26. http://www.fao.org/3/I9900EN/i9900en.pdf
27. https://foodsource.org.uk/sites/default/files/chapters/pdfs/foodsource_chapter_3.pdf
28. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
29. https://www.un.org/sustainabledevelopment/hunger/
30. http://www.fao.org/3/I9900EN/i9900en.pdf
31. http://www.fao.org/3/I9900EN/i9900en.pdf
32. https://data.worldbank.org/indicator/SL.IND.EMPL.ZS
33. https://sustainabledevelopment.un.org/content/documents/2537IDR2018_FULL_REPORT_1.pdf
34. https://www.bond.org.uk/news/2019/05/no-time-to-waste-the-plastic-crisis-and-the-worlds-poorest
35. https://publications.parliament.uk/pa/cm201719/cmselect/cmenvaud/1952/report-files/195204.htm
36. https://www.nielsen.com/eu/en/insights/article/2018/global-consumers-seek-companies-that-care-about-environmental-issues/
37. http://wedocs.unep.org/bitstream/handle/20.500.11822/25764/SDG12_Brief.pdf?sequence=1&isAllowed=y
38. https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management
39. https://www.unenvironment.org/regions/north-america/regional-initiatives/minimizing-food-waste
40. https://www.washingtonpost.com/news/theworldpost/wp/2018/07/31/food-waste/?utm_term=.3d567f74e323
41. https://www.forbes.com/sites/solitairetownsend/2018/11/21/consumers-want-you-to-help-them-make-a-difference/#6e50a6296954

42. https://www.jrf.org.uk/blog/acting-unfair-poverty-premiums-must-be-2017-priority
43. https://www.worldbank.org/en/topic/poverty/overview
44. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/2019-Tracking-SDG7-Report.pdf
45. Accelerating SDG 7 Achievement: Policy Briefs (2018)
46. https://sustainabledevelopment.un.org/sdg6
47. http://wuf9.org/programme/special-sessions/access-to-basic-services-for-all/
48. https://www.bbc.co.uk/bitesize/guides/zpmmmp3/revision/1
49. https://www.who.int/news-room/fact-sheets/detail/drinking-water
50. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/2019-Tracking-SDG7-Report.pdf
51. https://www.un.org/en/climatechange/un-climate-summit-2019.shtml
52. https://www.theguardian.com/environment/2018/dec/05/brutal-news-global-carbon-emissions-jump-to-all-time-high-in-2018
53. https://gflec.org/wp-content/uploads/2015/11/3313-Finlit_Report_FINAL-5.11.16.pdf?x28148
54. https://howmuch.net/articles/financial-literacy-around-the-world
55. https://gflec.org/wp-content/uploads/2015/11/3313-Finlit_Report_FINAL-5.11.16.pdf?x28148
56. https://www.adb.org/sites/default/files/publication/190672/adbi-wp591.pdf
57. https://www.greenbiz.com/article/why-mobilizing-private-capital-towards-sdgs-good-business
58. https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Life-Sciences-Health-Care/gx-lshc-hc-outlook-2019.pdf
59. https://www.who.int/news-room/detail/13-12-2017-world-bank-and-who-half-the-world-lacks-access-to-essential-health-services-100-million-still-pushed-into-extreme-poverty-because-of-health-expenses
60. https://www.unaids.org/en/topic/gender
61. https://bmjopen.bmj.com/content/8/9/e023013
62. https://www.lloyds.com/news-and-risk-insight/risk-reports/Library/Understanding-risk/Global-underinsurance-report
63. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5180358/
64. https://www.who.int/news-room/detail/13-12-2017-world-bank-and-who-half-the-world-lacks-access-to-essential-health-services-100-million-still-pushed-into-extreme-poverty-because-of-health-expenses
65. https://www.nap.edu/read/13444/chapter/1#iv
66. https://www.who.int/gpsc/country_work/gpsc_ccisc_fact_sheet_en.pdf
67. https://www.who.int/news-room/detail/05-07-2018-low-quality-health care-is-increasing-the-burden-of-illness-and-health-costs-globally
68. https://www.unglobalcompact.org/take-action/action/transportation-sector
69. https://www.scania.com/group/en/delivering-on-the-sdgs-through-sustainable-transport/
70. https://ec.europa.eu/clima/policies/transport_en
71. https://www.scania.com/group/en/delivering-on-the-sdgs-through-sustainable-transport/
72. https://unhabitat.org/sdg-11-synthesis-report/
73. https://www.c2es.org/content/international-emissions/
74. https://sustainabledevelopment.un.org/content/documents/8656Analysis%20of%20transport%20relevance%20of%20SDGs.pdf
75. https://unhabitat.org/sdg-11-synthesis-report/
76. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/780868/future_of_mobility_final.pdf
77. https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries
78. https://home.kpmg/content/dam/kpmg/xx/pdf/2017/05/sdg-transportation.pdf
79. https://sustainabledevelopment.un.org/content/documents/197282018_background_notes_SDG_11_v3.pdf
80. https://www.theguardian.com/public-leaders-network/2017/jun/06/transport-failing-disabled-people-new-technology-help
81. https://www.iea.org/publications/reports/globalevoutlook2019/
82. https://www.wttc.org/about/media-centre/press-releases/press-releases/2019/travel-tourism-continues-strong-growth-above-global-gdp/
83. https://www.wttc.org/about/media-centre/press-releases/press-releases/2019/travel-tourism-continues-strong-growth-above-global-gdp/
84. https://www.theguardian.com/sustainable-business/six-reasons-mass-tourism-unsustainable
85. https://ourworldindata.org/tourism
86. https://www.nationalgeographic.co.uk/travel/2018/08/overtourism-how-combat-its-effects
87. http://www.sustainablesids.org/wp-content/uploads/2018/10/UNWTO-Inclusive-Tourism-Report-2018.pdf
88. https://www.wttc.org/-/media/files/reports/policy-research/coping-with-success---managing-overcrowding-in-tourism-destinations-2017.pdf
89. https://www.wttc.org/-/media/files/reports/policy-research/coping-with-success---managing-overcrowding-in-tourism-destinations-2017.pdf
90. http://cf.cdn.unwto.org/sites/all/files/pdf/global_report_inclusive_tourism_destinations_en_web_0.pdf
91. https://www.climate2020.org.uk/the-road-to-cleaner-transport/
92. https://www.atag.org/facts-figures.html
93. https://news.nationalgeographic.com/news/2010/10/101005-planes-pollution-deaths-science-environment/
94. https://www.scmp.com/magazines/post-magazine/travel/article/2147435/six-leading-causes-tourist-deaths-and-how-avoid

4 Geographies

1. https://unstats.un.org/unsd/methodology/m49
https://esa.un.org/MigFlows/Definition%20of%20regions.pdf
https://esa.un.org/poppolicy/ExplanatoryNotes.aspx
2. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf
3. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf
4. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap29_FINAL.pdf
5. https://www.theguardian.com/cities/ng-interactive/2017/nov/03/three-degree-world-cities-drowned-global-warming
6. https://webstore.iea.org/co2-emissions-from-fuel-combustion-2018-highlights
7. https://unctad.org/en/Pages/ALDC/Least%20Developed%20Countries/UN-list-of-Least-Developed-Countries.aspx
8. https://www.brookings.edu/blog/future-development/2019/03/28/poverty-in-africa-is-now-falling-but-not-fast-enough/
9. https://data.unicef.org/topic/education/primary-education/
10. https://data.worldbank.org/indicator/SE.PRM.NENR
11. https://www.un.org/sustainabledevelopment/infrastructure-industrialization/
12. https://unstats.un.org/sdgs/indicators/database/
13. https://blog.lendoit.com/alternative-online-financing-for-development-in-africa-3a016e5e7632
14. https://www.worldhunger.org/africa-hunger-poverty-facts-2018/
15. http://www.winners-project.org/
16. https://www.odi.org/publications/7453-leaping-and-learning-linking-smallholders-markets
17. https://www.who.int/gho/maternal_health/mortality/maternal/en/index1.html
18. https://data.unicef.org/topic/maternal-health/maternal-mortality/
19. https://www.who.int/gho/maternal_health/skilled_care/skilled_birth_attendance_text/en/ and https://www.who.int/news-room/fact-sheets/detail/newborns-reducing-mortality
20. Please see appendix on SDG 3 for details.
21. Based on UN estimates, medium fertility variant. https://population.un.org/wpp/Download/Standard/Fertility/
22. https://sdgcafrica.org/wp-content/uploads/2019/07/AFR-SDGS-REPORT-FINAL.pdf
23. http://www.africa.undp.org/content/rba/en/home/sustainable-development-goals/goal-6-clean-water-and-sanitation.html
24. https://data.worldbank.org/indicator/SI.POV.NAHC?locations=HR
25. https://www.un.org/en/development/desa/population/publications/pdf/popfacts/PopFacts_2017-9.pdf
26. https://www.unescap.org/sites/default/files/SDG_04_ESCAP_SYB2016_SDG_baseline_report.pdf
27. https://www.unescap.org/sites/default/files/publications/ESCAP_Asia_and_the_Pacific_SDG_Progress_Report_2019.pdf
28. https://sdg.iisd.org/news/asia-pacific-not-on-track-to-achieve-any-sdgs-by-2030/
29. https://borgenproject.org/facts-about-poverty-in-asia/
30. https://www.unescap.org/sites/default/files/SDG_04_ESCAP_SYB2016_SDG_baseline_report.pdf
31. https://www.unescap.org/sites/default/files/SDG_04_ESCAP_SYB2016_SDG_baseline_report.pdf
32. https://qz.com/india/247389/teachers-who-dont-show-up-to-work-cost-india-1-5-billion-a-year/
https://www.povertyactionlab.org/evaluation/encouraging-teacher-attendance-through-monitoring-cameras-rural-udaipur-india
33. https://www.povertyactionlab.org/evaluation/encouraging-teacher-attendance-through-monitoring-cameras-rural-udaipur-india
34. https://www.huawei.com/-/media/CORPORATE/Images/PDF/v2-smart-agriculture-0517.pdf?la=en
35. https://www.airvisual.com/world-most-polluted-cities/world-air-quality-report-2018-en.pdf
36. https://www.who.int/sustainable-development/transport/health-risks/air-pollution/en/
37. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health
38. https://www.who.int/sustainable-development/transport/health-risks/air-pollution/en/
39. https://www.sei.org/featured/air-pollution-solutions-asia/
40. https://www.zte.com.cn/global/about/news/0222ma.html
41. https://www.nokia.com/about-us/news/releases/2018/10/04/nokia-demonstrates-ioc-solution-to-viettel-for-effective-management-of-smart-and-safe-city-operations-in-vietnam/
42. http://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf
43. https://www.iucn.org/commissions/commission-ecosystem-management/regions/oceania
44. http://worldpopulationreview.com/continents/oceania-population/
45. https://www.worldometers.info/world-population/australia-population/ and https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?end=2018&locations=NZ-AU-FJ-VU-FM&start=1998
46. https://www.adb.org/countries/micronesia/poverty
47. https://countryeconomy.com/demography/literacy-rate/solomon-islands
48. https://data.worldbank.org/indicator/SE.SEC.ENRR and https://data.worldbank.org/indicator/SE.SEC.NENR?locations=FM-AU-KI-VU
49. https://www.adb.org/sites/default/files/publication/428221/ict-education-pacific.pdf

50. https://eduze.com/
51. https://www.internetworldstats.com/stats6.htm
52. https://www.gsma.com/r/mobileeconomy/pacific-islands/
53. http://unpan1.un.org/intradoc/groups/public/documents/apcity/unpan046588.pdf
54. https://www.worldbank.org/en/news/feature/2018/06/11/micro-connections-connecting-the-federated-states-of-micronesia
55. https://www.newsecuritybeat.org/2018/07/family-planning-big-progress-sustainable-development-goals-and-heres/
http://researchonline.lshtm.ac.uk/3894556/
56. https://www.un.org/en/development/desa/population/publications/pdf/family/WFP2017_Highlights.pdf
57. Please see appendix on SDG 5 for details.
58. https://www.ippf.org/sites/default/files/2016-11/SDG%20and%20FP2020.pdf
59. Note this excludes some large countries in Oceania such as Australia, New Zealand and Fiji for which data from the World Bank is unavailable.
60. http://uis.unesco.org/en/blog/meet-sdg-4-data-measuring-youth-and-adult-literacy-and-numeracy
61. https://blogs.worldbank.org/edutech/promoting-literacy-mobile-phones-rural-papua-new-guinea
62. Please see appendix on SDG 4 for details.
63. https://www.cepal.org/en/pressreleases/poverty-latin-america-remained-steady-2017-extreme-poverty-increased-highest-level
64. http://povertydata.worldbank.org/poverty/region/LCN
65. https://www.cepal.org/en/pressreleases/poverty-latin-america-remained-steady-2017-extreme-poverty-increased-highest-level
66. http://accesstohealthcare.eiu.com/wp-content/uploads/sites/42/2017/06/AccesstohealthcareinLatinAmerica.pdf
67. http://accesstohealthcare.eiu.com/wp-content/uploads/sites/42/2017/06/AccesstohealthcareinLatinAmerica.pdf
68. https://unstats.un.org/sdgs/report/2017/goal-16/
69. https://undg.org/wp-content/uploads/2018/09/Challenges-and-Strategies-for-Sustainable-Development-in-Latin-America-and-the-Caribbean.pdf
70. https://unstats.un.org/sdgs/report/2016/goal-15/
71. https://www.dur.ac.uk/news/newsitem/?itemno=35289
72. Please see appendix on SDG 15 for details.
73. https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2019/02/Henry-Bridging-Digital-Divide.pdf
74. https://blog.global.fujitsu.com/fgb/2019-06-21/research-of-fetal-cardiac-ultrasound-screening-using-ai/
75. http://www.fao.org/americas/noticias/ver/en/c/239392/
https://www.worldbank.org/en/news/feature/2015/11/12/food-waste-habit-harming-latin-america
https://www.forbes.com/sites/daphneewingchow/2019/03/29/food-waste/#4423ab9372e6
76. http://www.fao.org/food-loss-and-food-waste/en/
77. http://www.fao.org/americas/noticias/ver/en/c/239392/
78. http://agenciabrasil.ebc.com.br/en/economia/noticia/2015-04/un-wants-cut-food-wastage-brazil
79. http://www.fao.org/3/a-i5504e.pdf
80. Please see appendix on SDG 12 for details.
81. https://www.unric.org/en/food-waste/27133-one-third-of-all-food-wasted
82. http://sindesperdicio.net/en/
83. https://www.economist.com/leaders/2019/08/01/deathwatch-for-the-amazon
84. http://www.fao.org/americas/prioridades/bosques/en/
85. Please see appendix on SDG 15 for details.
86. http://www.fao.org/state-of-forests/en/
87. http://sindesperdicio.net/en/
88. https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?locations=US-1W&most_recent_value_desc=true
89. https://unstats.un.org/sdgs/files/report/2019/secretary-general-sdg-report-2019--Statistical-Annex.pdf
https://collections.unu.edu/eserv/UNU:6341/Global-E-waste_Monitor_2017__electronic_single_pages_.pdf
90. Ibid
91. https://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight
92. https://www.cdc.gov/mmwr/volumes/68/wr/mm6818e1.htm?s_cid=mm6818e1_w
93. https://wir2018.wid.world/files/download/wir2018-full-report-english.pdf
94. Please see ICT sector section.
95. https://unstats.un.org/sdgs/files/report/2019/secretary-general-sdg-report-2019--Statistical-Annex.pdf
https://collections.unu.edu/eserv/UNU:6341/Global-E-waste_Monitor_2017__electronic_single_pages_.pdf
96. https://www.epa.gov/sites/production/files/2017-02/documents/ws-ourwater-california-state-fact-sheet.pdf
97. https://www.prnewswire.com/news-releases/us-water-utilities-to-invest-83-billion-in-smart-water-infrastructure-by-2027-300488062.html
98. https://www.weforum.org/agenda/2015/06/why-energy-efficiency-is-key-to-sustainable-development/
99. https://www.energymanagertoday.com/annual-energy-efficiency-spending-in-north-america-expected-to-reach-11-billion-by-2028-0181812/
100. https://fas.org/sgp/crs/misc/R45156.pdf
101. https://sustainabledevelopment.un.org/content/documents/26309Ms._Djaheezah_Subratty_UN_Environment.pdf
102. https://www.brooklyn.energy/about
103. https://ieep.eu/news/eurostat-2019-report-shows-mixed-picture-of-eu-s-progress-on-sdgs
104. https://www.sdgindex.org/
105. https://ec.europa.eu/commission/sites/beta-political/files/rp_sustainable_europe_30-01_en_web.pdf
106. https://ec.europa.eu/eurostat/documents/3217494/9940483/KS-02-19-165-EN-N.pdf/1965d8f5-4532-49f9-98ca-5334b0652820
107. https://ec.europa.eu/eurostat/documents/3217494/9940483/KS-02-19-165-EN-N.pdf/1965d8f5-4532-49f9-98ca-5334b0652820
108. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/2019-Tracking-SDG7-Report.pdf
109. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/2019-Tracking-SDG7-Report.pdf
110. https://sdg.iisd.org/news/snapshot-report-shares-europes-progress-on-sdgs-under-review/
111. https://ec.europa.eu/eurostat/documents/3217494/9940483/KS-02-19-165-EN-N.pdf/1965d8f5-4532-49f9-98ca-5334b0652820
112. http://www.fao.org/in-action/enteric-methane/en/
113. https://ec.europa.eu/jrc/en/news/reducing-methane-emissions-can-play-key-role-reducing-ozone-worldwide
114. https://ec.europa.eu/jrc/en/news/reducing-methane-emissions-can-play-key-role-reducing-ozone-worldwide
115. https://s3platform.jrc.ec.europa.eu/efficient-and-sustainable-manufacturing
116. europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf

