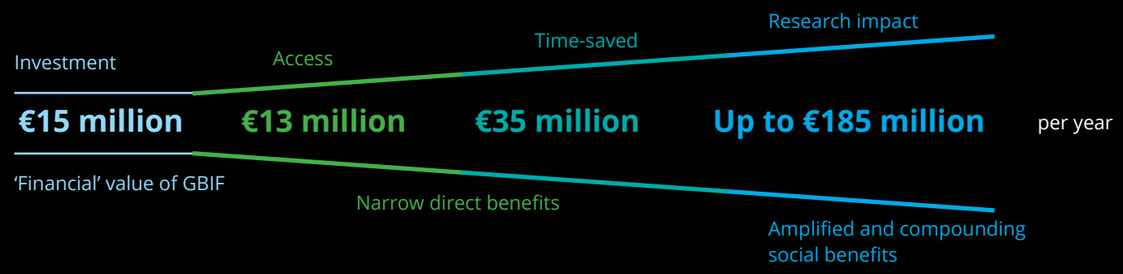
Deloitte.

Economic valuation and assessment of the impact of the GBIF network

GBIF Secretariat
June 2023

Deloitte
Access Economics

Every €1 invested in GBIF → **generates** **€3 of benefits to users** → **and** **up to €12 to society**



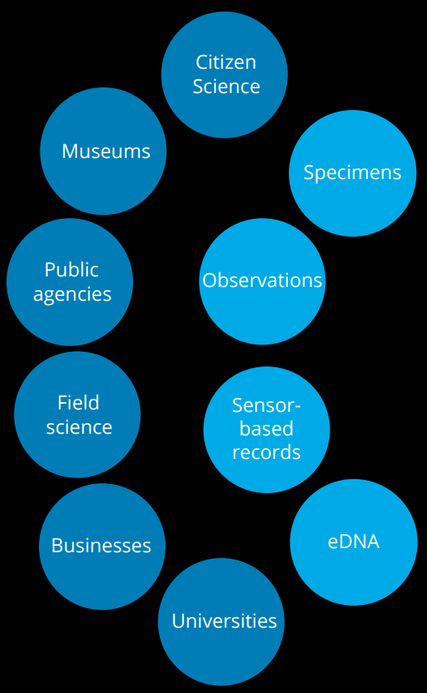
Data contributors

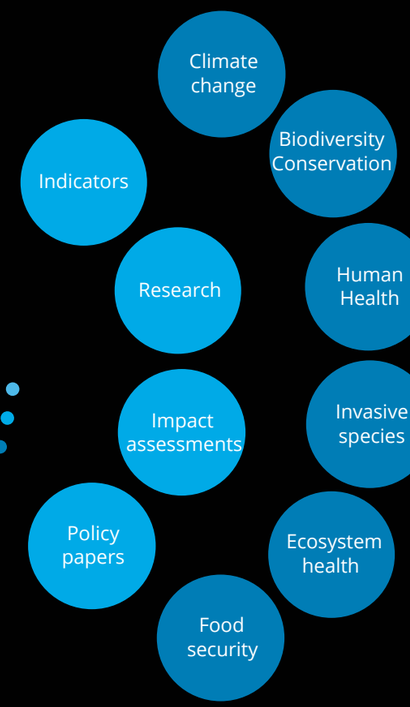
1,813
Data-publishing institutions

24% per year
Growth in contributions of occurrence data accessible through GBIF

Reduced duplication through data standards and shared R&D

Significant returns on the investment in species digitisation





Data users

115 billion
records downloaded/month

50 hours
Mean time per respondent spent searching for and accessing data from alternative source if GBIF was not available

47%
Respondents who would have found it impossible to achieve same research outcome in the absence of GBIF

A globally integrated platform

Data publishers collect species occurrence data fro m all realms and regions around the world and publish to the GBIF network so that it can be used by all.

Costs

€15 million per year

Contents

Executive summary

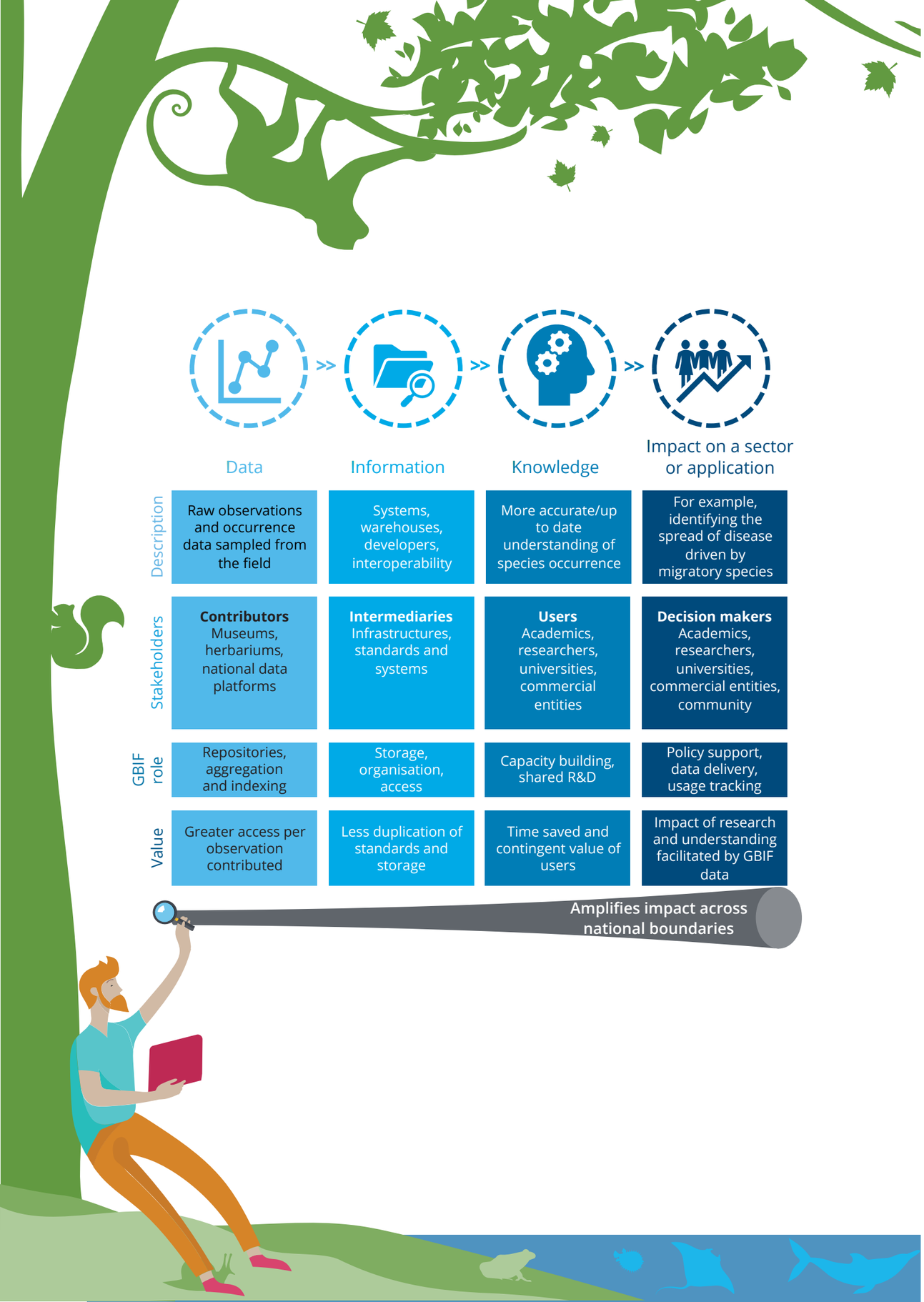
As the world confronts, mitigates and adapts to environmental degradation — whether it is climate warming, the impacts on our lands and oceans, or the immense loss of biodiversity – the knowledge offered by the Global Biodiversity Information Facility (GBIF) is critical.[1] Such knowledge facilitates exponential growth in society's understanding of life on our planet and how this information can be applied in conservation, policy and decision making across a broad range of areas. Open access to data about all types of life on Earth, wherever you are, is surely a wonder of the modern world. GBIF brings together the most current and comprehensive human knowledge on species occurrence to our fingertips.

Since GBIF's establishment in 2001, the volume of data it mediates and the impact of its uses have grown exponentially. As of August 2022, GBIF provided open access to over 2.2 billion species occurrence records across 75,000 datasets, with an average growth of 24% every year. This is in addition to a wide range of spatial data, visual data and taxonomic information. GBIF-mediated data is applied in over 7,500 peer-reviewed publications and policy papers, covering vast topics from climate change to the spread of invasive species and impacts on human health.[2]

Open access to biodiversity data is critical for effective knowledge diffusion, productivity and ultimately sustainable economic growth. It is the fundamental infrastructure on which scientific research and evidence for environmental policy can be based. It is an indispensable tool that streamlines the work of over 1,800 data publishers and 30,000 users, increasing the efficiency of public and private spending across economies and ultimately advancing scientific knowledge. It is essential to society's ability to assess species extinction risk.