5 ICT Sector Impact: the Catalyst for Sustainable Development

1. https://ec.europa.eu/jrc/en/predict/ict-sector-analysis-2019/data-metadata
2. https://a16z.com/2011/08/20/why-software-is-eating-the-world/
3. In this chapter, and based on the classification used in the PREDICT dataset commissioned by the European Commission, ICT manufacturing includes the manufacture of electronic components and boards; manufacture of computers and peripheral equipment; the manufacture of communication equipment; the manufacture of consumer electronics; and the manufacture of magnetic and optical media. This classification will be used throughout this report.
4. ICT services includes the wholesale of computers and other electronics and telecommunications equipment; telecommunications; software publishing; computer programming; data processing, hosting and related activities; web portals; and the repair of computers and communications equipment. This classification will be used throughout this report.
5. http://datatopics.worldbank.org/jobs/
6. https://www.globalknowledge.com/en-gb/resources/resource%20library/special-reports/2018%20it%20skills%20and%20salary%20report
7. https://news.crunchbase.com/news/q4-2018-closes-out-a-record-year-for-the-global-vc-market/
8. See www.deloitte.com/2030purpose
9. https://www.ben-evans.com/benedictevans/2019/5/28/the-end-of-mobile
10. https://www.ft.com/content/aa76e2a8-4ef2-11e8-9471-a083af05aea7
11. See https://www2.deloitte.com/insights/us/en/deloitte-review/issue-21/artificial-intelligence-and-the-future-of-work.html
12. This distinction between tasks (subject to automation with the growth of AI) and jobs (bundles of tasks, which change over time but are more rarely entirely displaced) is made here: https://a16z.com/2019/06/19/history-and-future-of-machine-learning/
13. https://www.weforum.org/agenda/2018/09/ai-and-robots-could-create-as-many-jobs-as-they-displace/
14. Data before 2000 is not available for many key economies and before 2005 is distorted by the end of the dotcom boom.
15. https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf
16. https://www.iea.org/digital/
17. https://www.mdpi.com/2078-1547/6/1/117
18. https://www.ericsson.com/en/conference-papers/the-future-carbon-footprint-of-the-ict-and-em-sectors
19. https://www.iea.org/weo/
20. http://www.responsiblemineralsinitiative.org/about/
21. https://www.cobaltinstitute.org/production-and-supply.html
22. Haskel, J. & Westlake, S. Capitalism without Capital: The Rise of the Intangible Economy (2017)
23. https://www.hermes-investment.com/ukw/wp-content/uploads/sites/80/2017/11/Hermes-Modern-Slavery-Take-Note-Cobalt.pdf
24. For example, in the EU: http://www.europarl.europa.eu/news/en/headlines/world/20170314STO66681/conflict-minerals-the-bloody-truth-behind-your-smartphone
25. For example, Samsung: https://images.samsung.com/is/content/samsung/p5/ua_ru/aboutsamsung/2017/About-us-sustainability-report-and-policy-confilct-mineral-policy-en.pdf
26. https://materialeconomics.com/publications/the-circular-economy
27. https://ec.europa.eu/growth/content/european-strategy-plastics-voluntary-pledges_en
28. https://home.kpmg/content/dam/kpmg/xx/pdf/2017/05/sdg-industrial-manufacturing.pdf
29. https://www.itu.int/en/ITU-D/Climate-Change/Pages/Global-E-waste-Monitor-2017.aspx
30. http://www.closingtheloop.eu/
31. https://www.mdpi.com/2078-1547/6/1/117
32. https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data
33. https://corporate.delltechnologies.com/en-us/social-impact/reporting/fy19-csr-report.htm
34. https://images.samsung.com/is/content/samsung/p5/uk/pdf/SustainabilityReport2019v2-en.pdf, pg. 40-41

35. https://www.swisscom.ch/en/about/company/sustainability/strategy/cr-strategy-2025.html
36. https://www.telecomitalia.com/content/dam/telecomitalia/en/archive/documents/sustainability/sustainability_reports/2018/TIM-Sustainability-Report-NFS-2018.pdf
37. https://www.ericsson.com/en/blog/2019/2/breaking-the-energy-curve-5g-energy-efficiency
38. https://www.iea.org/digital/#section-5-2
39. https://www.iea.org/digital/#section-5-1
40. http://www.cleancoins.io/#/info
41. https://libra.org/en-US/white-paper/?noredirect=en-US
42. http://ec.europa.eu/environment/waste/weee/index_en.htm
43. https://www.sciencedirect.com/science/article/pii/S0140988317301949
44. https://www.sciencedirect.com/science/article/pii/S0140988315003631
45. https://www.sciencedirect.com/science/article/pii/S0140988303000471
46. https://www.sciencedirect.com/science/article/pii/S0301421515001408
47. https://pdfs.semanticscholar.org/8e52/60a35163402b6ada126baddc023966252618.pdf
48. http://www.bbc.com/future/story/20180104-is-social-media-bad-for-you-the-evidence-and-the-unknowns
49. http://www.iemfa.org/emf-scientist-appeal-to-the-united-nations/
50. http://www.hse.gov.uk/radiation/nonionising/emf.htm
51. https://sites.bu.edu/cmcs/2018/12/06/the-isolating-web-do-filter-bubbles-narrow-down-our-mind/

6 Actions to Deliver a SMARTer2030

1. https://www.hbs.edu/faculty/Pages/item.aspx?num=54523
2. http://www.project-everyone.org/case-studies/worlds-largest-lesson/
3. https://sdgacademy.org/
4. For example, Encourage all to wear an SDG lapel pin to spark conversation https://shop.undp.org/products/sdg-lapel-pins
5. See www.deloitte.com/2030purpose
6. See https://www.grow-impact-investing.org/news/2018/10/8/better-reporting-landscape-report
7. https://www.jimcollins.com/concepts/bhag.html
8. See https://champions123.org
9. See The Art And Science Of Winning In the Digital Economy by Matthew Guest, 2019
10. For example, The World Benchmarking Alliance is an emerging example of a global organisation, supported by a range of industry and Government sponsors, which aims to hold other organisations to account for their impact, with a specific focus on digital transformation. https://www.worldbenchmarkingalliance.org/
11. In France, for example, a national roadmap for implementation of the SDGs has led to deep engagement with a wide variety of stakeholders, and presents a vision for future policy direction https://granddebat.fr
12. For example, the ITU, collaborating with Dial, have developed a framework for effective public investment in digital technologies that are intended to drive positive impact. https://www.itu.int/en/ITU-D/ICT-Applications/Documents/ICT4SGD/ITU-and-DIAL_SDG_Digital_Investment_Framework_Global_Call_To_Action-FINAL.pdf
13. The UN's High-level Panel on Digital Co-operation seeks to play this role on a global scale, and national and local governments can collaborate with industry to conduct similar initiatives at a more granular level. See https://digitalcooperation.org
14. See http://www3.weforum.org/docs/Media/AM17/The_Compact_for_Responsive_and_Responsible_Leadership_09.01.2017.pdf
15. See www.deloitte.com/2030purpose
16. See World Benchmarking Alliance https://www.worldbenchmarkingalliance.org/wp-content/uploads/2019/07/WBA-sevensystemstransformations-report.pdf
17. For example, Airtel, Tigo and Vodacom joined forces to connected the unconnected in rural Tanzania. The International Tourism Partnership (ITP) provides a non-competitive platform that aims to 'unite the hotel industry for a sustainable future', driving a set of actions focused on addressing SDGs including SDG 13. https://www.gsma.com/mobilefordevelopment/resources/airtel-tigo-vodacom-join-forces-connect-unconnected-rural-tanzaniahttps://www.tourismpartnership.org Champions 12.3 is a partnership led by food retailers that aims to address SDG target 12.3 regarding food waste. https://champions123.org/about
18. For example, Project Everyone, the 'brand agency for the Global Goals' seeks to "make the Goals famous". Through their 'Worlds' Largest Lesson' project millions of young people around the world are actively exploring the SDGs and how they can contribute to their achievement. http://www.project-everyone.org/case-studies/worlds-largest-lesson
19. https://www.fridaysforfuture.org

Case Study: AT&T

1. https://about.att.com/pages/company_profile
2. https://about.att.com/csr/home/environment/renewable-energy.html
3. https://about.att.com/ecms/dam/csr/PDFs/10x-ProgressReport-2019.pdf
4. https://about.att.com/ecms/dam/csr/PDFs/10x-ProgressReport-2019.pdf
5. https://about.att.com/ecms/dam/csr/PDFs/10x-ProgressReport-2019.pdf
6. https://about.att.com/ecms/dam/csr/aug2018/Grind2EnergyCase%20Study_FINAL.pdf
7. http://www.fao.org/save-food/resources/keyfindings/en/
8. The impacts were estimated using food waste data from January 2018 to September 2018 which was then extrapolated to estimate annual savings.
9. Allison K. Mihalich, Sr. Program Director of Sustainability, University of Notre Dame, Indiana
10. https://news.nd.edu/news/new-system-to-tackle-nonconsumable-food-waste-contribute-to-clean-energy-needs-of-local-farm/
11. http://nrra.net/sweep/the-cost-to-landfill-msw-in-the-us-continues-to-rise-despite-soft-demand/
12. https://nrra.net/sweep/no-end-in-sight-to-us-landfill-cost-increases-pacific-region-to-experience-highest-growth/

Case Study: Deutsche Telekom

1. http://origin.who.int/phe/health_topics/outdoorair/databases/background_information/en/index2.html
2. https://uk-air.defra.gov.uk/air-pollution/causes
3. https://www-03.ibm.com/press/us/en/pressrelease/35515.wss, https://www.apcoa.com/press/press-releases/article/apcoa-parking-study-search-for-parking-space-devours-time-and-money/, https://store.frost.com/strategic-analysis-of-smart-parking-market-in-europe-and-north-america.html
4. https://www.who.int/airpollution/ambient/health-impacts/en/
5. https://www.telekom.com/en/company/details/park-and-joy-soon-available-in-28-cities-536802
6. https://www.t-systems.com/de/en/references/overview/reference/park-and-joy-776696
7. https://www.telekom.com/en/company/details/park-and-joy-soon-available-in-28-cities-536802

Case Study: EIT Climate-KIC

1. https://www.climate-kic.org/
2. Overarching narrative EIT Climate-KIC
3. https://www.climate-kic.org/
4. Overarching narrative c-kic
5. https://www.climate-kic.org/
6. https://www.climate-kic.org/wp-content/uploads/2019/04/Climate-KIC-Annual-Report-2018.pdf
7. https://eit.europa.eu/news-events/news/eit-climate-kic-supported-winners-secures-over-eu15-million-funding
8. https://www.climathttps://www.climate-kic.org/success-stories/winners/e-kic.org/success-stories/winners/
9. https://www.climathttps://www.climate-kic.org/success-stories/winners/e-kic.org/success-stories/winners/
10. http://www.fao.org/3/a-i5251e.pdf
http://www.fao.org/3/Y1860E/y1860e11.htm
11. Creating a sustainable global food supply chain: the WINnERs project
12. http://www.winners-project.org/work-programmes/agriculture-weather-risk/
13. http://www.winners-project.org/work-programmes/contract-design/
14. http://www.winners-project.org/work-programmes/rural-adpatation/
15. https://eit.europa.eu/news-events/news/eit-climate-kic-supported-winners-secures-over-eu15-million-funding
16. http://www.winners-project.org/news/2016/nov/29/how-partnerships-can-create-resilient-food-supply-/

Case Study: T-Mobile

1. https://www.qualcomm.com/news/releases/2019/07/11/one-step-closer-nationwide-5g-t-mobile-qualcomm-and-ericsson-take-massive
2. https://www.t-mobile.com/responsibility/sustainability
3. https://www.t-mobile.com/news/tree-mobile-2019

Case Study: Verizon

1. https://www.verizon.com/about/news/verizon-5g-ultra-wideband-explained
2. https://www.verizon.com/about/sites/default/files/corporate-responsibility-report/2018/priorities/goals.html
3. https://www.verizon.com/about/news/verizon-goes-carbon-neutral-2035
4. https://www.barrons.com/articles/these-stocks-are-winning-as-ceos-push-for-a-sustainable-future-51549657527?mod=bol-social-tw
5. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
6. https://enterprise.verizon.com/en-gb/products/internet-of-things/smart-cities-and-communities/
7. https://www.verizonconnect.com/resources/article/best-fleet-management-2019/
8. I.e. those who generally arrive first at an emergency
9. https://www.dhs.gov/science-and-technology/first-responders
10. https://enterprise.verizon.com/resources/whitepapers/transforming-public-safety-with-safe-cities-technologies.pdf
11. https://www.genetec.com/about-us/news/press-center/press-releases/genetec-announces-citigraf-new-public-safety-decision-support-system
12. https://www.qwake.tech/
13. https://www.aerialapplications.com/blog/recap-aerial-applications-at-the-verizon-5g-first-responder-lab
14. http://www.blueforcedev.com/
15. https://adcormagnetsystems.com
16. https://kiana.io
17. https://www.imf.org/external/datamapper/CG_DEBT_GDP@GDD/CHN/FRA/DEU/ITA/JPN/GBR/USA/FADGDWORLD/GTM/MNG/MAR/SVN/SRB
18. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Police,_court_and_prison_personnel_statistics#One_police_officer_per_309_people

SDG 1 Deep Dive

1. https://sustainabledevelopment.un.org/sdg1
2. Based on UN projections of the world population in 2030
3. https://www.mercycorps.org/articles/climate-change-affects-poverty
4. "By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions"
5. https://www.ft.com/content/8cb63288-bc85-11e6-8b45-b8b81dd5d080
6. https://www.theguardian.com/commentisfree/2019/jun/12/why-are-we-still-pretending-trickle-down-economics-work
7. http://evonomics.com/joseph-stiglitz-inequality-unearned-income/
8. https://independentaustralia.net/politics/politics-display/trickle-down-economics-the-free-market-fable,9442
9. https://wir2018.wid.world/
10. https://www2.deloitte.com/content/dam/Deloitte/de/Documents/strategy/Global-Economic-Outlook-Q2-2017.pdf
11. https://theconversation.com/jeffrey-sachs-on-meeting-the-sustainable-development-goals-we-need-a-victory-of-ideas-66839
12. http://www.worldbank.org/en/topic/socialprotectionandjobs/publication/the-state-of-social-safety-nets-2018
13. https://www.irishtimes.com/opinion/jeffrey-sachs-ending-child-poverty-is-within-reach-1.3785873
14. https://sustainabledevelopment.un.org/sdg1
15. https://www.economist.com/americas-view/2013/02/28/the-end-of-poverty
16. https://www.jrf.org.uk/blog/five-steps-government-must-take-tackle-poverty
17. https://www.givedirectly.org/operating-model/
18. https://www.odi.org/publications/10505-cash-transfers-what-does-evidence-say-rigorous-review-impacts-and-role-design-and-implementation
19. https://www.princeton.edu/haushofer/publications/Haushofer_Shapiro_UCT_QJE_2016.pdf
20. https://givingcompass.org/article/what-crowdfunding-means-for-philanthropy/
21. https://www.justgiving.com/about-us
22. https://www.livemint.com/news/india/direct-benefit-transfer-helps-in-rs-1-41-trillion-savings-to-the-exchequer-1560134405912.html
23. https://www.thehindubusinessline.com/opinion/columns/all-you-wanted-to-know-about-jam-trinity/article22511736.ece
24. https://www.giscloud.com/blog/relevance-of-geospatial-and-cloud-technology-in-reaching-sustainability/
25. http://p.china.org.cn/2017-09/30/content_50029752.htm
26. https://socialfintech.org/684/
27. https://pariti.com/how-it-works
28. https://www.delltechnologies.com/en-us/perspectives/how-ai-can-help-fight-poverty/
    https://news.stanford.edu/2016/08/18/combining-satellite-data-machine-learning-to-map-poverty/
29. https://www.weforum.org/agenda/2014/08/saving-accounts-habit-research-poverty/
30. https://news.itu.int/mobile-money-poverty/
31. https://juntosglobal.com/our-solution/
32. https://juntosglobal.com/texting-people-out-of-poverty/
33. https://sdg-tracker.org/no-poverty
34. https://globalfindex.worldbank.org/
35. http://www.worldbank.org/en/news/feature/2016/10/14/promoting-land-rights-to-empower-rural-women-and-end-poverty
36. https://www.ifad.org/documents/38714170/39148759/Land+tenure+security+and+poverty+reduction.pdf/c9d0982d-40e4-4e1e-b490-17ea8fef0775
37. https://www.brookings.edu/blog/future-development/2017/07/26/why-developing-countries-get-stuck-with-weak-institutions-and-how-foreign-actors-can-help/
38. https://wir2018.wid.world/files/download/wir2018-full-report-english.pdf
39. https://www.gsmaintelligence.com/research/?file=5a33fb6782bc75def8b6d-c66af5da976&download
40. https://digitalcooperation.org/wp-content/uploads/2019/06/DigitalCooperation-report-for-web.pdf
41. https://www.mpesa.in/portal/customer/WelcomePage.jsp
42. https://edition.cnn.com/2017/02/21/africa/mpesa-10th-anniversary/index.html
43. https://www.vodafone.com/content/index/media/vodafone-group-releases/2017/m-pesa-10.html#
44. http://news.mit.edu/2016/mobile-money-kenyans-out-poverty-1208
45. https://www.pwc.com/gx/en/financial-services/pdf/how-Blockchain-tecnology-might-transform-insurance.pdf
46. http://aon.mediaroom.com/news-releases?item=137772
47. https://www.bbc.co.uk/news/world-africa-43640885
48. https://www.bigchaindb.com/usecases/government/benben/
49. http://www.unwomen.org/en/what-we-do/economic-empowerment
50. https://www.unicef.org/equity/archive/index_66602.html
51. https://www.jrf.org.uk/press/poverty-costs-uk-%C2%A378-billion-year-%E2%80%93-jrf-report
52. https://www.gsma.com/r/mobileeconomy/
53. https://data.worldbank.org/indicator/IT.NET.USER.ZS
54. https://www.theguardian.com/cities/2017/jan/09/rise-cashless-city-contactless-payments-exclusion-cashfree-society
55. FANG (or FAANG, including Apple) represents four of the largest technology companies in the US: Facebook, Amazon, Netflix and Alphabet (Google). BAT is China's equivalent, standing for Baidu, Alibaba and Tencent.
56. https://www.weforum.org/agenda/2019/05/big-tech-must-go-nonprofit-to-save-the-world/
57. https://www.theatlantic.com/business/archive/2018/02/amazon-warehouses-poor-cities/552020/
58. https://www.theguardian.com/technology/2019/jan/01/amazon-fulfillment-center-warehouse-employees-union-new-york-minnesota
59. https://learn.tearfund.org/~/media/files/tilz/circular_economy/2019-tearfund-consortium-no-time-to-waste-en.pdf?la=en
60. https://www.forbes.com/sites/vianneyvaute/2018/10/29/recycling-is-not-the-answer-to-the-e-waste-crisis/#1b50f8697381
61. https://www.spiegel.de/international/tomorrow/electronic-waste-in-africa-recycling-methods-damage-health-and-the-environment-a-1086221.html
62. http://theconversation.com/wongas-collapse-and-what-it-means-for-the-people-who-rely-on-payday-loans-102419
63. https://www.moneywise.co.uk/news/2019-01-25%E2%80%8C%E2%80%8C/surge-payday-loans-raises-concerns-about-consumer-debt
64. https://www.theguardian.com/society/2018/apr/03/crackdown-payday-loans-predatory-lending-mental-health-poverty

SDG 2 Deep Dive

1. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-2.pdf
2. https://www.sciencedirect.com/science/article/pii/S2211912417301293
3. https://www.un.org/sustainabledevelopment/hunger/
4. https://sustainabledevelopment.un.org/sdg2
5. http://www.winners-project.org/
6. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
7. https://www.theguardian.com/environment/2015/dec/02/arable-land-soil-food-security-shortage
8. https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf
9. https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf
10. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
11. Analysis of FAO Food Balance Sheets
12. https://sustainabledevelopment.un.org/sdg2
13. https://www.iisd.org/topic/agriculture-water-and-investment
14. https://docs.wfp.org/api/documents/WFP-0000099172/download/?_ga=2.20142395.243194895.1563444487-682920108.1563444487
15. https://sustainabledevelopment.un.org/sdg2
16. https://sustainabledevelopment.un.org/sdg2
17. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
18. https://www.un.org/sustainabledevelopment/hunger/
19. https://www.un.org/sustainabledevelopment/hunger/
20. https://www.huffpost.com/entry/ten-ways-to-end-hunger_b_4351633
21. http://www.winners-project.org/
22. http://www.fao.org/in-action/africa-digital-services-portfolio/en/
23. http://www.fao.org/save-food/resources/keyfindings/en/
24. https://www.libertyglobal.com/wp-content/uploads/2018/07/CR-Summary-Report-2017.pdf
25. https://innovation.wfp.org/project/building-blocks
26. https://innovation.wfp.org/project/building-blocks
27. http://www.goldenrice.org/Content2-How/how8_tests.php
28. https://news.microsoft.com/en-in/features/child-growth-monitor-malnutrition-india-microsoft-ai/
29. https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/white-paper-vci-technology-agribusiness-opportunities-drive-value.pdf
30. https://sdg-tracker.org/zero-hunger
31. http://www.thewp-group.co.uk/Is_Artificial_Intelligence_the_future_of_farming.html
32. https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/white-paper-vci-technology-agribusiness-opportunities-drive-value.pdf
33. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
34. https://www.un.org/sustainabledevelopment/hunger/
35. http://www.fao.org/3/I9900EN/i9900en.pdf
36. https://www.un.org/sustainabledevelopment/hunger/
37. https://www.un.org/sustainabledevelopment/hunger/
38. . http://www.fao.org/3/I9900EN/i9900en.pdf
39. http://www.fao.org/3/I9900EN/i9900en.pdf
40. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
41. https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/white-paper-vci-technology-agribusiness-opportunities-drive-value.pdf
42. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
43. https://www.digitalgreen.org/wp-content/uploads/2017/06/Digital-Green-Loop-brief-June2017.pdf
44. https://www.digitalgreen.org/wp-content/uploads/2017/06/Digital-Green-Loop-brief-June2017.pdf
45. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf

46. https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/white-paper-vci-technology-agribusiness-opportunities-drive-value.pdf
47. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
48. https://www1.wfp.org/news/wfp-boosts-food-security-connecting-smallholder-farmers-global-markets
49. https://producepay.com/en/
50. https://grameenfoundation.org/what-we-do/agriculture/connect-farmers-finance
51. https://grameenfoundation.org/what-we-do/agriculture/connect-farmers-finance
52. http://www.bce.ca/responsibility/corporate-responsibility/2018-cr-report/2018-csr-report.pdf
53. http://www.systemtransformation-sdg.gesi.org/case-studies.html
54. http://www.fao.org/3/CA2906EN/ca2906en.pdf
55. https://ictupdate.cta.int/en/article/satellite-data-for-agricultural-index-insurance-sid07c28703d-9b59-4e10-8940-30c3b5dd575b
56. https://bensonhill.com/design-better-crops-together-benson-hill-biosystems/crop-improvement-platform-cropos/
57. https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/white-paper-vci-technology-agribusiness-opportunities-drive-value.pdf
58. https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/white-paper-vci-technology-agribusiness-opportunities-drive-value.pdf
59. http://cdn.hpccsystems.com/pdf/Proagrica_CS_Final.pdf
60. https://sustainableamerica.org/blog/3-ways-ai-is-working-to-improve-agriculture/
61. https://www.telekom.com/en/media/media-information/enterprise-solutions/farm-2-0-intelligent-pasture-fences-and-autonomous-machinery-362202
62. http://www.systemtransformation-sdg.gesi.org/case-studies.html
63. https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf
64. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
65. http://www.fao.org/cgrfa/en/
66. http://www.fao.org/3/I9900EN/i9900en.pdf
67. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
68. https://foodsource.org.uk/sites/default/files/chapters/pdfs/foodsource_chapter_3.pdf
69. http://www.fao.org/3/I9900EN/i9900en.pdf
70. http://www.fao.org/3/I9900EN/i9900en.pdf
71. http://www.fao.org/3/I9900EN/i9900en.pdf
72. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
73. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
74. https://newsroom.ibm.com/2019-04-26-Yara-and-IBM-join-forces-to-transform-the-future-of-farming
75. https://www.phytoformlabs.com/
76. https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/white-paper-vci-technology-agribusiness-opportunities-drive-value.pdf
77. https://hbr.org/2017/05/how-digital-technology-is-changing-farming-in-africa
78. https://www.giz.de/en/workingwithgiz/43964.html
79. https://givingcompass.org/article/what-artificial-intelligence-can-do-for-smallholder-farmers/
80. http://www.fao.org/3/a-i4622e.pdf
81. https://www.business.att.com/content/dam/attbusiness/reports/iot-precision-king-case-study.pdf
82. CogX 2019 Conference, AI-griculture chat
83. https://www.eitfood.eu/blog/post/is-vertical-farming-really-sustainable
84. https://www.youtube.com/watch?v=nU1rlwcaDFQ
85. https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf
86. https://sustainabledevelopment.un.org/topics/foodagriculture
87. https://www.iisd.org/topic/agriculture-water-and-investment?page=1
88. https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf
89. https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf
90. https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf
91. https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf
92. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
93. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
94. https://politicsofpoverty.oxfamamerica.org/2013/04/the-growing-battle-between-mining-and-agriculture/
95. https://politicsofpoverty.oxfamamerica.org/2013/04/the-growing-battle-between-mining-and-agriculture/
96. https://www.theguardian.com/sustainable-business/2016/feb/18/automated-farming-food-security-rural-jobs-unemployment-technology
97. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
98. https://www.theguardian.com/sustainable-business/2016/feb/18/automated-farming-food-security-rural-jobs-unemployment-technology
99. https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/white-paper-vci-technology-agribusiness-opportunities-drive-value.pdf

SDG 3 Deep Dive

1. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-3.pdf
2. https://s3.amazonaws.com/ghwbpr-2019/UAE/GH19_Ch1.pdf
3. https://www.bing.com/videos/search?q=jeffrey+sachs+on+well+being&qs=PF&cvid=f8753f55dd434bd1bfc083980a2da1ec&cc=GB&setlang=en-GB&ru=%2fsearch%3fq%3djeffrey%2bsachs%2bon%2bwell%2bbeing%26form%3dEDGEAR%26qs%3dPF%26cvid%3df8753f55dd434bd1bfc083980a2da1ec%26cc%3dGB%26setlang%3den-GB&view=detail&mmscn=vwrc&mid=9511C4F84860AA85615D9511C4F84860AA85615D&FORM=WRVORC
4. https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/life-sciences-health-care/deloitte-uk-breaking-the-dependency-cycle-final.pdf
5. https://www.who.int/healthpromotion/frameworkforcountryaction/en/
6. https://unstats.un.org/sdgs/metadata/files/Metadata-03-01-02.pdf
7. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0199400
8. https://0-obgyn-onlinelibrary-wiley-com.wam.city.ac.uk/doi/full/10.1111/j.1471-0528.2012.03413.x
9. https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9827.pdf
10. https://obgyn.onlinelibrary.wiley.com/doi/full/10.1111/j.1471-0528.2009.02336.x
11. https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases
12. https://www.itu.int/en/ITU-D/ICT-Applications/Documents/Reports-BeHealthy-BeMobile/BD_BeHealthyBeMobile-FactPack_2017.pdf
    http://www.changetech.no/library/published/Happy_Ending-A_Randomized_Controlled_Trial_of_a_Digital_Multimedia_Smoking_Cessation_Intervention.pdf
    https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6485940/
13. https://www.un.org/sustainabledevelopment/health/
14. https://www.un.org/sustainabledevelopment/health/
15. https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/03/ENGLISH_Why_it_Matters_Goal_3_Health.pdf
16. https://1u0b5867gsn1ez16a1p2vcj1-wpengine.netdna-ssl.com/wp-content/uploads/2018/08/Bigger-Picture-Report.pdf
17. https://www.who.int/news-room/feature-stories/detail/know-your-hepatitis-status-increasing-access-to-testing-for-a-hidden-infection-
18. https://english.taiwanmobile.com/about/news/pressReleases_20190619_184153.html
19. https://japantoday.com/category/features/health/ai-used-to-detect-fetal-heart-problems
20. https://broadbandcommission.org/Documents/publications/EpidemicPreparednessReport2018.pdf
21. https://www.cytoreason.com/
22. https://undocs.org/E/2019/68
23. https://allafrica.com/stories/201903040043.html
24. https://bmcmededuc.biomedcentral.com/articles/10.1186/s12909-017-0935-y
25. https://www.accenture.com/us-en/success-amref-health-africa
26. https://www.accenture.com/us-en/success-amref-health-africa
27. https://www.itu.int/en/action/broadband/Documents/Harnessing-IoT-Global-Development.pdf
28. https://www.capgemini.com/wp-content/uploads/2017/11/health-insurance-trends-2018.pdf
29. https://www.forbes.com/sites/rachelwolfson/2019/02/16/cigna-and-sentara-healthcare-join-ibms-Blockchain-health-utility-network-to-improve-data-sharing/#2159881554bb
30. https://www.gnshealthcare.com/intervention-optimization/
31. www.bbc.com/future/story/20140516-i-operate-on-people-400km-away
32. https://sdg-tracker.org/good-health
33. https://broadbandcommission.org/Documents/working-groups/BBCOM%20WG%20Epidemic%20Preparedness%20Final%20Print%20(Executive%20Summary).pdf
34. https://www.healthtechevent.com/health-tech/new-medical-sensors-improve-health-outcomes-ebola-patients/
35. : https://www.who.int/ceh/risks/ewaste/en/
36. https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(13)70101-3/fulltext
37. https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(13)70101-3/fulltext
38. https://www.sciencedirect.com/science/article/pii/S2211883718300881
39. https://www.bbc.co.uk/news/health-48585036
40. https://www.who.int/air-pollution/news-and-events/how-air-pollution-is-destroying-our-health
41. https://www.tigermobiles.com/faq/texting-and-driving-statistics/
42. https://www.tigermobiles.com/faq/texting-and-driving-statistics/
43. https://www.tigermobiles.com/faq/texting-and-driving-statistics/
44. https://www.healthethicsblog.com/single-post/2017/11/14/Health-at-Hand-or-Wrist-Ethical-Considerations-for-Wearable-Fitness-Trackers-in-Clinical-Medicine
    https://www.who.int/news-room/feature-stories/detail/know-your-hepatitis-status-increasing-access-to-testing-for-a-hidden-infection-