The **value of connected data is far greater than the sum of its parts**.[3] The value of data grows as it is combined with other data and across the value chain of biodiversity data, GBIF amplifies the impact of data contributors, users and partners across national boundaries.

There is an important economic dividend from GBIF-mediated data – for every €1 invested there are €3 of benefits to users and up to €12 to society.



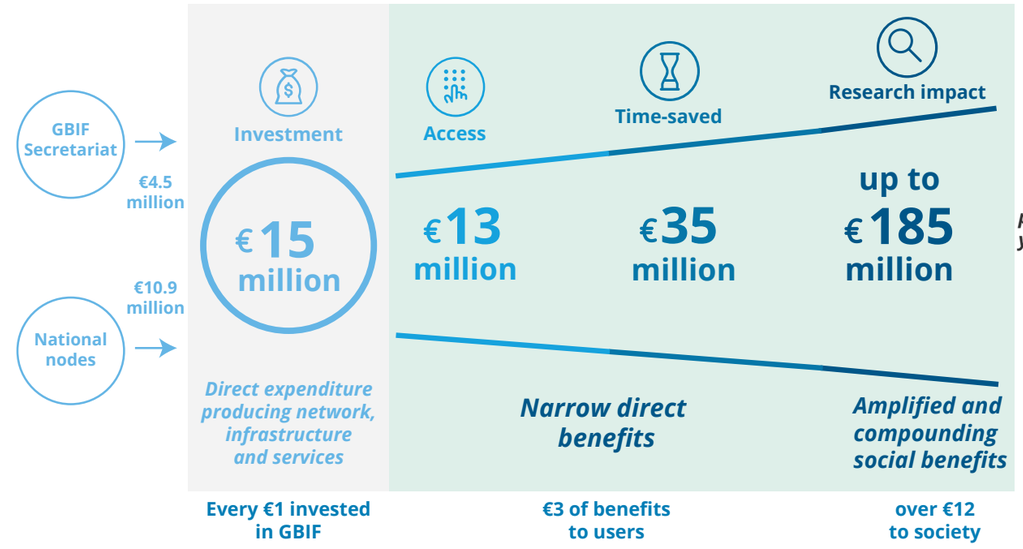
GBIF's activities are funded primarily by the world's gov-ernments, supplemented by a growing number of con-tributions from other sources. This analysis shows that these investments deliver significant benefits to users, including researchers, policy-makers and commercial entities, who gain value from time saved by access to high quality biodiversity information. GBIF provides numerous indirect benefits, including increased productivity from research and R&D investment, enhanced biodiversity conservation efforts and supporting research, projects and indicators contributing to Sustainable Development Goals.

Key findings

The most direct indicator of GBIF's value is the expenditure of the GBIF Secretariat and national nodes on providing its network, infrastructure and services – an average of **€15 million** per year.[4]

Specific economic benefits are created from this investment, particularly through providing free access (which is valued by users) and enabling time-saving use. Providing open access to biodiversity data is valued by users at **€13 million** per year. In addition, GBIF's 31,000 data users in 2021 saved an estimated 845,000 hours of total time that would have been spent search-ing for and accessing data required for their work by other means. This saved time is valued at **€35 million** per year based on the reported value of time from GBIF users – a significant time saving and a significant benefit to the ability of users to efficiently complete their work.

There are broader economic and societal benefits from the impact of activities supported by GBIF. Focusing just on research impact of GBIF-mediated data – which represents 70% of use cases – the global economy could benefit by up to **€185 million** per year due to GBIF-supported research.



Note: These values correspond to specific sources of value and are not intended to map directly to the biodiversity data value chain. These values are not additive. The value of volunteer time is not included in the above estimates.

Source: Deloitte Access Economics analysis.

GBIF provides a range of other important **sources of value** to its users, contributors and wider society that go beyond the measured quantitative estimates.

- **Users** of GBIF access its data an average of 8 hours per week. The most substantial and quantifiable benefit of GBIF is the time that is saves biodiversity data users, enabling more productive work and more effective decision-making. Over 90% of GBIF respondents said that their use of GBIF-mediated data contributes to Sustainable Development Goals.
- GBIF **expands the scope of what is possible.** Almost half of GBIF users would have found it impossible to achieve the same outcome in the absence of GBIF.
- Biodiversity data **contributors** invest significant resources in publishing the data they collect. These include museums, universities and researchers collecting observations on species in their home countries and abroad. GBIF amplifies the access to those contributions and the use per publication.
- GBIF **removes barriers** for users who would other-wise be unable to access data due to resource or technological constraints. This would diminish humanity's understanding of biodiversity globally.
- GBIF's technologies facilitate **recognition and citation** between users and contributors of individual datasets, a key value linkage in the field of research and science.
- Biodiversity does not recognise national borders. Global aggregation of species occurrence data ensures that scarce public resources are better allocated to conservation efforts. It ensures **policy decisions** are informed using more accurate data.
- GBIF provides an essential resource to **commercial entities** in assessing their impact on the environment and biodiversity. In particular, it provides a platform for sharing and pooling data generated through environmental impact assessments, acting as a global public good that reduces costs and proliferates open knowledge while providing a baseline for future planning.
- GBIF directly provides cost savings to other organisations by sharing and distributing digital infrastructure and centralised services. This bespoke technical development and maintenance at national or institutional levels supports and uplifts the global collection and sharing of biodiversity data.
- Volunteers contribute their time for various value-adding activities, such as translation or mentoring, and is valued at approximately **€958,000 per annum.** Note that this value only captures a limited set of roles for which there is sufficient data and is not included in the overall valuation estimates.

The economic benefits to society from GBIF, both measured and unmeasured, reflect its important role at a nexus of economic megatrends – such as reversing biodiversity decline, climate change and decarbonisation, expanding the digital economy and facilitating innovative research for sustainable economic growth. GBIF provides tools, insights and inspiration that add significant value in pursuit of addressing such societal challenges and creating new opportunities.

Interviews with prominent institutional users and contributors to GBIF's network emphasised the improved productivity, efficiency and impact of their work due to the existence of GBIF.

> ***GBIF's benefit is more than just employing less staff, it's about providing greater efficiency and relevancy in research and the ability to conduct research and publications that would not have been possible without GBIF.***
>
> Institut de Recherche pour le Développement, France