SDG 4 Deep Dive

1. https://www.un.org/sustainabledevelopment/goal-of-the-month-february-2019-quality-education/
2. speech, Madison Park High School, Boston, 23 June 1990; reported in various forms
3. http://uis.unesco.org/en/topic/out-school-children-and-youth
4. https://www.globalcitizen.org/en/content/un-refugee-agency-global-trends-report-unhcr-stats/
5. https://unesdoc.unesco.org/ark:/48223/pf0000246124
6. https://ourworldindata.org/income-inequality-since-1990
7. https://www.economist.com/graphic-detail/2018/04/24/a-study-finds-nearly-half-of-jobs-are-vulnerable-to-automation
8. https://www.gov.uk/government/publications/essential-digital-skills-framework
9. https://www.jou.ufl.edu/insights/19100/
10. http://blogs.worldbank.org/edutech/new-research-hub-use-technology-education-developing-countries
11. https://ssir.org/articles/entry/collective_impact
12. https://wol.iza.org/articles/what-is-economic-value-of-literacy-and-numeracy/long
13. http://disde.minedu.gob.pe/bitstream/handle/123456789/4336/The%20Impact%20of%20Literacy%2c%20Numeracy%20and%20Computer%20Skills%20on%20Earnings%20and%20Employment%20Outcomes.pdf?sequence=1&isAllowed=y
14. https://www.bmj.com/content/344/bmj.e1602
15. https://data.worldbank.org/indicator/SE.ADT.1524.LT.ZS?end=2018&start=2013
16. https://www.worldbank.org/en/topic/earlychildhooddevelopment
17. https://data.worldbank.org/indicator/SE.PRE.ENRR?end=2018&start=2013
18. https://scholar.harvard.edu/files/joshuagoodman/files/jole_version_without_page_numbers.pdf
19. https://data.unicef.org/topic/education/primary-education/
20. http://www.schoolsandhealth.org/pages/Anthropometricstatusgrowth.aspx
21. https://www.theguardian.com/global-development/2016/oct/05/un-universal-education-goal-fail-69-million-new-teachers-unesco
22. http://www.teachersforefa.unesco.org/v2/index.php/fr/newss-2/item/490-global-teacher-shortage-threatens-education-2030
23. https://ijccep.springeropen.com/articles/10.1186/s40723-018-0054-1
24. https://www.elixirpublishers.com/articles/1351260412_49%20(2012)%2010162-10165.pdf
25. https://echo360.com/
26. http://eduze.com/#contact
27. https://education.microsoft.com/skype-in-the-classroom/overview
28. https://onebillion.org/
29. https://borgenproject.org/lack-of-access-to-education/
30. https://www.eduncle.com/
31. https://betterlesson.com/professional-learning/our-impact/
32. http://www.teachersforefa.unesco.org/v2/index.php/fr/newss-2/item/490-global-teacher-shortage-threatens-education-2030
33. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/209114/Review_of_efficiency_in_the_schools_system.pdf
34. https://research-repository.griffith.edu.au/bitstream/handle/10072/68004/99982_1.pdf;sequence=1
35. http://www.classvr.com/virtual-reality-industry-work/large-scale-vr-deployments-to-ministries-of-education/
36. https://www.economist.com/graphic-detail/2018/04/24/a-study-finds-nearly-half-of-jobs-are-vulnerable-to-automation
37. https://www.iea.nl/publications/series-journals/policy-brief/july-2015-net-generation-ready-digital-citizenship
38. https://sdg-tracker.org/quality-education
39. https://www.povertyactionlab.org/evaluation/encouraging-teacher-attendance-through-monitoring-cameras-rural-udaipur-india
40. https://www.skillshare.com/about
41. https://corporate.delltechnologies.com/en-us/social-impact/transforming-lives/youth-learning.htm
42. https://www.ubongo.org/results/
43. https://www.matific.com/gb/en-gb/home/
44. https://www.swisscom.ch/dam/swisscom/en/about/media/publications/documents/cr-report-2011.pdf
45. https://www.theguardian.com/global-development/2014/jan/29/illiteracy-education-young-people-developing-countries
46. https://www.nber.org/papers/w11880
47. https://www.docebo.com/
48. https://www.literatorapp.com/
49. https://www.globalpartnership.org/blog/children-disabilities-face-longest-road-education
50. https://www.globalpartnership.org/blog/how-school-eye-health-programs-are-helping-kids-stay-school
51. http://data.uis.unesco.org/Index.aspx?queryid=156
52. https://www.girlsnotbrides.org/themes/education/
53. https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_574717/lang--en/index.htm
54. https://www.pearson.com/content/dam/one-dot-com/one-dot-com/global/Files/sustainability/2016-report/Summary_PearsonSustainabilityReport2016.pdf
55. https://www.civitaslearning.com/about/
56. https://www.forbes.com/sites/solrogers/2019/04/03/how-virtual-reality-can-help-those-with-autism/#15c71542198e
57. https://lsi.ku.edu/project/virtual-reality-opportunities-to-integrate-social-skills-voiss
58. https://www.theguardian.com/sustainable-business/2017/aug/24/nickel-mining-hidden-environmental-cost-electric-cars-batteries
59. https://www.businesstoday.in/current/corporate/social-media-affecting-workplace-productivity-report/story/238716.html

SDG 5 Deep Dive

1. https://www.un.org/sustainabledevelopment/gender-equality/
2. https://undocs.org/E/2019/68
3. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-5.pdf
4. https://sdg.iisd.org/news/global-index-finds-no-country-is-gender-equal/
5. https://www.un.org/sustainabledevelopment/gender-equality/
6. https://www.sciencedirect.com/science/article/pii/S0140673612608277
7. https://www.weforum.org/agenda/2018/07/the-economic-benefits-of-family-planning/
8. https://ajph.aphapublications.org/doi/full/10.2105/AJPH.2019.305051
9. http://researchonline.lshtm.ac.uk/3894556/
10. https://www.un.org/sustainabledevelopment/gender-equality/
11. https://www.un.org/sustainabledevelopment/gender-equality/
12. https://www.unodc.org/e4j/data/_university_uni_/global_report_on_trafficking_in_persons_2018.html
13. https://www.unodc.org/e4j/data/_university_uni_/global_report_on_trafficking_in_persons_2018.html
14. https://sustainabledevelopment.un.org/sdg5
15. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-5.pdf
16. https://sustainabledevelopment.un.org/sdg5
17. https://www.who.int/news-room/fact-sheets/detail/female-genital-mutilation
18. http://www.npwj.org/content/Using-SMS-spread-message-FGM-illegal.html
19. https://www.gsma.com/mobilefordevelopment/topic/safety-and-harassment/security-and-harassment-on-mobile-phones-a-growing-concern-for-women-in-emerging-markets/
20. https://www.projectcallisto.org/what-we-do
21. https://www.reuters.com/article/us-moldova-trafficking-technology-blockc/scan-on-exit-can-Blockchain-save-moldovas-children-from-traffickers-idUSKBN1JF00J
22. https://impakter.com/roar-good-helping-women-feeling-safer-athena/
23. https://aws.amazon.com/blogs/publicsector/using-technology-to-combat-human-trafficking/
24. https://research.adobe.com/news/research-collaboration-could-help-find-human-trafficking-victims/
25. https://gesi.org/blog/detail/fujitsu-and-digital-innovation-for-human-rights
26. https://www.un.org/sustainabledevelopment/gender-equality/
27. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-5.pdf
28. https://minnesota.cbslocal.com/2019/06/11/how-are-women-changing-the-face-of-fortune-500-companies/
29. https://unwomen.org.au/press-release-to-accelerate-gender-equality-un-women-launches-a-call-to-action-to-parliamentarians/
30. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2019/02/GSMA-The-Mobile-Gender-Gap-Report-2019.pdf
31. https://www.ncbi.nlm.nih.gov/pubmed/27940873
32. http://www.cgap.org/blog/m-pawa-1-year-mobile-banking-perceptions-use-tanzania
33. https://www.vodafone.com/content/index/about/sustainability/womens-empowerment/bringing-mobile-to-more-women.html
34. https://www.gsma.com/betterfuture/wp-content/uploads/2016/09/_UN_SDG_Report_FULL_R1_WEB_Singles_LOW.pdf
35. http://www.cherieblairfoundation.org/herventure/
36. https://www.hyperwallet.com/app/uploads/HW_The_Future_of_Gig_Work_is_Female.pdf?mkt_tok=eyJpIjoiTVRjMU9UQmlOakk1TW1WaSIsInQiOiJYaVQrNEtTTzUzNWliUzZOSTQ3R2wxTnlwYO0xZG9MZmErTnVXUkJVdGhMRm9EUW9GWTFcL1huaXZPbnBmdGN1RnBaWjAwa2tjTW5PXC82NnR5ZOo1VFcrOFhWbEZMbVd3UGcramZvdTgOY1YOQ3orMjlcL1wvVUpJaFBROVhMeXRyU1QifQ%3D%3D
37. https://www.hyperwallet.com/app/uploads/HW_The_Future_of_Gig_Work_is_Female.pdf?mkt_tok=eyJpIjoiTVRjMU9UQmlOakk1TW1WaSIsInQiOiJYaVQrNEtTTzUzNWliUzZOSTQ3R2wxTnlwYO0xZG9MZmErTnVXUkJVdGhMRm9EUW9GWTFcL1huaXZPbnBmdGN1RnBaWjAwa2tjTW5PXC82NnR5ZOo1VFcrOFhWbEZMbVd3UGcramZvdTgOY1YOQ3orMjlcL1wvVUpJaFBROVhMeXRyU1QifQ%3D%3D
38. https://www.un.org/sustainabledevelopment/gender-equality/
39. https://www.sciencedirect.com/science/article/abs/pii/S0010782416301639
40. https://academic.oup.com/heapol/article/33/2/155/4616250
41. https://www.undp.org/content/dam/undp/library/gender/UNDP%20Gender%20Equality%20Strategy%202018-2021.pdf
42. https://www.un.org/sustainabledevelopment/economic-growth/
43. https://www.amnesty.org.uk/online-abuse-women-widespread

44. https://www.womensaid.org.uk/information-support/what-is-domestic-abuse/onlinesafety/
45. http://theconversation.com/gender-inequality-is-alive-and-kicking-in-technology-92539
46. https://voxeu.org/article/ai-technology-and-gender-inequality
47. https://www.chathamhouse.org/event/gender-inequality-making-technology-solution-not-problem
48. https://www.chathamhouse.org/event/gender-inequality-making-technology-solution-not-problem
49. https://www2.deloitte.com/uk/en/pages/growth/articles/technology-career-pathways-gender-pay-gap.html
50. https://www.b2econsulting.com/what-is-the-impact-of-the-gig-economy-on-women-who-work-in-it-and-will-it-help-narrow-the-gender-gap/
51. https://www.policeone.com/investigations/articles/413888006-The-role-of-technology-in-human-trafficking-and-sexual-exploitation/
52. https://www.gsma.com/mobilefordevelopment/topic/safety-and-harassment/security-and-harassment-on-mobile-phones-a-growing-concern-for-women-in-emerging-markets/

SDG 6 Deep Dive

1. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-6.pdf
2. Guangzhe Chen, Senior Director of the Water Global Practice of the World Bank: https://www.worldbank.org/en/news/press-release/2017/08/28/millions-around-the-world-held-back-by-poor-sanitation-and-lack-of-access-to-clean-water
3. https://washmatters.wateraid.org/publications/climate-change-and-water-resources
4. https://www.un.org/africarenewal/magazine/may-july-2017/internet-everything-water
5. https://iwa-network.org/doing-more-with-less-the-new-paradigm-for-achieving-sdg6/
6. https://www.conservation.org/priorities/fresh-water
   https://sustainabledevelopment.un.org/content/documents/19901SDG6_SR2018_web_3.pdf
7. http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en
8. http://www.fao.org/land-water/water/water-scarcity/en/
9. https://www.watercalculator.org/water-use/climate-change-water-resources/
10. 53 of the 187 countries for which data is available
11. 91 of the 187 countries for which data is available
12. http://apps.who.int/gho/data/node.wrapper.imr?x-id=4818
13. https://www.who.int/features/qa/70/en/
14. A smart water network would be connected using mobile and internet networks, incorporating IoT sensors at both the consumption and distribution levels and optimising data using AI and machine learning.
15. 105 of the 187 countries for which data is available
16. https://www.unwater.org/publication_categories/sdg-6-synthesis-report-2018-on-water-and-sanitation/
17. https://sustainabledevelopment.un.org/sdg6
18. https://www.who.int/news-room/fact-sheets/detail/drinking-water
19. https://edition.cnn.com/2016/03/04/us/flint-water-crisis-fast-facts/index.html
20. https://www.washingtonpost.com/news/wonk/wp/2017/09/21/flints-lead-poisoned-water-had-a-horrifyingly-large-effect-on-fetal-deaths-study-finds/
21. https://www.worldbank.org/en/topic/water/publication/wash-poverty-diagnostic
22. https://www.worldbank.org/en/topic/water/overview#2
23. https://washmatters.wateraid.org/blog/faecal-sludge-management-a-critical-pathway-to-safely-managed-sanitation
24. https://www.worldbank.org/en/topic/water/publication/wash-poverty-diagnostic
25. https://sustainabledevelopment.un.org/content/documents/195716.29_Formatted_2018_background_notes_SDG_6.pdf
26. http://fortune.com/2017/11/21/virtual-reality-charities-donations/
27. https://aftershock.wateraid.org/
28. https://www.unicef.org/esa/sites/unicef.org.esa/files/2018-09/UNICEF-Somalia-2015-FN-Mobile.pdf
29. https://www.ewaterpay.com/
30. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2018/04/Africa-Water-Enterprises-Using-IoT-to-monitor-and-introduce-pre-payment-for-remote-water-stands-in-The-Gambia.pdf
31. http://www.oxwater.uk/about.html
32. http://www.ox.ac.uk/news/2017-02-28-smart-handpumps-predict-depths-groundwater-africa
33. http://www.oxwater.uk/oxford-smart-handpump.html
34. https://www.wired.com/story/how-Blockchain-could-protect-californias-aquifer/
35. https://newsroom.ibm.com/2019-02-08-State-of-California-Tackles-Drought-with-IoT-Blockchain
36. https://greenseesaw.com/page/
37. http://wash.health.go.ke/clts/index.jsp
38. https://www.un.org/sustainabledevelopment/water-and-sanitation/
39. https://www.wwf.org.uk/what-we-do/projects/water-stewardship
40. https://support.worldwildlife.org/site/Advocacy?cmd=display&page=UserAction&id=825
41. https://support.worldwildlife.org/site/Advocacy?cmd=display&page=UserAction&id=971
42. https://www.waterworld.com/international/utilities/article/16201296/flying-high-how-water-is-adopting-drones
43. https://res-www.zte.com.cn/mediares/zte/Investor/20180315/E6.pdf
44. https://www.gsma.com/iot/wp-content/uploads/2016/10/Cost-Effective-Care-for-the-Environment-1.pdf
45. https://spectrum.ieee.org/tech-talk/telecom/internet/a-massive-iot-sensor-network-keeps-watch-over-a-1400kilometer-canal
46. https://www.ibm.com/blogs/client-voices/ai-and-iot-help-boost-water-quality-in-china/
47. https://www.ibm.com/blogs/client-voices/ai-and-iot-help-boost-water-quality-in-china/
48. https://www.iotforall.com/iot-changing-wastewater-management/
49. https://www.ibm.com/blogs/research/2016/08/used-iot-data-optimize-wastewater-treatment/
50. https://www.ibm.com/blogs/research/2016/08/used-iot-data-optimize-wastewater-treatment/
51. https://www.wri.org/blog/2015/06/nasa-satellite-data-help-show-where-groundwater-and-where-it-isn-t
52. https://medium.com/descarteslabs-team/global-scale-water-monitoring-in-the-cloud-c38cb4e9fe56
    https://www.globalcitizen.org/en/content/google-united-nations-water-database/
53. https://www.wsp.com/en-GB/insights/getting-smarter-about-water
54. https://sustainabledevelopment.un.org/sdg6
55. https://www.unwater.org/publication_categories/sdg-6-synthesis-report-2018-on-water-and-sanitation/
56. https://en.unesco.org/news/water-drives-job-creation-and-economic-growth-says-new-report
57. http://pubdocs.worldbank.org/en/588881494274482854/Water-Scarce-Cities-Initiative.pdf
58. https://www.oecd.org/agriculture/topics/water-and-agriculture/
59. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
60. https://www.tapoff.co.za/#
61. https://www.suez.com/en/news/press-releases/on-connect-coach
62. https://goexplorer.org/instant-water-recycling-creates-closed-loop-shower-system/
63. https://orbital-systems.com/product/
64. https://medium.com/datadriveninvestor/digital-water-transformation-the-promise-of-artificial-intelligence-7d88fb07e79b
65. https://www.emagin.ai/industries
66. https://emerj.com/ai-sector-overviews/ai-for-weather-forecasting/
67. https://www.business.att.com/content/dam/attbusiness/briefs/iot-smart-irrigation-brief.pdf
68. https://www.hydropoint.com/resources/research-studies/
69. https://sustainabledevelopment.un.org/content/documents/19901SDG6_SR2018_web_3.pdf
70. https://www.who.int/news-room/fact-sheets/detail/drinking-water
71. https://www.ewaterpay.com/
72. https://www.worldbank.org/en/topic/water/publication/wash-poverty-diagnostic
73. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
74. https://sustainabledevelopment.un.org/content/documents/19901SDG6_SR2018_web_3.pdf
75. https://www.rubiconglobal.com/blog-electronic-waste-problem/
76. https://www.unenvironment.org/news-and-stories/press-release/un-report-time-seize-opportunity-tackle-challenge-e-waste
77. https://spectrum.ieee.org/telecom/internet/the-internet-of-trash-iot-has-a-looming-ewaste-problem
78. https://www.iea.org/weo/water/