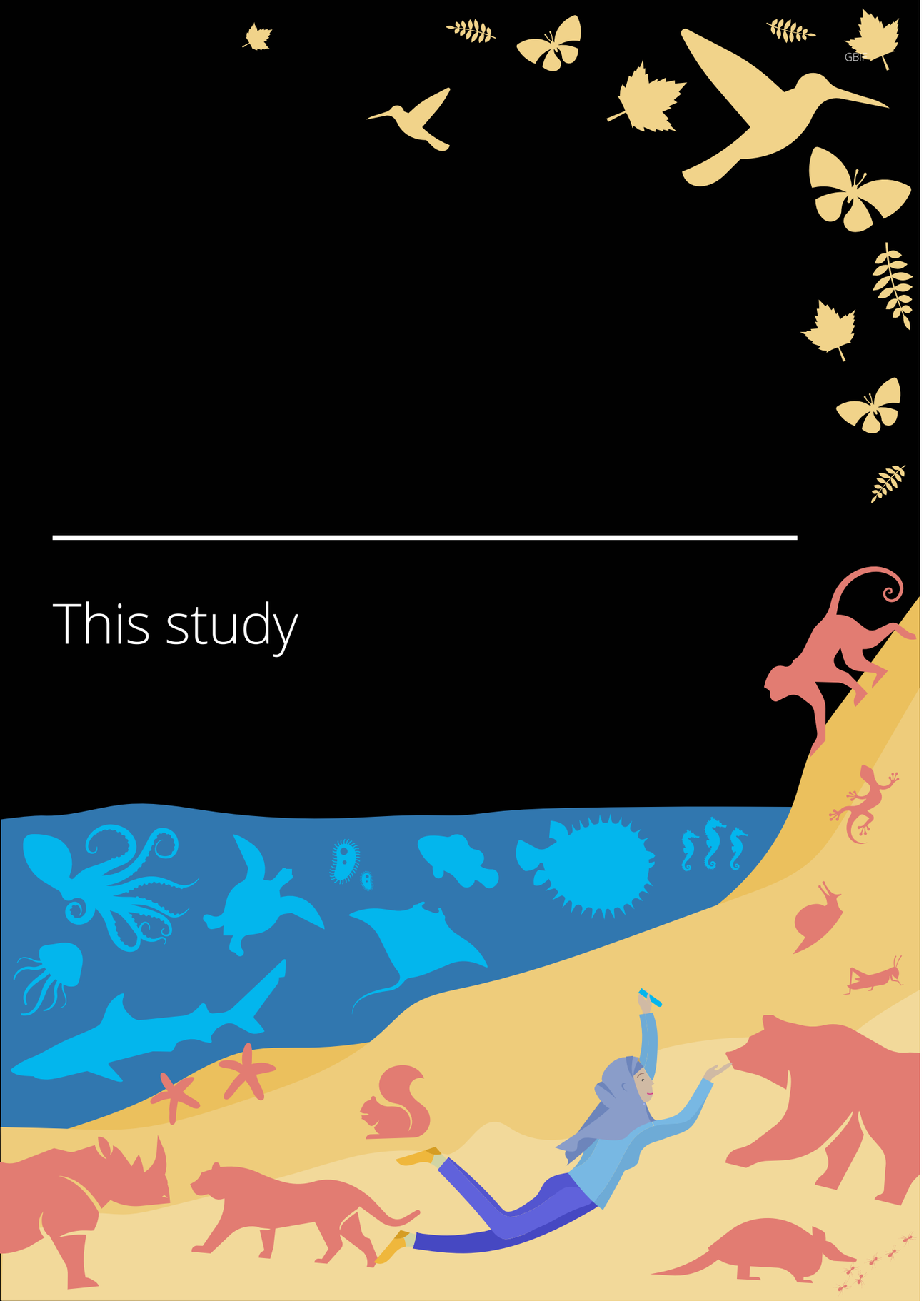
> ***No one else provides such wide datasets as GBIF. Because of that data, this may provide cost and time savings from having to collect data from [other] museums.***
>
> National Museum of Nature and Science, Japan

> ***We had an ageing infrastructure, which we replaced with a GBIF-hosted portal.***
>
> United States Geological Survey

Approach

Deloitte Access Economics conducted an independent economic valuation of GBIF's network, infrastructure and services. Guiding this economic assessment was the framing of the biodiversity data value chain and GBIF's role within it.

The analysis and findings are based on a global survey of GBIF users as primary research, accompanied by interviews, materials provided by GBIF and an extensive review of relevant academic literature. The primary research received over 600 responses from users around the world (Appendix B). National nodes were separately surveyed to understand the national-level investments in GBIF-related activities that are independent of the funding to the GBIF Secretariat (Appendix B). Interviews were held with eight institutions across the network (Appendix C). Combined, these methods provide the quantitative and qualitative findings on the economic value and impact of GBIF.



This study

Deloitte Access Economics conducted an independent economic valuation of GBIF's network, infrastructure and services. Guiding this economic assessment was the framing of the biodiversity data value chain and GBIF's role within it. This analysis accounts for both the benefits provided to users of GBIF-mediated data, and the broader benefits to society that emerge as a result of research, policy-making and commercial decisions supported by GBIF-mediated data.

A recent Twenty-Year Review by the GBIF Committee on Data of the International Science Council (CODATA) provides a detailed summary of the network's history and current state and emphasised a need to better communicate GBIF's impact and value. This economic valuation study directly responds to the recommendation that GBIF "[c]ommission, or suggest Participants to commission, a study or targeted studies on the monetary value of sharing biodiversity data and of the added value that data infrastructures provide to it."[5] This study builds on this review and other analyses[i] by focusing on the monetary value of GBIF's impact.

The analysis and findings of this study are based on a global survey of GBIF users as primary research, accompanied by interviews, materials provided by GBIF and an extensive review of relevant academic literature. The primary research received over 600 responses from users around the world (Appendix B). National Nodes were separately surveyed to understand the national-level investments in GBIF-related activities that are independent of the funding to the GBIF Secretariat (Appendix B). Interviews were held with eight institutions across the network (Appendix C). Combined, these methods provide the quantitative and qualitative findings on the economic value and impact of GBIF.

The subsequent chapters

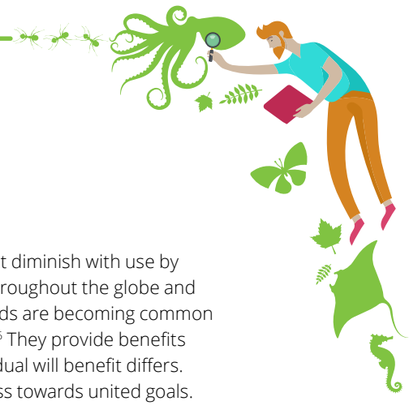
1. provide a biodiversity value chain framework to conceptualise GBIF's role in value creation
2. detail the economic valuation approach, including both quantitative and qualitative methods
3. provide quantitative estimates of GBIF's economic value, related to specific components of the biodiversity data value chain

Our quantitative analysis considers multiple methods for estimating the economic value of GBIF. These methods range from being narrowly defined, most directly attributed to GBIF and the value of its network and services to users, o being broadly defined, capturing some of the more wide-ranging indirect benefits created by GBIF for society at-large. While these methods are not all necessarily additive, comparisons between these methods yields some insight into the total value that GBIF creates. Our analysis primarily focuses on users and impact benefits related to the application of GBIF-mediated data.

There are significant potential benefits to data contributors and wider society as well, a selection of which are considered qualitatively in the 'Other sources of value' section. These provide a more holistic understanding of value that GBIF provides and can help to guide future research.

[i] For example, Heberling et al 2021 provides a detailed analysis of the research impact of GBIF-mediated data.

How does GBIF create economic value?



GBIF as a global collective good

Global collective goods (or services) are non-rivalrous (i.e., they do not diminish with use by others) and non-excludable (i.e., can be used any person or group) throughout the globe and are provided through the cooperation of multiple nations. These goods are becoming common in our increasingly digital, interconnected and interdependent world.[6] They provide benefits to the global population, however, the extent to which any one individual will benefit differs. These benefits can also span generations and support global progress towards united goals. In the face of unprecedented global challenges, such as climate change and biodiversity loss, global collective goods are more important than ever.

National-level investment, whether through global budget contributions to fund the GBIF Secretariat and its Work Programme, or through funding the National nodes to support digitisation and data mobilisation activities, produces the collective good that is GBIF. This open access platform creates significant global value that benefits all nations, including those that do not directly invest in the infrastructure.

Although a national-level cost benefit analysis is out of scope in this analysis, it is highly likely that national investors gain benefits which are greater than the cost of investment in GBIF. Some of these benefits include global data digitisation, access to digital infrastructure, knowledge sharing and learning, efficiencies in research budgets due to faster data access, and the use of this data to inform policy and research, which are explored further elsewhere in the report.

Significant investment has taken place over time to create GBIF as it is today. This one-off, up-front investment now generates ongoing benefits. As a mature, growing infrastructure, GBIF stimulates positive feedback as greater biodiversity data generates more knowledge, encourages more participation in data sharing, and progressively increases the value and effectiveness of the network.

GBIF's role in the biodiversity value chain

GBIF adds value across all stages of the data value chain, allowing governments, NGOs, businesses and scientists to make more informed decisions and open new lines of inquiry for ground-breaking research. The journey from collecting data to effecting change is one in which GBIF plays a pivotal role, facilitating easier access to data for those who need it, and providing the analytical tools to make sense of the data. This section will outline how GBIF interacts with both its contributors and its users to create value. To frame this discussion, we will consider how GBIF interacts with each stage of its value chain from raw data to application.

What is GBIF?

GBIF—the Global Biodiversity Information Facility—is an international network and data infrastructure funded by the world's governments and aimed at providing anyone, anywhere, open access to data about all types of life on Earth.

As of August 2022, GBIF provided open access to over 2.2 billion species occurrence records across 75,000 datasets.[7] This is in addition to millions of associated images and recordings, as well as comprehensive taxonomic information. GBIF-mediated data has been applied in over 7,500 peer-reviewed publications and policy papers, covering vast topics from climate change to the spread of invasive species and impacts on human health.[8] It is fundamental to our ability to assess the risk of extinction for thousands of species.[9]

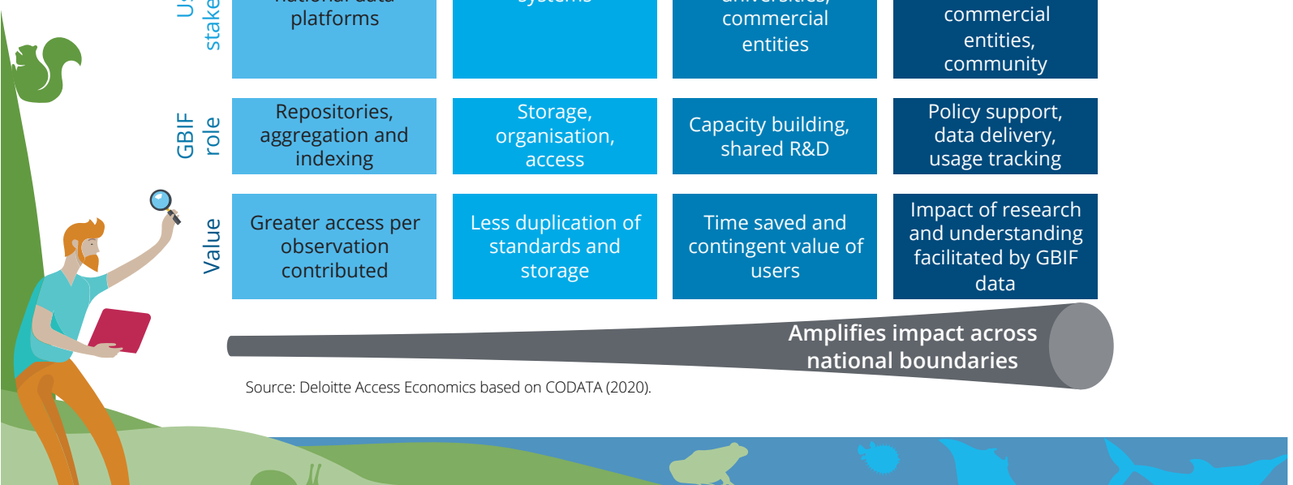
The goods and services that embody the GBIF network and data infrastructure, and therefore the scope of this economic valuation, include expenditure by the GBIF Secretariat and the national nodes in GBIF-related activities.

Figure 1.1 GBIF's role in the biodiversity data value chain

	Data	Information	Knowledge	Impact on a sector or application
Description	Raw observations and occurrence data sampled from the field	Systems, warehouses, developers, interoperability	More accurate/up to date understanding of species occurrence	For example, identifying the spread of disease driven by driven by migratory species
Users/ stakeholders	**Contributors** Museums, herbariums, national data platforms	**Intermediaries** Infrastructures, standards and systems	**Users** Academics, researchers, universities, commercial entities	**Decision makers** Academics, researchers, universities, commercial entities, community
GBIF role	Repositories, aggregation and indexing	Storage, organisation, access	Capacity building, shared R&D	Policy support, data delivery, usage tracking
Value	Greater access per observation contributed	Less duplication of standards and storage	Time saved and contingent value of users	Impact of research and understanding facilitated by GBIF data

Amplifies impact across national boundaries

Source: Deloitte Access Economics based on CODATA (2020).



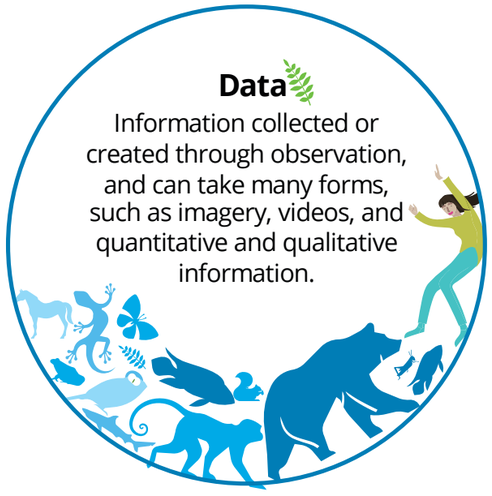
Data

The 'data' stage of the value chain represents the point of collection and contribution of biodiversity information to GBIF's networks. This information is raw, voluminous and diverse in format. There are close to 75,000 individual datasets now hosted on GBIF and this collection has been growing at a rate of 24% per year for the past 20 years.

GBIF creates value at the 'data' stage primarily by lowering the costs to digitisation and increasing the returns to individual data contributors: every species occurrence uploaded to the GBIF platform is almost immediately accessible anywhere in the world, increasing the use per euro spent on collection and digitisation.

GBIF has also been instrumental in kick-starting the drive towards the digitisation of biodiversity data, with many institutions now beginning to upload their collections onto the GBIF network.

A specific example of how GBIF creates this value is in the operation of an Integrated Publishing Toolkit (IPT) a free, open-source software tool used to publish and share biodiversity datasets through the GBIF network. The existence of this tool creates a degree of standardisation across datasets that both facilitates the easy access and understanding of any data in the GBIF network, and the ability to easily compare and combine datasets from many organisations, across all parts of the world.



1883
publishing institutions.

> ***The very existence of a place [such a GBIF] where data can be aggregated has stimulated the digitisation and therefore greater aggregation of [biodiversity] data.***
>
> – the Natural History Museum UK, 5 August 2022.

Information

The 'information' stage of the value chain is more intangible than the 'data' stage, but no less valuable. It ensures that raw data is able to be organised, stored and distributed to those who need it to create new knowledge. It represents the systems, standards, warehouses, developers and interoperability that GBIF's network consists of, all over the world.

The most significant source of value that GBIF may provide at the 'information' stage is in setting standards. This greatly reduces the required investments at the national level and improves interoperability across borders. This value is difficult to quantify, but could be in the order of billions of euros, according to a similar economic valuation study of a bioinformatics platform.[10]

Data contributors and publishing institutions have identified that integrating their data into the broader GBIF platform provides them with both organisational savings and more analytical tools. Data storage, as an example, can represent a prohibitive cost for smaller institutions. There are also significant savings to institutions in developer and IT staff time by being able to leverage a global network of bioinformatics professionals.

GBIF stands out from other infrastructures in its expressly international scope and its ability to accelerate and amplify the lifecycle of biodiversity data. Information collected and published on GBIF can then be used repeatedly to inform research, rather than being confined to one time use after collection. GBIF also helps to accelerate the time from collection to use, with weekly updates integrating local publications of datasets so that it be used anywhere in the world.[11]

> ***For small and medium sized museums, they don't have the IT servers or developers, so [GBIF] provides [data] servers for free, which reduces costs for them***
>
> – Anne-Sophie Archambeau, IRD, France, 9 August 2022.

Knowledge

The 'knowledge' stage of the value chain relates to how users access GBIF-mediated data to create new ideas and insights. An important feature of knowledge in biodiversity data is in assessment and understanding of **data quality**.

GBIF's contribution to knowledge is most broadly described as providing a more accurate, complete and up-to-date understanding of species occurrence and biodiversity, globally.

GBIF-mediated data is accessed by a broad spectrum of parties interested in using it to effect change. From governments and NGOs to academics and citizen scientists, GBIF-mediated data is used to answer questions both large and small. The existence of GBIF, which provides open access to an all-encompassing pool of biodiversity data, allows these data users to do what they do more efficiently and with more accuracy. With this understanding, organisations can undertake their analysis with greater confidence.

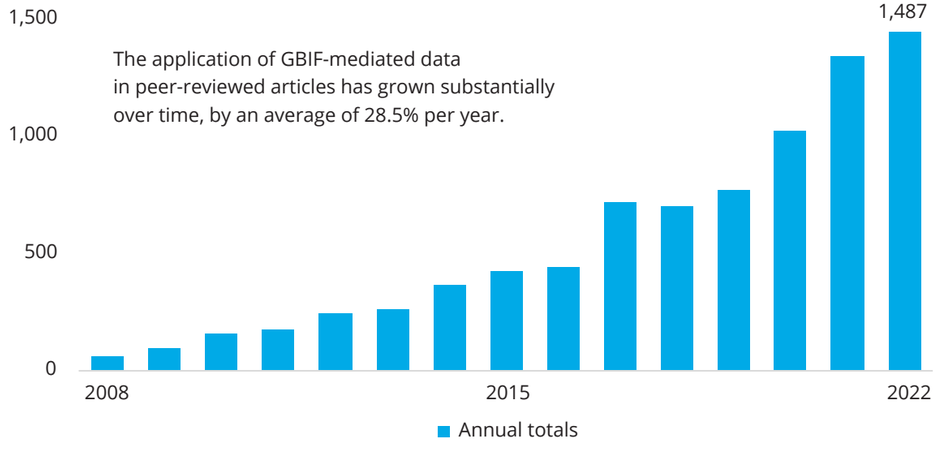
This access is important for users of GBIF-mediated data, with almost **50% of surveyed users reporting that they would not be able to access the data they need to complete their work without GBIF**. Moreover, even for those who are able to find alternative sources of data, they save significant time in not needing to search for those sources.