SDG 7 Deep Dive

1. https://sustainabledevelopment.un.org/content/documents/22877UN_FINAL_ONLINE_20190523.pdf
2. https://sustainabledevelopment.un.org/content/documents/22877UN_FINAL_ONLINE_20190523.pdf
3. https://sustainabledevelopment.un.org/content/documents/22877UN_FINAL_ONLINE_20190523.pdf
4. https://unstats.un.org/sdgs/metadata/files/Metadata-07-03-01.pdf
5. https://www.itu.int/dms_pub/itu-t/oth/4B/01/T4B010000050001PDFE.pdf
6. https://www.itu.int/dms_pub/itu-t/oth/4B/01/T4B010000050001PDFE.pdf
7. https://www.cdp.net/en/climate/carbon-pricing
8. https://www.iea.org/access2017/#section-1-1
9. https://www.worldbank.org/en/news/feature/2018/04/18/access-energy-sustainable-development-goal-7
10. https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019
11. https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019
12. https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019
13. https://sustainabledevelopment.un.org/content/documents/22877UN_FINAL_ONLINE_20190523.pdf
14. https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019

15. https://sustainabledevelopment.un.org/content/documents/22877UN_FINAL_ONLINE_20190523.pdf
16. https://sustainabledevelopment.un.org/content/documents/22877UN_FINAL_ONLINE_20190523.pdf
17. https://sustainabledevelopment.un.org/sdg7
18. https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019Report.pdf
19. https://sustainabledevelopment.un.org/content/documents/22877UN_FINAL_ONLINE_20190523.pdf
20. https://sustainabledevelopment.un.org/content/documents/22877UN_FINAL_ONLINE_20190523.pdf
21. https://www.irena.org/documentdownloads/publications/smart_grids.pdf
22. https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019pdf
23. https://nexleaf.org/
24. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Off-grid_RE_Access_2019.pdf
25. https://acumen.org/wp-content/uploads/2017/07/Lean-Data-Report-Evdience-Review-On-Affordability.pdf
26. https://www.iotone.com/casestudy/remote-monitoring-amp-predictive-maintenance-app-for-a-solar-energy-system/c604
27. http://www.hackthewind.io/
28. https://www.boldare.com/work/case-study-predictive-maintenance/
29. https://www.nrel.gov/docs/fy15osti/63033.pdf
30. https://cleantx.org/wp-content/uploads/2019/01/CleanTX_ERCOT_Report_Jan_2019.pdf
31. https://cleantx.org/the-influence-of-information-technology-on-the-energy-mix-in-texas/
32. https://www.boldare.com/work/case-study-predictive-maintenance
https://www.brookings.edu/research/how-artificial-intelligence-will-affect-the-future-of-energy-and-climate/
33. https://www.researchgate.net/publication/254012204_Predicting_solar_generation_from_weather_forecasts_using_machine_learning
34. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Landscape_Blockchain_2019.pdf?la=en&hash=1BBD2B93837B2B7BF0BA-F7A14213B110D457B392+G53
35. https://www.technologyreview.com/s/604227/blockchain-is-helping-to-build-a-new-kind-of-energy-grid/
36. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/2019-Tracking-SDG7-Report.pdf
37. https://sustainabledevelopment.un.org/content/documents/18041SDG7_Policy_Brief.pdf
38. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/2019-Tracking-SDG7-Report.pdf
39. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/321852/Policy_Factsheet_-_Smart_Grid_Final__BCG_.pdf
40. https://www.itu.int/dms_pub/itu-t/oth/4B/01/T4B010000050001PDFE.pdf
41. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/2019-Tracking-SDG7-Report.pdf
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/321852/Policy_Factsheet_-_Smart_Grid_Final__BCG_.pdf
42. https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019
43. https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019
44. https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019
45. http://www.thewp-group.co.uk/4_reasons_why_smart_meters_are_the_future_of_energy_efficiency.html
46. https://www.sms-plc.com/insights/blogs-news/smart-meters-inspire-86-of-people-to-take-energy-saving-actions/
47. https://www.smartenergygb.org/en/resources/press-centre/press-releases-folder/smart-meter-usage-october-2017?tab=1&docspage=1
48. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/321852/Policy_Factsheet_-_Smart_Grid_Final__BCG_.pdf
49. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/657144/DSR_Summary_Report.pdf
50. https://www.worldbank.org/en/news/feature/2018/04/18/access-energy-sustainable-development-goal-7
51. http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/Chapte19.en.html
52. https://rpds.princeton.edu/sites/rpds/files/media/dinkelman_electricity_0810.pdf
53. https://webstore.iea.org/download/summary/343?fileName=English-WEO-Air-Pollution-ES.pdfhttps://webstore.iea.org/download/summary/343?fileName=English-WEO-Air-Pollution-ES.pdf
54. https://webstore.iea.org/download/summary/343?fileName=English-WEO-Air-Pollution-ES.pdfhttps://webstore.iea.org/download/summary/343?fileName=English-WEO-Air-Pollution-ES.pdf
55. https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019
56. https://www.smart-energy.com/industry-sectors/smart-energy/energy-market-needs-radical-reform-to-protect-the-vulnerable-uk-watchdog/
57. https://www.cgap.org/blog/keeping-lights-repayment-challenges-paygo-solar
58. https://www.sciencedaily.com/releases/2019/06/190606101822.htm

SDG 8 Deep Dive

1. https://sustainabledevelopment.un.org/sdg8
2. https://www.un.org/sustainabledevelopment/economic-growth/
3. https://www2.deloitte.com/content/dam/Deloitte/es/Documents/tecnologia/Deloitte_ES_tecnologia_economic-and-social-impacts-of-google-cloud.pdf
4. https://www.oecd-ilibrary.org/economics/digital-dividend-policies-to-harness-the-productivity-potential-of-digital-technologies_273176bc-en;jsessionid=4BBKI-ybwEtfxa2fWh56Nbi3.ip-10-240-5-25
5. http://www3.weforum.org/docs/WEF_GITR_Chapter1.2_2015.pdf
6. https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/finance/deloitte-uk-technology-and-people.pdf
7. https://www.tandfonline.com/doi/abs/10.1080/02681102.2012.694794
8. http://www.ub.edu/irea/working_papers/2017/201708.pdf
9. https://science.sciencemag.org/content/354/6317/1288
10. https://globalfindex.worldbank.org/
11. https://unctad.org/en/Docs/dtlstict2011d1_en.pdf
12. https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG
13. https://sustainabledevelopment.un.org/sdg8
14. https://www.imf.org/en/Publications/WEO/Issues/2019/03/28/world-economic-outlook-april-2019#Full%20Report%20and%20Executive%20Summary
15. https://goexplorer.org/
https://www.unglobalcompact.org/library/5241
16. https://labs.telstra.com/
17. https://images.samsung.com/is/content/samsung/p5/uk/pdf/SustainabilityReport2019v2-en.pdf
18. https://www.business.att.com/products/collaborate.html
19. https://www2.deloitte.com/content/dam/Deloitte/tr/Documents/public-sector/deloitte-nl-ps-smart-cities-report.pdf
20. https://www.nebengers.com/
https://www.youtube.com/watch?v=K_nNudC4pV4
21. https://cointelegraph.com/news/china-shenzhen-special-economic-zone-to-use-Blockchain-for-electronic-tax-invoices
https://www.researchgate.net/publication/327338538_Blockchain_Applications_and_the_Sustainable_Development_Goals_-_Analysis_of_Blockchain_technology's_potential_in_creating_a_sustainable_future
22. https://www2.deloitte.com/content/dam/Deloitte/es/Documents/tecnologia/Deloitte_ES_tecnologia_economic-and-social-impacts-of-google-cloud.pdf
23. https://hbr.org/2017/03/augmented-reality-is-already-improving-worker-performance
24. https://www2.deloitte.com/content/dam/insights/us/articles/4780_State-of-AI-in-the-enterprise/DI_State-of-AI-in-the-enterprise-2nd-ed.pdf
25. https://www.computerweekly.com/news/252438105/IT-set-to-gain-the-most-from-AI-and-automation
26. https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS
27. https://www.bi.team/wp-content/uploads/2019/01/Annual-update-report-BIT-2017-2018.pdf
28. https://thebeat.co/en/
29. http://blogs.worldbank.org/developmenttalk/gig-economy-growth-pains
https://www.wamda.com/2016/10/home-cooked-food-finally-gets-taste-delivery-services-jordan
30. https://sustainabledevelopment.un.org/sdg8
31. http://www.unwomen.org/en/news/in-focus/csw61/women-in-informal-economy
32. https://www.ft.com/content/1ed9ec8d-d81b-34b3-a615-3a31c8a62a2c
33. https://news.un.org/en/story/2018/12/1027271
34. https://sustainabledevelopment.un.org/sdg8
35. https://www.glassdoor.com/about-us/
36. https://www.reuters.com/article/us-Blockchain-coca-cola-labor/coca-cola-u-s-state-dept-to-use-Blockchain-to-combat-forced-labor-idUSKCN1GS2PY
37. https://www.researchgate.net/publication/328657407_A_Blockchain-Based_Decentralized_System_for_Proper_Handling_of_Temporary_Employment_Contracts
38. https://hbr.org/2017/03/augmented-reality-is-already-improving-worker-performance
39. https://www.sciencedirect.com/science/article/pii/S0924271618300479
40. https://www.newscientist.com/article/2138163-volunteers-teach-ai-to-spot-slavery-sites-from-satellite-images/
41. https://elibrary.worldbank.org/doi/abs/10.1093/wbro/lky001
42. https://www.gsma.com/mobilefordevelopment/mobile-money/
43. https://datacatalog.worldbank.org/dataset/global-financial-inclusion-global-findex-database
44. https://www.amdocs.com/mobile-financial-services
45. www.uport.me
46. https://lendoit.com/
47. https://www2.deloitte.com/ch/en/pages/innovation/articles/automation-report.html
48. https://ec.europa.eu/knowledge4policy/foresight/topic/changing-nature-work/new-technologies-automation-work-developments_en
49. https://www.bbc.co.uk/news/business-47691078
50. https://www.itu.int/dms_pub/itu-s/opb/gen/S-GEN-ISSUEPAPER-2018-1-PDF-E.pdf

SDG 9 Deep Dive

1. https://sdg.iisd.org/commentary/policy-briefs/how-can-progress-on-infrastructure-industry-and-innovation-contribute-to-achieving-the-sdgs/
2. https://www.un.org/sustainabledevelopment/infrastructure-industrialization/
3. https://www.un.org/sustainabledevelopment/infrastructure-industrialization/
4. https://www.itu.int/web/pp-18/en/backgrounder/6050-icts-to-achieve-the-united-nations-sustainable-development-goals
5. https://www.forbes.com/sites/bernardmarr/2018/09/02/what-is-industry-4-0-heres-a-super-easy-explanation-for-anyone/#5e8f4f999788
6. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/smart-factory-connected-manufacturing.html?icid=dcom_promo_featured|il;en
7. https://www.plm.automation.siemens.com/global/en/our-story/glossary/industry-4-0/29278
8. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
9. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/smart-factory-connected-manufacturing.html?icid=dcom_promo_featured|il;en
   https://www.i-scoop.eu/industry-4-0/#Data_and_optimization_across_the_value_chain_benefits_and_IT_OT_and_cyber-physical_systems_in_smart_anything
10. https://www.i-scoop.eu/industry-4-0/supply-chain-management-scm-logistics/
11. https://www.i-scoop.eu/industry-4-0/#Data_and_optimization_across_the_value_chain_benefits_and_IT_OT_and_cyber-physical_systems_in_smart_anything-VR
12. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
13. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-9.pdf
14. https://www.un.org/sustainabledevelopment/infrastructure-industrialization/
    https://sdg.iisd.org/commentary/policy-briefs/how-can-progress-on-infrastructure-industry-and-innovation-contribute-to-achieving-the-sdgs/
15. https://sustainabledevelopment.un.org/sdg9
16. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/smart-factory-connected-manufacturing.html?icid=dcom_promo_featured|il;en
    https://www.i-scoop.eu/industry-4-0/#Data_and_optimization_across_the_value_chain_benefits_and_IT_OT_and_cyber-physical_systems_in_smart_anything
17. https://www.i-scoop.eu/industry-4-0/supply-chain-management-scm-logistics/
18. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/smart-factory-connected-manufacturing.html?icid=dcom_promo_featured|il;en
19. https://isid.unido.org/about-isid.html
20. https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/technology/lu-Blockchain-internet-things-supply-chain-traceability.pdf
21. https://www.ibm.com/Blockchain/industries/supply-chain
22. https://www.ibm.com/downloads/cas/1VBZEPYL
23. https://www.seebo.com/machine-learning-ai-manufacturing/
24. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/smart-factory-connected-manufacturing.html?icid=dcom_promo_featured|il;en
25. http://www.bce.ca/responsibility/corporate-responsibility/2018-cr-report/2018-csr-report.pdf
26. https://www.ibm.com/downloads/cas/1VBZEPYL
27. https://www.i-scoop.eu/industry-4-0/supply-chain-management-scm-logistics/
28. https://www.pressroom.ups.com/pressroom/ContentDetailsViewer.page?ConceptType=Factsheets&id=1426321616277-282
29. https://www.microlise.com/fleet-management/fleet-telematics/
30. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/process-and-operations/us-cons-predictive-maintenance.pdf
31. https://www.cio.com/article/3309058/5-ways-industrial-ai-is-revolutionizing-manufacturing.html
32. https://www.ibm.com/case-studies/armstrong-fluid-technology
33. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/smart-factory-connected-manufacturing.html?icid=dcom_promo_featured|il;en
34. https://www.cio.com/article/3309058/5-ways-industrial-ai-is-revolutionizing-manufacturing.htm
35. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/smart-factory-connected-manufacturing.html?icid=dcom_promo_featured|il;en
36. https://news.ewmfg.com/blog/the-future-of-virtual-reality-vr-in-manufacturing
37. https://www.i-scoop.eu/industry-40-virtual-reality-vr-augmented-reality-ar
38. https://www.bloomberg.com/news/articles/2019-05-20/google-glass-finds-a-new-home-at-the-factory
39. https://www.bloomberg.com/news/articles/2019-05-20/google-glass-finds-a-new-home-at-the-factory
40. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
41. https://sdg.iisd.org/commentary/policy-briefs/how-can-progress-on-infrastructure-industry-and-innovation-contribute-to-achieving-the-sdgs/
42. https://www2.deloitte.com/insights/us/en/focus/digital-maturity/digital-innovation-ecosystems-organizational-agility.html
43. https://pdfs.semanticscholar.org/6d37/fd42bf26730263b3a3f397a6076ab60e2980.pdf
44. https://www.i-scoop.eu/industry-4-0/#Data_and_optimization_across_the_value_chain_benefits_and_IT_OT_and_cyber-physical_systems_in_smart_anything-VR
45. http://unsdsn.org/wp-content/uploads/2015/09/ICTSDG_InterimReport_Web.pdf
46. https://ec.europa.eu/knowledge4policy/publication/role-science-technology-innovation-policies-foster-implementation-sustainable_en
47. https://ec.europa.eu/knowledge4policy/publication/role-science-technology-innovation-policies-foster-implementation-sustainable_en
48. https://onlinelibrary.wiley.com/doi/abs/10.1348/096317907X202464
49. https://www.pwc.com/gx/en/issues/high-growth-markets/assets/disrupting-africa-riding-the-wave-of-the-digital-revolution.pdf
50. https://www.forbes.com/sites/joemckendrick/2013/10/28/how-cloud-adds-a-new-dimension-to-innovation/#73b81230caf6
51. https://climathon.climate-kic.org/en/
52. https://forrestbrown.co.uk/news/Blockchain-technology-beyond-bitcoin/
53. https://www.wipo.int/wipo_magazine/en/2018/01/article_0005.html
54. http://breakthrough.unglobalcompact.org/site/assets/files/1454/hhw-16-0017-d_c_artificial_intelligence.pdf
    https://www.cio.com/article/3309058/5-ways-industrial-ai-is-revolutionizing-manufacturing.html
55. https://ai.google/research/teams/brain/
56. https://ai.google/research/pubs/pub48231
57. https://www.jabil.com/insights/blog-main/augmented-reality-in-product-design
    https://www.rss.org.uk/Images/PDF/events/2018/Castruccio-5-Sept-2018.pdff.
58. https://sgwdesignworks.com/virtual-reality-prototyping/
59. https://www.un.org/sustainabledevelopment/infrastructure-industrialization/
60. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
61. https://www.un.org/sustainabledevelopment/infrastructure-industrialization/
62. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
63. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-9.pdf
    https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
64. https://sdg.iisd.org/commentary/policy-briefs/how-can-progress-on-infrastructure-industry-and-innovation-contribute-to-achieving-the-sdgs/
65. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
66. https://www.liberianobserver.com/news/mpw-mobile-app-for-citizens-report-infrastructure-issues/
67. https://www.jra.org.za/find-and-fix-mobile-app
68. https://www.vice.com/en_us/article/3daak3/how-iot-can-help-monitor-and-rebuild-aging-infrastructure
69. https://www.raconteur.net/technology/smart-city-data-management
70. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
71. Interview with Studiomapp CTO, July 31 2019
72. https://www.mottmac.com/views/bim-advances-sustainability
73. https://www.cowi.com/insights/virtual-real-may-unlock-savings-in-complex-infrastructure-and-construction
74. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
75. https://www.cowi.com/insights/virtual-real-may-unlock-savings-in-complex-infrastructure-and-construction
76. https://www.arup.com/perspectives/virtual-and-augmented-reality-changing-the-way-we-design-and-build-infrastructure
77. https://www.worldbank.org/en/topic/smefinance
78. https://www.mckinsey.com/industries/financial-services/our-insights/mobile-money-in-emerging-markets-the-business-case-for-financial-inclusion
79. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
80. https://unstats.un.org/sdgs/report/2019/The-Sustainable-Development-Goals-Report-2019.pdf
    https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
81. https://core.ac.uk/download/pdf/73973506.pdf
82. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
83. https://www.mckinsey.com/industries/financial-services/our-insights/mobile-money-in-emerging-markets-the-business-case-for-financial-inclusion
84. https://www.telegraph.co.uk/business/business-club/finance/mobile-finance-for-smes/
85. https://www.ferratumgroup.com/
86. http://www.oecd.org/finance/ICOs-for-SME-Financing.pdf
87. https://www.researchgate.net/publication/327338538_Blockchain_Applications_and_the_Sustainable_Development_Goals_-_Analysis_of_Blockchain_technology's_potential_in_creating_a_sustainable_future
88. https://www.forbes.com/sites/forbesproductgroup/2018/01/11/the-ripple-effect-of-cryptocurrencies/#3c811a966080
89. https://www.bitbond.com/
90. http://unsdsn.org/wp-content/uploads/2015/09/ICTSDG_InterimReport_Web.pdf
91. https://www.telegraph.co.uk/connect/small-business/business-solutions/apps-to-help-sme-owners-run-their-companies/
92. https://isid.unido.org/about-isid.html
93. https://deloitte.wsj.com/cio/2018/06/15/how-cloud-can-boost-innovation-2/
94. https://deloitte.wsj.com/cio/2018/06/15/how-cloud-can-boost-innovation-2/
95. (ITU, 2016)
96. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
97. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
98. https://learningenglish.voanews.com/a/itu-internet-access/4224811.html
99. https://sdg.iisd.org/commentary/policy-briefs/how-can-progress-on-infrastructure-industry-and-innovation-contribute-to-achieving-the-sdgs/
100. https://www-file.huawei.com/-/media/corporate/pdf/sustainability/2018/2018-csr-report-en.pdf?la=en

101. https://www.itnews.com.au/news/telstra-puts-drones-into-production-in-tasmania-475838
102. https://www.un.org/sustainabledevelopment/infrastructure-industrialization/
103. https://www.un.org/sustainabledevelopment/infrastructure-industrialization/
104. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
105. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
106. https://www.nature.com/articles/s41893-019-0256-8
107. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
108. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
109. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
110. https://sustainabledevelopment.un.org/content/documents/14363SDG9format-revOD.pdf
111. https://docplayer.net/amp/20368863-How-information-and-communications-technology-can-achieve-the-sustainable-development-goals-ict-sdgs.html
112. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
113. https://www.weforum.org/agenda/2019/01/how-a-circular-approach-can-turn-e-waste-into-a-golden-opportunity/
114. https://ict4dblog.wordpress.com/2018/04/23/industry-4-0-to-digital-industrialisation-when-digital-technologies-meet-industrial-transformation/
115. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
116. https://ict4dblog.wordpress.com/2018/04/23/industry-4-0-to-digital-industrialisation-when-digital-technologies-meet-industrial-transformation/
117. https://www.bbc.co.uk/news/business-48760799
118. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf

SDG 10 Deep Dive

1. https://sustainabledevelopment.un.org/content/documents/2754713_July_PM_2._Leaving_no_one_behind_Summary_from_UN_Committee_for_Development_Policy.pdf
2. https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-10-reduced-inequalities.html ;https://sustainabledevelopment.un.org/sdg10
3. https://oxfamilibrary.openrepository.com/bitstream/handle/10546/620599/bp-public-good-or-private-wealth-210119-summ-en.pdf?utm_source=indepth
4. https://www.un.org/esa/desa/papers/2017/wp152_2017.pdf
5. https://eppi.ioe.ac.uk/CMS/Portals/0/PDF%20reviews%20and%20summaries/Mobile%20financial%202017%20Alampay%20report.pdf
6. https://wir2018.wid.world/files/download/wir2018-full-report-english.pdf
7. https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-10-reduced-inequalities.html
8. http://www3.weforum.org/docs/WEF_GITR_Chapter1.2_2015.pdf
9. https://www.sciencedirect.com/science/article/pii/S1043951X11000393
10. http://remittanceprices.worldbank.org
11. Assuming that one mobile RSP enters each corridor where no mobile RSPs currently operate.
12. https://www.un.org/en/events/family-remittances-day/un-action.shtml
13. https://www.sciencedirect.com/science/article/pii/S0743016715300176; http://www.worldbank.org/en/publication/wdr2016
14. https://www.itu.int/dms_pub/itu-s/opb/gen/S-GEN-ISSUEPAPER-2018-1-PDF-E.pdf
15. https://wir2018.wid.world/files/download/wir2018-full-report-english.pdf
16. https://www.un.org/sustainabledevelopment/inequality/
17. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2015/06/DigitalLiteracy_v6_WEB_Singles.pdf, http://sewarudi.com/
18. https://www.tele2.com/media/news/sho-helping-newly-arrived-immigrants-and-swedish https://reachforchange.org/en/partnering-for-change/tele2-nokia-and-reach-for-change
19. https://1u0b5867gsn1ez16a1p2vcj1-wpengine.netdna-ssl.com/wp-content/uploads/2018/08/Bigger-Picture-Report.pdf
20. https://www.itu.int/en/ITU-D/Digital-Inclusion/Pages/default.aspx
21. https://levelapp.net
22. https://media.nesta.org.uk/documents/digital_democracy.pdf
23. https://www-file.huawei.com/-/media/corporate/pdf/sustainability/2017-huawei-sustainability-report-en.pdf?la=en-gb
24. https://nomad-vr.com/
25. https://remarkable.org.au/accelerator/
26. https://exchange.telstra.com.au/ceos-named-joan-john-vr-may-tip-balance/
27. https://equalreality.com/
28. https://about.att.com/story/2018/aira_added_to_retail_stores.html
29. https://www.microsoft.com/en-us/ai/seeing-ai
30. http://www.bce.ca/responsibility/corporate-responsibility/2018-cr-report/2018-csr-report.pdf
31. https://www.unhcr.org/uk/figures-at-a-glance.html
32. https://sustainabledevelopment.un.org/sdg10
33. https://www.gsma.com/mobilefordevelopment/uncategorized/accelerating-the-digitisation-of-international-remittances-through-mobile-money/
34. https://www.iom.int/migapp
35. https://refunite.org/
36. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2018/05/Mobile_Money_Competing_with_informal_channels_to_accelerate_the_digitisation_of_remittances.pdf
37. https://www.unhcr.org/blogs/unhcr-accepting-proposals-digital-identity/
38. https://migranet.io
39. https://www.finextra.com/pressarticle/73218/simbapay-chatbot-powers-international-remittance-payments
40. https://www.unescap.org/sites/default/files/06Chapter4.pdf
41. https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx
42. https://www.nber.org/papers/w11986
43. https://ec.europa.eu/knowledge4policy/foresight/topic/changing-nature-work/new-technologies-automation-work-developments_en , https://www.bbc.co.uk/news/business-47691078

SDG 11 Deep Dive

1. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf https://sustainabledevelopment.un.org/sdg11,
2. https://www.un.org/sustainabledevelopment/cities/
3. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
4. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-11.pdf https://sustainabledevelopment.un.org/content/documents/197282018_background_notes_SDG_11_v3.pdf
5. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
6. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
7. http://www.euro.who.int/__data/assets/pdf_file/0006/74715/E86650.pdf?ua=1
8. http://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf
9. https://unhabitat.org/sdg-11-synthesis-report/
10. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
11. https://unhabitat.org/sdg-11-synthesis-report/
12. https://unhabitat.org/sdg-11-synthesis-report/
13. https://unhabitat.org/sdg-11-synthesis-report/
14. https://unhabitat.org/sdg-11-synthesis-report/
15. https://unhabitat.org/sdg-11-synthesis-report/
16. https://unhabitat.org/sdg-11-synthesis-report/
17. https://www.business.att.com/content/dam/attbusiness/reports/Smart%20Cities%20for%20All-Playbook.pdf
18. http://breakthrough.unglobalcompact.org/site/assets/files/1454/hhw-16-0017-d_c_artificial_intelligence.pdf
19. https://siliconcanals.nl/crowdfunding/oslo-based-construction-tech-startup-which-uses-ai-to-build-sustainable-cities-just-scored-e22m-funding-heres-what-you-need-to-know/
20. https://www.studiomapp.com/en/
21. https://gowlingwlg.com/en/insights-resources/articles/2019/how-will-vr-change-the-way-we-plan-smart-cities/
22. https://www.sheffield.ac.uk/polopoly_fs/1.790401!/file/vrardesign.pdf
23. http://www.interactivearchitecture.org/lab-projects/palimpsest
24. https://www2.deloitte.com/content/dam/Deloitte/au/Documents/future-of-cities/deloitte-future-of-cities-dtt_citysynergy-whitepaper_20190423.pdf
25. https://www.nokia.com/sites/default/files/2019-05/Nokia_People_and_Planet_Report_2018.pdf#page=47
26. https://enterprise.verizon.com/products/internet-of-things/smart-cities-and-communities/
27. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
28. https://unhabitat.org/sdg-11-synthesis-report/
29. https://unhabitat.org/sdg-11-synthesis-report/
30. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
31. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
32. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
33. https://roomiapp.com/
34. http://www.bce.ca/responsibility/corporate-responsibility/2018-cr-report/2018-csr-report.pdf
35. https://www.investinBlockchain.com/Blockchain-housing-crisis/
36. https://www.thestar.com.my/tech/tech-news/2018/08/02/with-drones-and-satellites-india-gets-to-know-its-slums/#F4wikV3q22dEYGQE.99
37. https://blogs.worldbank.org/sustainablecities/resilient-housing-joins-machine-learning-revolution
38. http://parametric.support/optimization/
39. http://urbanspatialanalysis.com/portfolio/proof-of-concept-using-predictive-modeling-to-prioritize-building-inspections/
40. https://geniebelt.com/blog/10-futuristic-technologies-that-are-changing-construction
41. https://unhabitat.org/sdg-11-synthesis-report/
42. https://unhabitat.org/sdg-11-synthesis-report/
43. https://sustainabledevelopment.un.org/content/documents/197282018_background_notes_SDG_11_v3.pdf
44. https://unhabitat.org/sdg-11-synthesis-report/
45. https://www.sutp.org/files/contents/documents/resources/E_Fact-Sheets-and-Policy-Briefs/SUTP_GIZ_FS_Avoid-Shift-Improve_EN.pdf

46. https://journify.es/business/
47. https://www.greenappsandweb.com/en/android-en/rewarding-sustainable-mobility-solutions/
48. https://www.belfastlive.co.uk/news/belfast-news/driver-drowsiness-detector-launched-northern-14217991
49. https://www.carkeys.co.uk/news/5-smart-road-technologies-for-the-roads-of-the-future
50. https://i.dell.com/sites/doccontent/corporate/corp-comm/en/Documents/mobility-open-data.pdf?newtab=true
51. https://unhabitat.org/sdg-11-synthesis-report/
52. https://res-www.zte.com.cn/mediares/zte/Investor/20180315/E6.pdf
53. http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf
54. https://www.sciencedirect.com/science/article/pii/S235286481730247X
55. https://www.un.org/sustainabledevelopment/cities/
56. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
57. https://unhabitat.org/sdg-11-synthesis-report/
58. https://unhabitat.org/sdg-11-synthesis-report/
59. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
60. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
61. https://unhabitat.org/sdg-11-synthesis-report/
62. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf &
63. http://pure.iiasa.ac.at/id/eprint/15347/1/TWI2050_Report08112018.pdf
64. https://unhabitat.org/sdg-11-synthesis-report/
65. http://www.fujitsu.com/global/about/resources/news/press-releases/2018/0723-01.html
66. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2015/02/GSMA_Dialog_DEWN_Disaster_Emergency_Warning_Network.pdf
67. https://1u0b5867gsn1ez16a1p2vcj1-wpengine.netdna-ssl.com/wp-content/uploads/2018/08/Bigger-Picture-Report.pdf
68. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
69. http://www.fujitsu.com/au/about/resources/news/press-releases/2018/innovative-smart-drains-solution-reduces-risk-of-flooding.html
70. http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf
71. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pd
72. https://phys.org/news/2018-03-mobile-disaster-relief.html
73. https://ieeexplore.ieee.org/document/8370421
74. https://www.arm.com/solutions/utilities
75. https://www.telecomitalia.com/content/dam/telecomitalia/en/archive/documents/sustainability/sustainability_reports/2018/TIM-Sustainability-Report-NFS-2018.pdf
76. https://www.raconteur.net/technology/smart-city-data-management
77. https://www.telecomitalia.com/content/dam/telecomitalia/en/archive/documents/sustainability/sustainability_reports/2018/TIM-Sustainability-Report-NFS-2018.pdf
78. https://gowlingwlg.com/en/insights-resources/articles/2019/how-will-vr-change-the-way-we-plan-smart-cities/
79. https://www.eonreality.com/portfolio-items/virtual-disaster-preparedness/
80. https://www.arm.com/solutions/utilities
81. https://downloads.nest.com/press/documents/energy-savings-white-paper.pdf
82. https://www.dabbel.eu/.
83. https://res-www.zte.com.cn/mediares/zte/Investor/20180315/E6.pdf
84. https://unhabitat.org/sdg-11-synthesis-report/
85. https://unhabitat.org/sdg-11-synthesis-report/
86. https://unhabitat.org/sdg-11-synthesis-report/
87. https://unhabitat.org/sdg-11-synthesis-report/
88. https://www.business.att.com/content/dam/attbusiness/reports/Smart%20Cities%20for%20All-Playbook.pdf
89. https://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
90. ihttps://www.itu.int/en/sustainable-world/Documents/Fast-forward_progress_report_414709%20FINAL.pdf
91. https://www.forbes.com/sites/forbestechcouncil/2017/06/19/the-problems-with-smart-cities/#f03a1216067f
92. https://vanderbiltindustries.com/news/examining-the-risks-and-benefits-of-smart-cities
93. https://vanderbiltindustries.com/news/examining-the-risks-and-benefits-of-smart-cities