The open access data movement emphasises equity and equality of opportunity in democratising knowledge. GBIF **removes barriers** to access for users and groups who would otherwise be unable to contribute data, due to resource or technological constraints. This would diminish humanity's understanding of biodiversity globally.

84%

of GBIF-mediated data is used in research or the application of that research in policy

Peer-reviewed articles using GBIF-mediated data



Impact

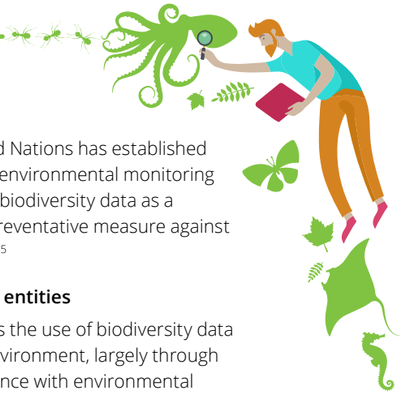
The 'impact' stage of the value chain is the broadest category, describing the wide range of positive economic outcomes that are supported by GBIF. Most directly, this is generated through the advancement of scientific knowledge facilitated through GBIF's platform. It is also used and applied to the decisions made by policymakers, NGOs, academic institutions and commercial entities.

At the highest level, research based on GBIF-mediated data supports primary research breakthroughs. Decisions at the science-policy interface, such as through the IBES, require an aggregated data source on species occurrence provided by GBIF-mediated data. Commercial decisions all over the world are increasingly shaped by their consideration of their possible impact on ecosystems, with GBIF providing a key source of information in these decisions.

Almost all GBIF users, 92%, identified that their use of GBIF-mediated data was linked to achieving Sustainable Development Goals.[12] As expected, 30% of these were aimed at goals directly related to environmental protection and rehabilitation. However, the remaining 60% contributed to goals with far-reaching impacts including sustainable cities and communities, educational outcomes and good health and well-being.

Even at the level of an individual researcher, GBIF facilitates and amplifies the impact of individuals through its Digital Object Identifier citation system. This enables a key source of value to flow between data user and knowledge producer, supporting the impact of research and facilitating further funding to meaningful research.

> ***Working with GBIF has been instrumental … Being able to tap into other GBIF node managers is a resource in itself***
>
> – SANBI, South Africa, 10 August 2022.



Biodiversity data in decision making…

Biodiversity data is critical to decision-making across the public and private sector. In 2022, the World Economic Forum listed biodiversity loss and ecosystem collapse as one of three greatest threats to humanity within the next ten years.[13] Urgent and well-informed decision-making regarding the conservation of species and biodiversity is therefore required.

… for policy

Biodiversity-focused decisions are complex, and are only made more difficult in the context of increasing climatic change. Decisions need to be made regarding where to invest limited resources to retain and mitigate losses of biodiversity, requiring the identification of which species and ecosystems to focus efforts towards, and how to manage these initiatives. It would be impossible to make these decisions without collection of biodiversity data, and the ability to share it with those who can make useful inferences from it. Without this sharing of data and knowledge, **essential biodiversity conservation decisions would be too complex to solve.**[14]

Further, the benefits of biodiversity information are not confined to environmental and scientific fields, it can be used to inform decisions relating to a vast array of topics, such as the spread of disease, land use and agriculture. As an example, changes in natural environments can enable the growth of diseases, such as Zoonotic diseases (disease transmitted from animals to humans).

As such, the United Nations has established the importance of environmental monitoring and the sharing of biodiversity data as a preparatory and preventative measure against future pandemics.[15]

… for commercial entities

Another example is the use of biodiversity data in a commercial environment, largely through regulatory compliance with environmental impact assessments, which inform land use and development decisions. Environmental impact assessments are, largely, a legal requirement when undertaking land use changes or infrastructure development, to ensure biodiversity is accounted for and support the 2030 Agenda for Sustainable Development and the Strategic Plan for Biodiversity.[16]

"We have used [GBIF] to assess potential endangered species distribution within local development [of] oil projects." – survey respondent, Mexico

Globally integrated biodiversity data helps to identify gaps in understanding for commercial entities. In South Africa, an array of developments have been proposed for an area known as Karoo, involving shale gas exploration, farming and renewable energy infrastructure, among other elements. However, the region had been poorly surveyed for biodiversity, which has impeded efforts to identify priority habitats that would be sensitive to these proposed changes to land use. As such, there have been a number of large biodiversity projects aimed at filling these biodiversity knowledge gaps, in order to inform strategic environmental assessments and decision making and allow for sustainable development that will have minimal impacts on priority habitats.[17]

Valuation approach

Building on the biodiversity value chain, and GBIF's role within this, this section outlines the approach taken to estimating an economic value of GBIF's network, infrastructure and services.

Data collection

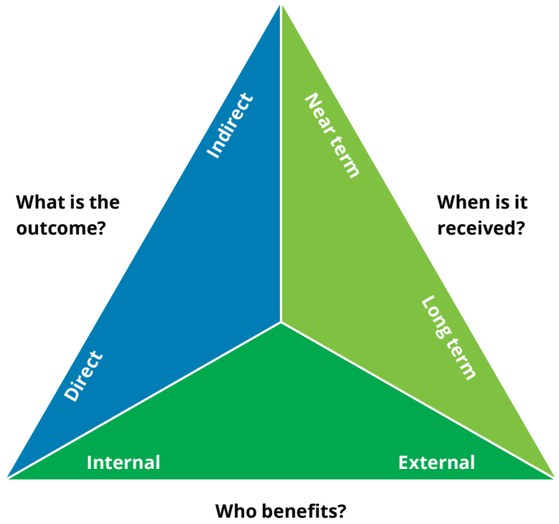
The economic valuation is grounded in observations and data from a range of sources, including a global survey of GBIF users as primary research, interviews of institutional stakeholders, materials provided by GBIF and an extensive review of relevant academic literature. The primary research received over 600 responses from users around the world from a diversity of institutions and biodiversity data applications (Appendix B). Online interviews were held with eight institutions across the network to both validate survey findings and develop a more holistic understanding of GBIF's economic value beyond the metrics collected through the survey (Appendix C). Combined, these methods provide the quantitative and qualitative findings on the economic value and impact of GBIF.

Assessing value, impacts and benefits

This information and data is then analysed within an assessment framework for benefits realisation (Figure 1.2). These dimensions are required to quantify benefits and include:

- What is the outcome? It is important to define the precise outcome that is caused by GBIF's network, infrastructure and services. This requires a hypothetical conception of a 'world without GBIF'. In designing our survey and in data analysis, we have assumed that, in the absence of GBIF, national governments, NGOs and other organisations will still maintain their own decentralised biodiversity databases, and contributors will still collect and distribute data. Outcomes of interest are then the extent to which GBIF adds value across the biodiversity value chain relative to this alternative. Outcomes that have been quantified here relate to data access, time savings and increased research and development.
- Who benefits? The economic value that GBIF contributes to accrue to certain groups and individuals. The 'Who benefits' box describes GBIF's network in more detail.
- When is it received? The timing of benefits is economically significant, relative to investment in GBIF today. All benefits within this analysis are quantified for the current period, but it should be recognised that GBIF's contribution to research usually has long-run impacts with the use and re-use of new data and knowledge.

Figure 1.2 Assessment framework for benefits realisation

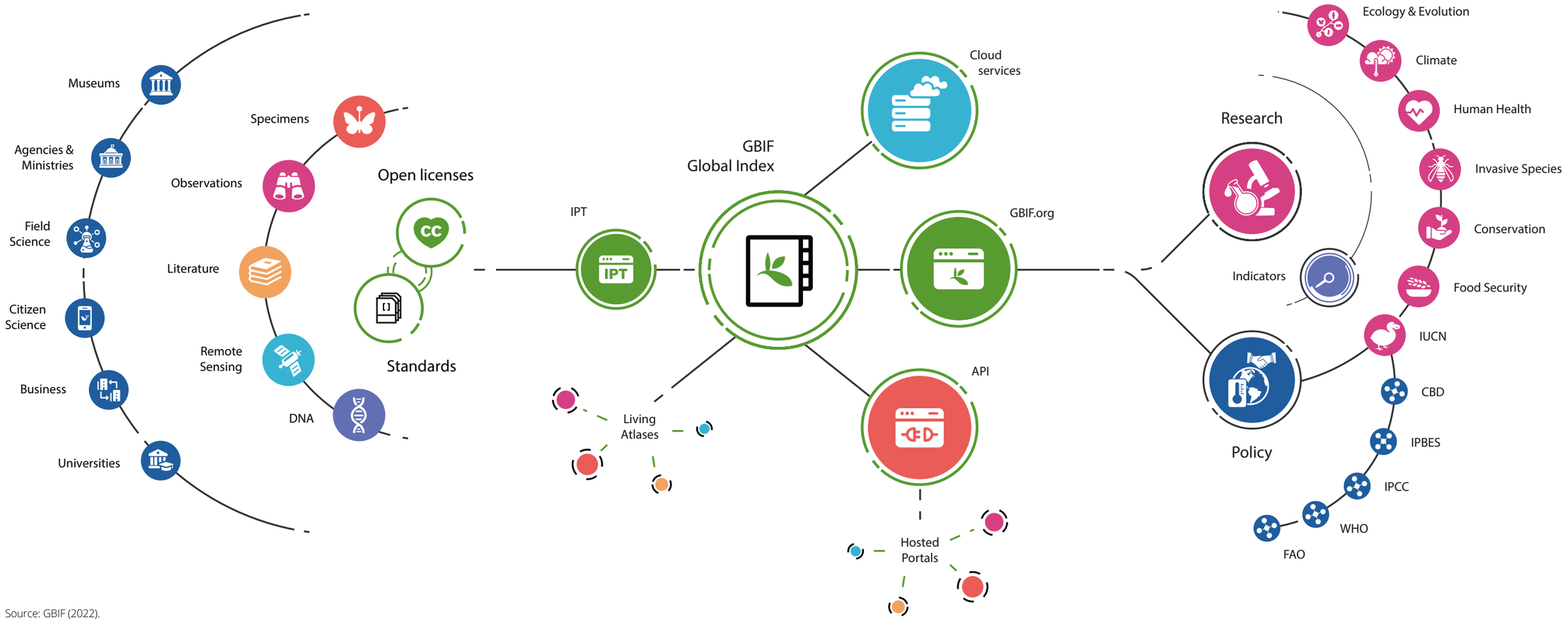


Source: Beagrie et al 2010 and KRDS 2011.

Who benefits

GBIF acts as a network and mediator, bringing together a diverse range of users and contributors (Figure 1.3). The beneficiaries GBIF's network, infrastructure and services consist of data users, and data contributors. Notably many GBIF users partake in both these activities. These users and contributors include researchers, policy makers, commercial firms and others.

Figure 1.3 GBIF as a mediator and infrastructure supporting biodiversity data access



Source: GBIF (2022).

Quantitative methods

Our quantitative analysis considers multiple methods for estimating the economic value of GBIF. These methods range from being narrowly defined, most directly attributed to GBIF and the value of its network and services to users, to being broadly defined, capturing some of the broader indirect benefits created by GBIF for society more broadly. While these methods are not all necessarily additive, comparisons between these methods yields some insight into the total value that GBIF creates. Our analysis primarily focuses on users and impact benefits related to the application of GBIF mediated data.

Four categories of economic value are quantified:

1. **Investment value:** the direct cost of producing GBIF's network, infrastructure and services. This involves expenditure of the GBIF Secretariat and by national nodes on GBIF-related activities. Volunteers also provide significant in-kind resources in the provision of GBIF. Given data limitations, the value of this time is not added to the investment value, but is discussed separately.
2. **Access value:** the direct non-market value that users place on having access to GBIF-mediated data.
3. **Time-saved value:** the value of users' time that is saved by having access to GBIF-mediated data.
4. **Research impact value:** the flow-on value to society of R&D activity that occurs with the support of GBIF-mediated data.

Qualitative methods

There are significant potential benefits to data contributors and wider society as well, a selection of which are considered qualitatively in the 'Other sources of value' section. These include GBIF's contribution to biodiversity conservation, supporting research and teaching capacity and in providing efficiencies to individual institutions. These provide a more holistic understanding of value that GBIF provides and can help to guide future research.

What is the economic value of GBIF today?

The economic value of GBIF is quantified in this section, leveraging results from Deloitte's primary research of GBIF users, data provided by GBIF and previous estimates from the applied economics literature. In understanding economic value, each of these components represent a distinct conception of value. It is important to note, that the investment value 'creates' the other categories of value, also described as 'benefits' to users and wider society.

Figure 1.4 The economic value of GBIF

Note: These values correspond to specific sources of value, and are not intended to map directly to the biodiversity data value chain. These values are not additive.

Source: Deloitte Access Economics analysis.

Investment value

The most direct indicator of GBIF's value is the direct expenditure on the production of its goods and services. Also referred to as its investment value, this category captures the direct expenditure by the GBIF Secretariat and national nodes in providing the shared network, infrastructure and services. Although this conception of value is narrow, it 'creates' the other categories of value.

Over the last five years, the GBIF Secretariat spent an average of €4.5 million per year.[18] National nodes spent an estimated €10.9 million in 2022 according to a recent survey (Appendix A).[19] The total investment value of the GBIF network is therefore **€15.4 million.**

This estimate includes the investment of national nodes in what are described as 'GBIF-related activities'. This may include, but is not limited to, the coordination of networks of people and institutions to produce, manage, and use biodiversity data and the facilitation of the delivery of biodiversity information for the international GBIF network.[20]

In theory, we do not seek to include investment in the local infrastructure of national nodes as well as the investments made by data contributors in producing the information that is then hosted on GBIF. This expenditure may have taken place at the national level with or without the existence of GBIF. Both expenditure categories are a part of the research process or may have occurred in the absence of GBIF and are therefore treated as 'sunk costs' (i.e., excluded).

Volunteer effort

It is also important to recognise that **volunteer time and effort is another essential resource that contributes to the running of GBIF.** Volunteers are utilised in several different streams of work for GBIF, such as translating the GBIF user interface and key web content to remove language barriers, reviewing funding proposals, and mentoring and training to enhance capacity across the GBIF network. The time spent volunteering reflects the perceived value of GBIF, and the extent to which people within its network are willing to further support the infrastructure in order to maintain and improve the GBIF network.

Volunteers assist in translating GBIF content into nine languages other than English. These activities consist of translating web content, strategies, guides and other content published to the site. Overall, it is estimated that 76 translation volunteers contribute a total of 2,400 hours to this activity.

Mentors and trainers who volunteer with GBIF run a number of capacity enhancing programs in order to uplift the mobilisation and use of biodiversity data. These programs also facilitate further collaboration and networking across the GBIF community. It has been estimated that nine trainer volunteers contribute at least 1,712 hours of their time, in aggregate, whilst 114 mentors contribute at least 1,880 hours of their time, in aggregate, to support these activities.

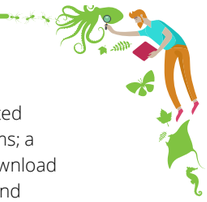
These two streams of volunteers are not the only way in which people within the GBIF network contribute their time to support the infrastructure, however, these two streams are the most easy to value given higher levels of data collection. Combined, the time of volunteer translators, trainers and mentors **is valued at approximately €958,000 per annum** (see Appendix D).

Access value

The access value of GBIF denotes the value that users place on being able to access GBIF-mediated data and its analytical tools.[21]

As a free, open access platform, data users do not face a fee to access. Non-market valuation techniques are therefore required to provide estimates of the economic value to data users. A survey of GBIF users, collected willingness-to-pay information for access to the data they would ordinarily receive through GBIF. The results of this survey, weighted by region of respondent, were extrapolated across the total number of GBIF-mediated data downloads, providing a valuation of the benefits received directly by GBIF users (Appendix A).

With over 253,000 data downloads in 2021, we estimate that generates **€13 million** per year of total economic value to users to access GBIF. This figure alone provides a benefit cost ratio of €3 to every €1 invested in GBIF's networks and is the narrowest estimate of value for GBIF's user group.



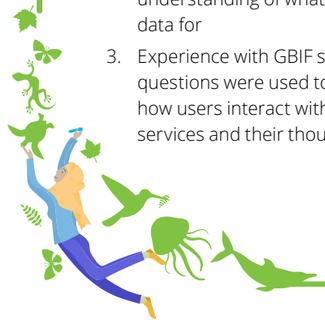
Primary research survey of GBIF users

A user survey was developed and distributed in order to gain a greater understanding of how data from the GBIF network is accessed and used. An essential goal of the survey was to capture willingness-to-pay data in order to estimate the value of GBIF to its users. As such, the survey was split into the following sections:

1. Demographic survey questions – these were used to gain an understanding of who uses GBIF-mediated data
2. Valuation survey questions – these were used to reveal users' willingness to pay and gain a greater understanding of what users use GBIF-mediated data for
3. Experience with GBIF survey questions – these questions were used to gain an understanding on how users interact with GBIF-mediated data and services and their thoughts on the platform itself

The survey was distributed to GBIF-mediated data and service users via three key streams; a web-pop on GBIF.org when users go to download data, correspondence from a GBIF node, and correspondence from the GBIF Secretariat. Survey responses were most commonly from users who accessed the survey via the web pop-up link.