SDG 12 Deep Dive

1. https://www.un.org/sustainabledevelopment/wp-content/uploads/2018/09/Goal-12.pdf
2. https://www.unenvironment.org/explore-topics/resource-efficiency/what-we-do/one-planet-network
3. https://dera.ioe.ac.uk/10987/1/00344-2010BKT-EN.pdf
4. http://www.fao.org/food-loss-and-food-waste/en/
5. http://www.fao.org/save-food/resources/keyfindings/en/
6. https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html
7. http://wedocs.unep.org/bitstream/handle/20.500.11822/25764/SDG12_Brief.pdf?sequence=1&isAllowed=y
8. https://sustainabledevelopment.un.org/sdg12
9. https://www.globalpolicywatch.org/blog/2019/03/25/sustainable-development-footprint/
10. https://www.change.org/p/tesco-ban-the-sales-of-eggs-from-caged-and-barn-kept-hens
11. https://www.tandfonline.com/doi/full/10.1080/10253866.2018.1456428Y
12. https://gikibadges.com/
13. http://www.conecomm.com/research-blog/2015-cone-communications-ebiquity-global-csr-study
https://sustainablebrands.com/read/stakeholder-trends-and-insights/study-81-of-consumers-say-they-will-make-personal-sacrifices-to-address-social-environmental-issues
14. https://veo.world/join-as-a-vendor
15. https://www.getaround.com/
16. https://www.pwc.com/gx/en/sustainability/assets/Blockchain-for-a-better-planet.pdf
17. https://www.xpansiv.com/our-impact/
18. https://www.xpansiv.com/2019/06/24/cbl-markets-and-xpansiv-launch-a-new-era-for-commodities-production-data-can-now-be-traded-on-a-spot-exchange-2/
19. https://unleash.org/solutions/coink/
20. https://www.impak.eco/en/impak-coin/
21. https://www.provenance.org/explore
22. https://www.weforum.org/agenda/2017/09/augmented-and-virtual-reality-will-change-how-we-create-and-consume-and-bring-new-risks/
23. https://sgwdesignworks.com/virtual-reality-prototyping/?cn-reloaded=1
24. https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management
25. https://www.worldbank.org/en/news/immersive-story/2018/09/20/what-a-waste-an-updated-look-into-the-future-of-solid-waste-management
26. https://unu.edu/publications/articles/consumers-vanguards-sustainability.html
27. http://wedocs.unep.org/bitstream/handle/20.500.11822/25764/SDG12_Brief.pdf?sequence=1&isAllowed=y
28. https://www.theatlantic.com/technology/archive/2019/03/china-has-stopped-accepting-our-trash/584131/
29. https://www.ellenmacarthurfoundation.org/our-work/activities/ce100
30. https://creatoracademy.youtube.com/page/lesson/edu-channel-start
31. https://www.ifixit.com/Right-to-Repair
32. https://www.lovefoodhatewaste.com/why-save-food
33. https://olioex.com/about/our-impact/
34. https://www.researchgate.net/publication/45267331_Contribution_of_Online_Trading_of_Used_Goods_to_Resource_Efficiency_An_Empirical_Study_of_eBay_Users
35. https://www.statista.com/statistics/242235/number-of-ebays-total-active-users/
36. https://us.vestiairecollective.com/about/
37. https://www.ellenmacarthurfoundation.org/assets/downloads/publications/A-New-Textiles-Economy_Full-Report_Updated_1-12-17.pdf
38. https://smarter.am/fridgecam/
39. http://www3.weforum.org/docs/WEF_Innovation_with_a_Purpose_VF-reduced.pdf
40. https://www.zestlabs.com/zest-fresh-for-growers-and-suppliers/
41. https://about.att.com/ecms/dam/csr/otherpdfs/ATT-Connected-Pallets-Case-Study-2017.pdf
42. https://www.enevo.com/
43. https://www.fujitsu.com/au/solutions/business-technology/sustainability/smart-ewaste-bins/
44. https://www.telecomitalia.com/content/dam/telecomitalia/en/archive/documents/sustainability/sustainability_reports/2018/TIM-Sustainability-Report-NFS-2018.pdf
45. https://www.winnowsolutions.com/vision
46. https://cdn2.hubspot.net/hubfs/650776/AI%20Guide/AI%20Guide_2.pdf
47. https://www.telegraph.co.uk/business/electronic-shelf-labels/reduce-food-waste/
48. https://www.wasteless.co/case-studies
49. https://www.recyclingtoday.com/article/wasteexpo-2018-robots-ai-mrf/
50. https://www.apple.com/uk/newsroom/2018/04/apple-adds-earth-day-donations-to-trade-in-and-recycling-program/
51. https://sustainabledevelopment.un.org/sdg12
52. https://www.brookings.edu/blog/up-front/2019/01/08/how-corporations-are-approaching-sustainability-and-the-global-goals/
53. https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/risk/lu-sustainability-board-2018.pdf
54. https://www.unpri.org/sustainable-markets/how-effective-are-corporate-disclosure-regulations/211.article
55. https://www.cdsb.net/sites/default/files/cdsb_report_1_esg.pdf
56. http://www.sdg.org/#about
57. https://ecochain.com/
58. https://alice.si/#Applications
59. https://casestudy.impak.eco/en/
60. https://www.datamaran.com/
61. https://www.americangeosciences.org/critical-issues/faq/how-does-recycling-save-energy
62. https://www.ipcc.ch/site/assets/uploads/2019/08/4.-SPM_Approved_Microsite_FINAL.pdf

63. https://sustainabledevelopment.un.org/content/documents/18809ScienceandTechnologyMajorGroupSectotalPaper_HLPF2018.pdf
64. https://www.forbes.com/sites/vianneyvaute/2018/10/29/recycling-is-not-the-answer-to-the-e-waste-crisis/#59afa7d77381
65. Please see [ICT sector as an exemplar] for more discussion of e-waste and the steps being taken to mitigate it
66. https://www.huckmag.com/art-and-culture/tech/the-tech-industry-has-a-serious-sustainability-problem/
67. https://www.ft.com/content/a8f5c780-f46d-11e7-a4c9-bbdefa4f210b
68. https://www.huffingtonpost.co.uk/entry/fast-fashion-influencers-instagram-fashion-nova-waste-climate-change_n_5c5ae8ffe4b0871047598750
69. https://www.wired.com/story/instagram-in-app-shopping-feature/?verso=true
70. https://www.thegrocer.co.uk/marketing/icelands-palm-oil-ad-ranked-most-powerful-xmas-2018-ad/574500.article
71. http://www.wwf.org.my/?26425/Palm-Oil-Boycotts-Not-The-Answer

SDG 13 Deep Dive

1. https://unfccc.int/news/unfccc-25th-anniversary-climate-action-is-more-urgent-than-ever
2. https://www.nature.com/articles/d41586-018-06827-x
3. https://www.marketwatch.com/story/6-ways-to-prepare-your-finances-for-climate-change-2016-12-20
4. https://www.scientificamerican.com/article/co2-levels-just-hit-another-record-heres-why-it-matters/
5. https://sustainabledevelopment.un.org/sdg13
6. https://unfccc.int/topics/action-on-climate-and-sdgs
7. https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/sr15_headline_statements.pdf
8. https://ourworldindata.org/natural-disasters
9. https://sustainabledevelopment.un.org/sdg13
10. https://www.nature.com/articles/s41558-018-0141-x
11. https://www.carbonbrief.org/tourism-responsible-for-8-of-global-greenhouse-gas-emissions-study-finds
12. https://science.sciencemag.org/content/360/6392/987
13. https://www.wri.org/blog/2018/12/new-global-co2-emissions-numbers-are-they-re-not-good
14. https://iopscience.iop.org/article/10.1088/1748-9326/aaf303/pdf
15. https://www.btplc.com/Purposefulbusiness/Ourapproach/Ourpolicies/ICT_Carbon_Reduction_EU.pdf
16. https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/sr15_headline_statements.pdf
17. https://interactive.carbonbrief.org/impacts-climate-change-one-point-five-degrees-two-degrees/?utm_source=web&utm_campaign=Redirect
18. https://www.theguardian.com/cities/ng-interactive/2017/nov/03/three-degree-world-cities-drowned-global-warming
19. https://sustainabledevelopment.un.org/content/dºCuments/22398Summary_dºCument_Copenhagen_FINAL_for_website.pdf
20. https://foodsource.org.uk/sites/default/files/chapters/pdfs/foodsource_chapter_3.pdf
21. http://i.dell.com/sites/dºCcontent/corporate/corp-comm/en/DºCuments/telecommute-study.pdf
22. https://www.techuk.org/images/programmes/Technology%20-%20Enabling%20CO2%20reductions%20Final%20Digital%20Version.pdf
23. http://www.gesicloudimpact.org/emission-calculator?ar=80&cc=c n&cs=all&tt=all
24. http://www.systemtransformation-sdg.gesi.org/case-studies.html
25. https://www.sap.com/dmc/exp/2018-01-unglobalgoals/7_Affordable_Clean_Energy.html
26. https://www.researchgate.net/publication/327338538_BlºCkchain_Applications_and_the_Sustainable_Development_Goals_-_Analysis_of_BlºCkchain_technology's_potential_in_creating_a_sustainable_future
27. https://www.researchgate.net/publication/327338538_BlºCkchain_Applications_and_the_Sustainable_Development_Goals_-_Analysis_of_BlºCkchain_technology's_potential_in_creating_a_sustainable_future
28. https://www.researchgate.net/publication/327338538_BlºCkchain_Applications_and_the_Sustainable_Development_Goals_-_Analysis_of_BlºCkchain_technology's_potential_in_creating_a_sustainable_future
29. https://www.carbonx.ca/
30. https://www.goldstandard.org/sites/default/files/dºCuments/cli_report_dec18.pdf
31. https://www.independent.co.uk/environment/satellites-power-station-emissions-climate-change-space-google-watt-time-a8922241.html
32. https://www.carbontracker.org/reports/nowhere-to-hide/
33. https://unfccc.int/news/climate-change-poses-increasing-risks-to-global-stability
34. https://azure.microsoft.com/en-gb/blog/using-ai-and-iot-for-disaster-management/
35. https://www.itu.int/en/ITU-D/Emergency-Telecommunications/DºCuments/2019/GET_2019/Disruptive-Technologies.pdf
36. https://www.itu.int/en/ITU-D/Emergency-Telecommunications/DºCuments/2019/GET_2019/Disruptive-Technologies.pdf
37. https://www.itu.int/en/ITU-D/Emergency-Telecommunications/DºCuments/2019/GET_2019/Disruptive-Technologies.pdf
38. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2015/02/GSMA_Dialog_DEWN_Disaster_Emergency_Warning_Network.pdf
39. https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2018-26/nhess-2018-26.pdf
40. https://www.ifrc.org/en/what-we-do/beneficiary-communications/tera/ ,
41. 40 https://www.ifrc.org/Global/ifrc.org/news/TERA%20Product%20Description%20Final.pdf
42. https://www.fujitsu.com/global/about/resources/news/press-releases/2019/0128-01.html
43. https://www.itu.int/en/ITU-D/Emergency-Telecommunications/Pages/Response.aspx
44. https://www.itu.int/en/ITU-D/Emergency-Telecommunications/DºCuments/2019/GET_2019/Disruptive-Technologies.pdf
45. https://gcn.com/articles/2019/01/10/ai-disaster-response.aspx
46. https://hub.packtpub.com/ai-rescue-5-ways-machine-learning-can-assist-emergency-situations/
47. https://hub.packtpub.com/ai-rescue-5-ways-machine-learning-can-assist-emergency-situations/
48. https://infermedica.com/product/call-center-triage/
49. http://aidr.qcri.org/
50. http://aidr.qcri.org/
51. https://hub.packtpub.com/ai-rescue-5-ways-machine-learning-can-assist-emergency-situations/
52. http://intertisement.com/cases/ar-tool-for-climate-change-city-planning/
53. https://www.bbc.co.uk/news/uk-politics-48540004
54. https://wriorg.s3.amazonaws.com/s3fs-public/How_to_Strengthen_the_Institutional_Architecture_for_Capacity_Building_to_Support_the_Post-2020_Climate_Regime.pdf
55. https://www.wri.org/blog/2015/12/3-reasons-why-capacity-building-critical-implementing-paris-agreement
56. https://www.sdgdata.gov.au/goals/climate-action/13.3.1
57. https://www.opml.co.uk/blog/how-to-build-institutional-capacity-to-tackle-climate-change
58. https://wriorg.s3.amazonaws.com/s3fs-public/How_to_Strengthen_the_Institutional_Architecture_for_Capacity_Building_to_Support_the_Post-2020_Climate_Regime.pdf
59. https://www.itu.int/en/ITU-R/information/Pages/climate-change.aspx
60. https://www.researchgate.net/publication/329314128_Immersive_Virtual_Reality_Field_Trips_Facilitate_Learning_About_Climate_Change
61. https://www.nationalgeographic.com/environment/2019/07/artificial-intelligence-climate-change/
62. https://pubs.giss.nasa.gov/abs/mo01100t.html
63. https://blogs.ei.columbia.edu/2018/06/05/artificial-intelligence-climate-environment/
64. https://e360.yale.edu/features/can-artificial-intelligence-help-build-better-smarter-climate-models
65. http://www.worldbank.org/content/dam/Worldbank/dºCument/Climate/Climate%20and%20Poverty%20Conference/D1S1_Hallegatte_CCandPov_9Fev_v6.pdf
66. http://www.worldbank.org/content/dam/Worldbank/dºCument/Climate/Climate%20and%20Poverty%20Conference/D1S1_Hallegatte_CCandPov_9Fev_v6.pdf
67. https://www.nature.com/articles/nclimate2470
68. https://www.sciencedirect.com/science/article/pii/S0048969717320399
69. https://www.theguardian.com/science/2018/ºCt/10/climate-impact-lab-cimate-change-cost-suicide
70. https://www.sciencedirect.com/science/article/pii/S0959378018301596
71. https://www.climatefinance-developmenteffectiveness.org/topic/gender-and-poverty-and-climate-change-finance

SDG 14 Deep Dive

1. https://www.unenvironment.org/explore-topics/oceans-seas
2. https://sustainabledevelopment.un.org/topics/oceanandseas
3. https://oceanconference.un.org/sdg14
4. https://www.weforum.org/projects/a-new-vision-for-the-ocean
5. https://publications.europa.eu/en/publication-detail/-/publication/676bb-d4a-7dd9-11e9-9f05-01aa75ed71a1/language-en/
6. https://news.itu.int/technology-saving-oceans/
7. http://www.unesco.org/new/en/natural-sciences/ioc-oceans/focus-areas/rio-20-ocean/ocean-governance/+https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
8. https://www.weforum.org/agenda/2018/07/fish-stocks-are-used-up-fisheries-subsidies-must-stop/
9. This estimate uses data from the FAO, and the rates of impact and adoption are based on a survey of experts. See the [technical appendix] for more detail.
10. https://sustainabledevelopment.un.org/content/documents/22828Pratikto_PPT.pdf