The survey had a total 605 responses, and accepted responses between 23 June and 27 July 2022. The majority of data user who responded indicated that they worked for a public research institution (42% of responses), followed by government workers (18%) and private not-for-profit users (15%). While there is limited data to benchmark this to, the 2020 CODATA review identified scientists and academics as the first line of users targeted by GBIF, and that government scientists and policy makers were another key user of GBIF-mediated data, which aligns to this result.



Time-saved value

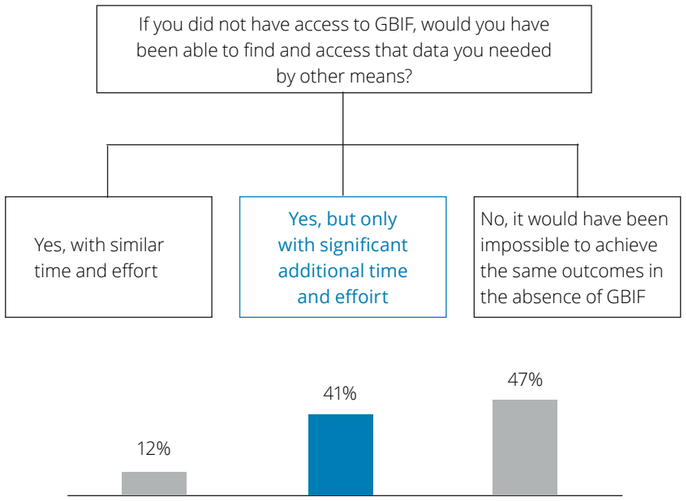
GBIF facilitates significant efficiencies and time savings in finding, analysing and interpreting biodiversity data. The survey results showed that the existence of GBIF streamlines users' ability to find and use the data they need to conduct their research. Interviews with prominent data users and contributors (Appendix C) helped to validate this finding.

Open access to a globally aggregated source of biodiversity data saves users, and organisations, time and allows this time to be put towards more productive uses. The time-saved value is an estimation of the total value of the time saved by having access to GBIF, compared to locating the relevant data elsewhere.

The researchers who use GBIF-mediated data saved an estimated 845,000 hours of total time in 2021 that would have been spent searching for and accessing data required for their work by other means. This time is valued at **€35 million**, according to the reported time values of GBIF users (Appendix A).

The survey showed that for certain users (12%), a lack of access to GBIF would have had little time cost to them. Conversely, a plurality of users (47%) would have found it impossible to 'achieve the same outcome in the absence of GBIF'. For the remaining users (41%), the availability of GBIF provides a quantifiable saving of time. This third group is the focus of the time-saved value estimate.

Figure 1.5 Majority of users could not do their work without GBIF access and many others would require significant additional time and effort



Research impact value

The value of more accessible and higher quality biodiversity data provides significant flow-on impacts to research outcomes, policy-making and commercial decisions. GBIF-mediated data has been leveraged by organisations to combat the impacts of climate change, improve agricultural productivity and food security, and provide new ways of understanding and fostering biodiversity.

Estimating the value of GBIF's contribution to scientific research outcomes is one significant component of these flow-on impacts. The economic value of investment in primary scientific research, also referred to as research and development (R&D) expenditure, lies in its advancement of the technical frontier of human knowledge, which ultimately contributes to economic and productivity growth.

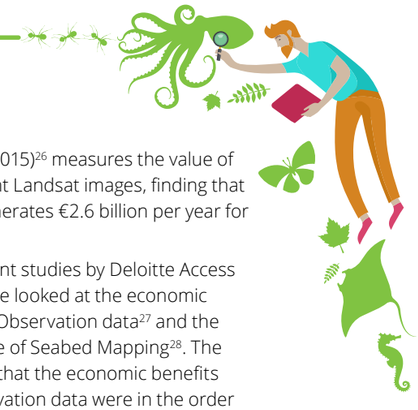
Following an approach adopted by Beagrie et al.,[22] an estimate of the wider economic value of GBIF mediated research can be proxied by an understanding of the amount of time invested in such research (derived from the survey) multiplied by external macroeconomic estimates of average returns to R&D investment. R&D facilitated by GBIF creates benefits across a wide variety of industries, including agriculture and food production, biosecurity, and human health. These research breakthroughs then spread throughout the economy, improving productivity, and enabling further incremental R&D to occur. Moreover, R&D in one industry can be utilised by other industries, to further boost productivity and spur economic growth.

Limiting the time invested estimate only to respondents who identify as 'researchers', we estimate an average time working with GBIF-mediated data to be up to 313 hours per year. Valuing this time, each re-spondent 'invests' €13,000 worth of time per year con-ducting research access and using GBIF-mediated data (Appendix A).

If research based on GBIF-mediated data generated similar average macroeconomic returns to R&D globally, the research impact of GBIF-mediated data would be estimated at **€185 million** per year.

This range reflects the uncertainty around the return to R&D parameter. Even with a narrow definition of R&D value (time value of researchers), these estimates show that at least by an order of magnitude there is likely to be significant returns to research that is supported by GBIF.

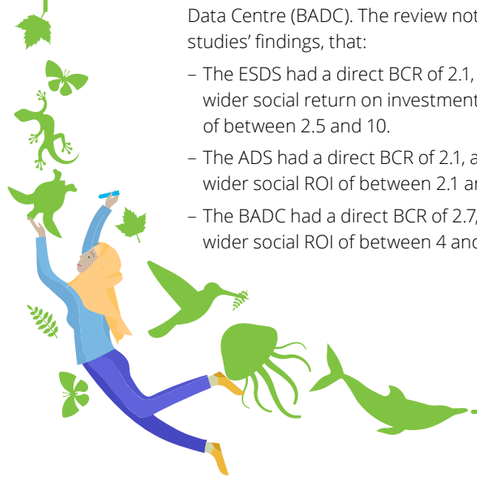
> ***If GBIF did not exist, it would make it considerably more difficult for me to find information vital to the success of my work.***
>
> – GBIF user, United States



Previous studies valuing open data and biodiversity information

Several recent studies focus on the value and impact of open scientific data platforms. While each focus on different contexts and adopt a range of methods and measures, a summary of their findings is included to provide a sense of how the estimates for GBIF compare:

- Beagrie & Houghton (2021) estimated the value of the European Molecular Biology Laboratory and the European Bioinformatics Institute (EMBL-EBI), finding the return on investment in R&D facilitated by EMBL-EBI to be worth around €2.6 billion per year. They also found that users of EMBL-EBI data enjoy €1.5 billion per year in direct benefits, with a benefit to cost ratio (BCR) of 11 to 1.[23]
- A recent study by Deloitte Access Economics (2021) looked at the indirect benefits that might arise from increasing the rate of taxonomic discoveries, predicting a BCR ofbetween 4 and 35 to 1.[24]
- Beagrie & Houghton (2014) conducted a review of three studies that valued UK-based data centres. These studies presented valuations of the Economic and Social Data Service (ESDS), the Archaeological Data Service (ADS) and the British Atmospheric Data Centre (BADC). The review noted each studies' findings, that:
  - The ESDS had a direct BCR of 2.1, and a wider social return on investment (ROI) of between 2.5 and 10.
  - The ADS had a direct BCR of 2.1, and a wider social ROI of between 2.1 and 8.3.
  - The BADC had a direct BCR of 2.7, and a wider social ROI of between 4 and 12.[25]
- Loomis et al. (2015)[26] measures the value of US Government Landsat images, finding that the service generates €2.6 billion per year for Landsat users.
- Two other recent studies by Deloitte Access Economics have looked at the economic value of Earth Observation data[27] and the economic value of Seabed Mapping[28]. The reports found that the economic benefits of Earth observation data were in the order of €1.7 billion per year, and the economic benefits of Seabed mapping data were €6.2 billion per year.
- Lateral economics (2021)[29] estimates the extent to which investment in the National Collaborative Research Infrastructure Strategy (NCRIS) supports post-COVID-19 economic recovery. The study found that the NCRIS has a return on investment in the order of 7.5:1, and has the potential to boost GDP by $46 million.
- Popov et al. (2021)[30] estimates the value of digitising natural history collections, with a specific focus on the Natural History Museum in London. The study identifies five key thematic areas by which to measure the value of the science collections, alongside typical returns on investment in scientific research, and efficiency savings from open data. They find that the value of digitising natural history collections exceeds £2 billion over 30 years, and represents a seven to ten times return on investment.