11. Open science is built on the idea that methods, observations, and reporting should be made available to anyone who needs or is interested in it. Through the use of data science, the raw data is analysed in a reproducible way, and turned into useful information –also to be freely, and readily available.
12. http://www.oceanhealthindex.org/
13. https://www.revocean.org/platform/oceandata/
14. https://blogs.microsoft.com/green/2018/04/19/the-nature-conservancy-case-study/
15. https://www.greenpeace.org.uk/what-we-do/oceans/plastics/
16. As of 2016
17. http://www3.weforum.org/docs/WEF_The_New_Plastics_Economy.pdf
18. https://publications.europa.eu/en/publication-detail/-/publication/676bbd4a-7dd9-11e9-9f05-01aa75ed71a1/language-en/
19. https://waitrose.pressarea.com/pressrelease/details/78/NEWS_13/10259
20. https://www.plasticbank.com/
21. https://www.cleanwatercoin.org/
22. https://www.weforum.org/agenda/2018/06/this-ai-is-learning-to-recognize-ocean-plastic-using-drone-photos/
23. https://www.ft.com/content/8028d802-c883-11e8-86e6-19f5b7134d1c
24. https://www.digitaltrends.com/cool-tech/robot-swan-water-quality/
25. https://www.seafoodsource.com/news/environment-sustainability/trinidad-and-tobago-fishers-hope-water-monitoring-buoy-will-ease-oil-spill-fears
26. https://www.oceannetworks.ca/oceans-20-internet-things-ocean
27. https://www.research.ibm.com/5-in-5/ai-microscope/
28. https://www.theguardian.com/environment/2019/jun/23/great-pacific-garbage-patch-floating-plastic-trap-deployed-again https://theoceancleanup.com/technology/
29. https://www.weforum.org/agenda/2018/07/fish-stocks-are-used-up-fisheries-subsidies-must-stop/
30. https://www.datalimitedtoolkit.org/
31. https://sfg-ucsb.github.io/afamGuidanceDocument
32. https://fishpath.org/Questionnaire https://www.pewtrusts.org/en/research-and-analysis/issue-briefs/2019/04/the-link-between-effective-fisheries-management-and-ending-harmful-subsidies
33. (https://eachmile.co/mfish).
34. https://docktodish.com/
35. https://www.worldwildlife.org/pages/bait-to-plate
36. https://www.provenance.org/tracking-tuna-on-the-blockchain#pilot-phase-1
37. https://vericatch.com/contact/
38. http://i.dell.com/sites/doccontent/corporate/corp-comm/en/Documents/fy17-cr-report.pdf
39. https://www.studiomapp.com/en/
40. https://www.pewtrusts.org/en/research-and-analysis/issue-briefs/2015/03/project-eyes-on-the-seas
41. https://www.oceanmind.global/about/
42. https://www.flywirecameras.com/
43. https://shellcatch.com/welcome/
44. https://www.camio.com/
45. http://www.oceanhealthindex.org/region-scores/key-findings
46. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
47. https://oceanconference.un.org/sdg14
48. https://www.un.org/en/sections/issues-depth/climate-change/

SDG 15 Deep Dive

1. https://sustainabledevelopment.un.org/content/documents/200087.8_Formatted_Background_NoteSDG_15.pdf
2. https://www.un.org/sustainabledevelopment/blog/2019/05/nature-decline-unprecedented-report/
3. https://www.ipbes.net/system/tdf/spm_3bi_ldr_digital.pdf?file=1&type=node&id=28335
4. Latest data is from 2012
5. https://sustainabledevelopment.un.org/content/documents/19850SDG15_Highlights.updated_format.pdf
6. https://unstats.un.org/sdgs/report/2019/The-Sustainable-Development-Goals-Report-2019.pdf
7. https://www.ipbes.net/news/Media-Release-Global-Assessment
8. https://wedocs.unep.org/bitstream/handle/20.500.11822/25765/SDG15_Brief.pdf?sequence=1&isAllowed=y
9. https://www.un.org/sustainabledevelopment/biodiversity/
10. https://www.ipbes.net/system/tdf/spm_3bi_ldr_digital.pdf?file=1&type=node&id=28335
11. https://sustainabledevelopment.un.org/topics/forests
12. https://www.un.org/sustainabledevelopment/biodiversity/
13. http://www.fao.org/3/v4360e/V4360E08.htm
14. https://www.ipbes.net/system/tdf/spm_3bi_ldr_digital.pdf?file=1&type=node&id=28335
15. http://www.eubrazilopenbio.eu/Pages/Home.aspx
16. http://www.esa.int/Our_Activities/Observing_the_Earth/Space_for_our_climate/Satellite_data_instrumental_in_combating_desertification
17. https://www.microsoft.com/en-us/ai/ai-for-earth-projects?activetab=pivot1:primaryr5
18. https://www.globalforestwatch.org/
19. https://www.huawei.com/en/about-huawei/cases/rainforest-connection
20. https://www.blog.google/technology/ai/fight-against-illegal-deforestation-tensorflow/
21. https://stats.unctad.org/Dgff2016/planet/goal15/index.html
22. http://datatopics.worldbank.org/sdgatlas/SDG-15-life-on-land.html http://www.fao.org/state-of-biodiversity-for-food-agriculture/en/
23. https://www.un.org/sustainabledevelopment/biodiversity/
24. https://www.arm.com/company/sustainability/read-our-reports
25. https://www.safaricentralgame.com/
26. https://www.rhinocoin.com/
27. http://admin.indiaenvironmentportal.org.in/files/mstripes-ppt.pdf
28. https://www.telekom.com/en/media/media-information/archive/narrowband-radio-combats-bee-mortality-488686
29. https://news.mongabay.com/2017/12/counting-tigers-on-smartphones/
30. https://earthranger.com/
31. http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf
32. https://www.microsoft.com/en-us/ai/ai-for-earth-projects?activetab=pivot1:primaryr8
33. https://www.wildbook.org/doku.php
34. https://www.predicts.org.uk/
35. https://www.inaturalist.org/pages/seek_app
36. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
37. http://www.fao.org/3/I9535EN/i9535en.pdf
38. https://www.ipbes.net/system/tdf/spm_3bi_ldr_digital.pdf?file=1&type=node&id=28335
39. https://www.worldwildlife.org/threats/illegal-wildlife-trade

SDG 16 Deep Dive

1. https://sustainabledevelopment.un.org/post2015/transformingourworld
2. http://www.oecd.org/dac/accountable-effective-institutions/Achieving%20the%20Impossible%20can%20we%20be%20SDG16%20believers.pdf
3. https://worldjusticeproject.org/our-work/research-and-data/global-insights-access-justice-2019
4. http://www.oecd.org/dac/accountable-effective-institutions/Achieving%20the%20Impossible%20can%20we%20be%20SDG16%20believers.pdf
5. https://www.wired.co.uk/article/les-gilet-jaunes-yellow-vest-protests-in-france-facebook
6. https://www.centreforpublicimpact.org/technology-disrupting-political-systems/
7. https://www.usip.org/publications/2018/05/how-peace-tech-changing-global-conflict
8. https://sdg.iisd.org/news/leaders-discuss-private-sector-role-in-sdg-16/
9. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2017/01/Innovations-in-Mobile-Birth-Registration_Insights-from-Tigo-Tanzania-and-Telenor-Pakistan.pdf
10. https://data.unicef.org/resources/progress-for-every-child-2018/
11. Angola, Chad, Democratic Republic of the Congo, Bangladesh, Ethiopia, Guinea-Bissau, Somalia, Liberia, Malawi, United Republic of Tanzania, Zambia.
12. https://www.youtube.com/watch?v=cUChmbMiAeE
13. This hypothetical scenario assumes that the proportion of children under 5 years of age whose births have been registered with a civil authority could increase to 30.3% by 2030 through the targeted adoption of mobile birth registration. The status quo uses the current proportion of children with births registered. The dataset is sourced from the UN Statistics Division.
14. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6293880/
15. http://visionofhumanity.org/app/uploads/2019/06/GPI-2019-web003.pdf
16. https://www.usip.org/publications/2018/05/how-peace-tech-changing-global-conflict
17. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
18. https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/technology/lu-Blockchain-internet-things-supply-chain-traceability.pdf
19. https://www.un.org/sustainabledevelopment/peace-justice/
20. https://www.unglobalcompact.org/docs/issues_doc/rule_of_law/B4ROL_Framework_Business_Examples.pdf
21. https://www.ericsson.com/en/about-us/sustainability-and-corporate-responsibility/technology-for-good/humanitarian-response/wpdi
22. https://www.2030vision.com/news/the-sustainability-2030vision-story
23. https://www.unglobalcompact.org/docs/issues_doc/rule_of_law/B4ROL_Framework_Business_Examples.pdf
24. http://www.businessfor2030.org/goal-16-promote-justice-1
25. https://www.chainpoint.com/our-customers/tonys-chocolonely/
26. https://www.unglobalcompact.org/docs/issues_doc/rule_of_law/B4ROL_Framework_Business_Examples.pdf
27. https://www.thehagueinstituteforglobaljustice.org/latest-insights/latest-insights/commentary/how-can-technology-help-prevent-conflict-and-build-peace/

28. https://www.stabilityjournal.org/articles/10.5334/sta.cp/
29. https://www.usip.org/publications/2018/05/how-peace-tech-changing-global-conflict
30. https://www.knightscope.com/knightscope-k5
31. https://worldjusticeproject.org/sites/default/files/documents/WJP%20Access%20to%20Justice-Online%20Version%20%281%29.pdf
32. https://unstats.un.org/sdgs/report/2017/goal-16/
33. https://namati.org/wp-content/uploads/2018/06/Technology-in-Case-Management-for-Legal-Empowerment-The-Engine-Room.pdf
34. https://www.imf.org/en/News/Articles/2018/12/04/sp112918-corruption-disintegration
35. https://www.un.org/ga/search/view_doc.asp?symbol=E/2016/75&Lang=E
36. https://www.un.org/ga/search/view_doc.asp?symbol=E/2016/75&Lang=E
37. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
38. https://www.unglobalcompact.org/docs/issues_doc/rule_of_law/B4ROL_Framework_Business_Examples.pdf
    https://blogs.microsoft.com/on-the-issues/2016/04/19/microsoft-partners-legal-services-corporation-pro-bono-net-create-access-justice-portal/
39. https://www.telenor.com/sustainability/digital-birth-registration/giving-pakistani-children-an-identity/
40. https://www.itu.int/en/ITU-D/ICT-Applications/Pages/digital-identity.aspx
41. https://www.unglobalcompact.org/docs/issues_doc/rule_of_law/B4ROL_Framework_Business_Examples.pdf
42. https://www.worldbank.org/en/topic/governance/brief/anti-corruption
43. https://voatz.com/faq.html
44. https://core.ac.uk/download/pdf/11049357.pdf
45. https://core.ac.uk/download/pdf/11049357.pdf
46. https://www.worldbank.org/en/topic/governance/brief/anti-corruption
47. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
48. https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf
49. https://www.ohchr.org/EN/NewsEvents/Pages/HumanRightsDefenders.aspx
50. https://sustainabledevelopment.un.org/content/documents/1916816Forum2017AnnualShowcaseOutcomeDocument.pdf
51. https://www.constituteproject.org/
52. https://www.unglobalcompact.org/docs/issues_doc/rule_of_law/B4ROL_Framework_Business_Examples.pdf
53. https://www.sdg16hub.org/interlinkages
    https://www.smithsonianmag.com/innovation/is-a-lack-of-water-to-blame-for-the-conflict-in-syria-72513729/
54. https://www.ncbi.nlm.nih.gov/books/NBK493718/
55. https://news.un.org/en/story/2015/02/491972
56. https://www.worldbank.org/en/topic/governance/brief/anti-corruption
57. https://www.worldbank.org/en/topic/governance/brief/anti-corruption
58. https://www.oecd.org/corruption/putting-an-end-to-corruption.pdf
59. https://www.hrw.org/news/2016/03/25/digital-disruption-human-rights
60. https://www.hoover.org/research/emerging-technologies-and-their-impact-international-relations-and-global-security
61. https://www.stopkillerrobots.org/
62. https://www.paccsresearch.org.uk/blog/technology-can-create-conflict/
63. https://www.hrw.org/news/2016/03/25/digital-disruption-human-rights
64. https://unctad.org/meetings/en/SessionalDocuments/ecn162019d2_en.pdf
65. http://blueprint.unglobalcompact.org/sdgs/sdg16/

SDG 17 Deep Dive

1. https://news.un.org/en/story/2015/09/509732-un-adopts-new-global-goals-charting-sustainable-development-people-and-planet
2. https://sustainabledevelopment.un.org/sdg17
3. https://sustainabledevelopment.un.org/sdg17
4. https://sustainabledevelopment.un.org/content/documents/20075195972018_background_notes_SDG_17.pdf
5. https://sustainabledevelopment.un.org/content/documents/2153OnlineTechnology%20Facilitation%20Knowledge%20Platform%20Oct%2028%202015_clean_final.pdf
6. https://sustainabledevelopment.un.org/content/documents/2153OnlineTechnology%20Facilitation%20Knowledge%20Platform%20Oct%2028%202015_clean_final.pdf
7. https://www.un.org/ga/search/view_doc.asp?symbol=E/HLPF/2019/6&Lang=E
8. https://www.e-lucid.com/
9. https://sustainabledevelopment.un.org/content/documents/245112128312112017153333RoadmapforaSustainableFinancialSystem.pdf
10. Official Development Assistance
11. https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-17-partnerships-for-the-goals.html
12. https://sustainabledevelopment.un.org/sdg17
13. http://www.unwomen.org/en/news/in-focus/women-and-the-sdgs/sdg-17-partnerships-for-the-goals
14. https://www.itu.int/en/sustainable-world/Pages/goal17.aspx
15. Foreign Direct Investment
16. https://www.un.org/esa/ffd/wp-content/uploads/2014/12/ICESDF.pdf
17. https://www.gov.uk/government/publications/making-tax-digital
18. https://www.bitpesa.co/
19. https://www.un.org/esa/ffd/wp-content/uploads/2014/12/12Dec14-statement-TWN-partnerships.pdf
20. http://www.unrisd.org/flagshipblog-ellersiek
21. http://www.unrisd.org/flagshipblog-ellersiek
22. https://www.sei.org/wp-content/uploads/2018/11/sdg-17-partnerships-for-the-goals-review-of-research-needs-1.pdf
23. https://www.un.org/sustainabledevelopment/globalpartnerships/
24. http://webtv.un.org/watch/amina-j.-mohammed-deputy-secretary-general-video-message-on-why-partnerships-matter/6053667900001/
25. https://www.unglobalcompact.org/what-is-gc
26. http://www.fao.org/cfs/en/
27. https://unfccc.int/climate-action/marrakech-partnership-for-global-climate-action
28. https://business.un.org/en/info/about
29. https://www.worldbenchmarkingalliance.org/
30. http://unstats-undesa.opendata.arcgis.com/
31. https://paris21.org/news-center/news/using-adapt-measure-progress-towards-sdgs
32. https://www.worldbenchmarkingalliance.org/
33. https://www.sopact.com/
34. https://www.util.co/

Methodology

1. https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%202019%20refinement_Eng.pdf
2. https://sustainabledevelopment.un.org/content/documents/12067Understanding%20and%20mapping%20important%20interactions%20among%20SDGs.pdf
3. https://council.science/cms/2017/05/SDGs-Guide-to-Interactions.pdf
4. https://unstats.un.org/home/
5. https://sdg-tracker.org/
6. https://sustainabledevelopment.un.org/
7. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5682387/
8. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0199400
9. https://www.sciencedirect.com/science/article/pii/S235234091830708X#t0015
10. https://www.who.int/goe/publications/goe_mhealth_web.pdf
11. https://www.who.int/goe/publications/goe_mhealth_web.pdf
12. https://www.iea.org/access2017/#section-1-1
13. https://www.who.int/goe/publications/goe_mhealth_web.pdf
14. http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/FWF_and_climate_change.pdf
15. https://data.cdp.net/Emissions/2017-Cities-Community-wide-Emissions-Map/tm82-jqbh
16. https://ec.europa.eu/jrc/en/predict
17. https://www.iea.org/digital/
18. IEA (2018) CO2 Emissions from Fuel Combustion: Highlights. https://webstore.iea.org/co2-emissions-from-fuel-combustion-2018-highlights. All rights reserved.
19. IIEA (2018) Energy Efficiency Indicators. https://webstore.iea.org/energy-efficiency-indicators-2018-highlights. All rights reserved.
20. https://www.mdpi.com/2071-1050/10/9/3027
21. https://www.mdpi.com/2078-1547/6/1/117
22. https://www.ipcc.ch/site/assets/uploads/2018/03/emissions_scenarios-1.pdf, pg. 83-84
23. https://www.iea.org/digital/#section-5
24. https://www.iea.org/digital/
25. https://www.iea.org/statistics/efficiency/
26. https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf
27. http://wds.iea.org/WDS/pdf/Efficiency_indicators_Documentation.pdf
28. https://www.dell.com/learn/us/en/uscorp1/corp-comm/environment_carbon_footprint_products
29. https://www.apple.com/uk/environment/
30. https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-iii.pdf
31. https://www.iea.org/weo/

For more information, please visit:

digitalwithpurpose.gesi.org

To fully support the transformation required by the SDGs, digital technologies need to be developed and deployed with positive societal impact in mind and within a context of shared aspiration: **digital with purpose.**

For more information, please visit:

digitalwithpurpose.gesi.org