Other sources of value provided by GBIF

In addition to the specific contribution to research impact, there are numerous other benefits that GBIF indirectly supports. This section describes these outcomes quantitatively where possible, but does not necessarily monetise these values.

Biodiversity conservation

Biodiversity does not recognise national borders. Globally aggregating species occurrence data ensures that scarce public resources are better allocated to conservation efforts. It ensures policy decisions are informed using more accurate data.

One specific example of this is in the identification of endangered species. Of the 20,000 data deficient species on the IUCN Red List, it has recently been estimated that 56% of these could be threatened. By aggregating and improving access to otherwise disconnected and disparate sources of species occurrence data, GBIF improves the ability of researchers and scientists to correctly evaluate a species' extinction risk. These assessments can lead to policies and interventions that aim to preserve and recover a species population.

Recent research on spider species, for example, has found that GBIF-mediated data, when combined with existing literature, was able to increase the number of IUCN Red List classifications by 3.3%. Improvements in data quality by GBIF will lead to a greater level of data sufficiency, leading to the identification of these species as threatened, and creating value for a society that enjoys and wishes to foster biodiversity.

Supporting research and teaching capacity

GBIF-mediated data is widely used by universities, both in a research and teaching capacity.[31] The use of biodiversity data provided by GBIF allows students to develop practical analytical skills, and to solve real-world problems with real biodiversity data. This is exemplified by the University Abomey-Calavi (see case study).

Case study: University of Abomey-Calavi

Benin's University of Abomey-Calavi is at the forefront of training the next generation of biodiversity informatics professionals. The University's two-year master's program in biodiversity informatics is deeply connected to the nation's forest management, wildlife management and public health sectors. Students of this program use GBIF-mediated data to identify real-world problems facing these industries, and use their knowledge to develop solutions as part of their final capstone project.

This emphasis on practical pedagogy, facilitated by the GBIF-mediated data, means that graduates are well placed to take on a wide range of jobs, both in Benin and across Africa. Many graduates develop research management and coordination skills to continue developing research and contributions to the GBIF platform. Others work with NGOs in Benin, or go into municipal level jobs across Beninand Africa more broadly. On the strength of this master's program, the University of Abomey-Calavi was able to establish ties to well-renowned academics across Africa, and throughout the world.

All this has meant that Benin has been at the forefront of biodiversity research in Africa, the benefits of which are able to be reaped by all GBIF users, with more than 1 million specimens being published to GBIF in Benin alone, with 80 per cent of that coming directly from the University of Abomey-Calavi.

An important finding of this particular case is **the two-way exchange of value between the University of Abomey-Calavi and GBIF**. The university program and its students benefit directly from having open access to biodiversity data all over the world. From GBIF's perspective, these important data users then also become data contributors.

Institutional sources of value

Interviews with nine prominent institutional users and contributors to GBIF's network revealed a number of specific sources of value. These both validated the survey findings, but also revealed novel impact channels for institutions who note improved productivity, efficiency and impact of their work due to the existence of GBIF. A selection of quotes are presented below.

> ***GBIF's benefit is more than just employing less staff, its about providing greater efficiency and relevancy in research and the ability to conduct research and publications that would not have been possible without GBIF***
>
> – Institut de Recherche pour le Dévelopement

> ***'No one else provides such wide datasets as GBIF. Because of that data, this may provide cost and time savings from having to collect data from [other] museums***
>
> – National Museum of Nature and Science

> ***The way in which GBIF supports shared innovation and shared R&D provides time savings to institutions … they also facilitate the expansion of scope by providing access to data on Australia shared by international institutions***
>
> – Atlas of Living Australia

> ***We had an ageing infrastructure, which we replaced with a GBIF-hosted portal***
>
> – the United States Geological Survey

Many of these institutions were able to identify and quantify direct financial savings that can be attributed to GBIF (Figure 1.5). Potentially duplicated employment across the GBIF network is able to be saved for these institutions. There were also identified capital costs savings through access to GBIF's digital infrastructure, lowering institution-level costs to own and manage separate data portals.

The savings identified in Figure 1.6 are a snapshot. It is possible that, across the globe, there are many more institutions who are able operate with lower direct costs through access to the GBIF network.

Figure 1.6 Institutional level efficiencies derived from GBIF

Institutional level-efficiencies	Employment saved	Wage cost saved	Capital cost saved
National History Museum	10 FTE	€543,000 *Per annum*	
Colombian Biodiversity Infomation System	<1 FTE	<€25,000 *Per annum*	€8,100 *Per annum*
United States Geological Survey	2 FTE	€184,000 *Per annum*	€11,300 *Per annum*

Direct expenditure savings due to the existence of GBIF

Note: wage cost saved is estimated using average wage data for the professional, scientific and technical industry in relevant countries

Future considerations

This report has conducted an economic valuation of GBIF's network, infrastructure and services. It has drawn on surveys of GBIF users and national nodes, alongside individual interviews and desktop analysis. However, the value presented in this report, and the methodologies utilised to derive these values, are not the only way to consider and estimate the value of GBIF. Given its global reach, wide-ranging value-adding activities, and the complexity of its impact, there are several ways in which GBIF's value can be considered and estimated. Further, the impact of GBIF is likely to change over time – growing with the number of data contributors and data users.

As such, this section lays out other approaches that could be utilised in future studies of GBIF's value and impact.

Direct impact metrics for ongoing monitoring

GBIF already collects a large range of useful metrics on an ongoing basis, such as citations and data downloads, which provide insight into the level of usage and need for GBIF-mediated data. However, in order to replicate this study, or a similar economic valuation, there may be a need to expand these regularly collected metrics, so as to gain a greater, and continued, understanding of the types of users of GBIF-mediated data, and how they use data.

As recommended in the CODATA review, the collection, and public presentation of GBIF-related 'success stories' are a qualitative approach to communicating the direct impact of GBIF. The 2022 Science Review is a strong example of this.

Further direct capturing and monitoring of GBIF's role in providing data for scientific and societal benefit will provide quantitative and aggregated indicators that can complement these 'success stories' and support future economic valuations.[32] One example of this could be to replicate the national node survey used to derive the investment value presented in this report for all new nodes, or across all nodes every few years. This would support a continued body of data surrounding national nodes, capturing their contribution to the GBIF network.

Other approaches to estimating economic value

Thematic approach

A thematic approach in future valuations would provide a more granular view to sources of research value. This would be especially beneficial in identifying and quantifying research areas with the greatest value, and can provide compelling case studies between GBIF-mediated data and outcomes downstream in the data value chain. These are, however, generally less suited to providing an aggregate estimate of value.

The CODATA review highlighted how a thematic approach could consider GBIF's value as flowing from data to knowledge and its impacts on specific sectors.[33] The review suggests that further micro-level research into specific examples within this chain would allow a greater understanding of GBIF's contributions to wider societal benefits. For example, further research could be made into the value proposition of GBIF from the perspective of its various programs.[34] One of which is the contribution GBIF makes to human capital development through its capacity enhancing and training programs. This is particularly of benefit to educators in developing nations, who can leverage GBIF's vast experience and resources to uplift capability within their region. While the benefits of GBIF to training and improving the capacity of other institutions is touched on here, it is not necessarily quantified and thus could be a useful future research consideration.

A thematic approach was utilised in a recent valuation of digitising the Natural History Museum collection, and identifies key themes of research that is enabled by this digitisation.[35] For each theme, such as medical discovery or mineral exploration, benefits are estimated by considering how data digitisation has contributed to scientific research and to wider applications.

This report's economic valuation of GBIF has considered a macro-relationship between investment in primary research and breakthroughs which raise economic productivity. It has also discussed the contribution that open access to GBIF data has made to biodiversity conservation.

De-duplication value

Open data can provide significant value to data users through the de-duplication of research efforts. Global access to open data allows for the reallocation of time that would have otherwise been spent on gathering data already provided by GBIF, allowing this time to be spent on more productive research.[36] As such, estimates which attempt to value this benefit would calculate the time saved by researchers due to the availability of GBIF and compute a value of the R&D that can be conducted as a result.

This view to GBIF's value, however, would be double counting the value derived in our research impact value calculations. As such, this methodology could be used instead of, rather than being in addition to, the research impact value presented in this report.

Macroeconomic and fiscal impact

An Australian study was conducted to estimate the extent to which investment in a national research infrastructure supported economic stimulus during recovery from the COVID pandemic.[37] The National Collaborative Research Infrastructure Strategy (NCRIS) is designed to enhance Australia's infrastructure for scientific research and its application. This study takes a traditional economic and fiscal impact approach, estimating the value of additional employment, wages, and economic activity generated by government investment. Overall, the study found that the NCRIS is a $7.1 billion initiative, with a return on investment in the order of 7.5:1. Contributing to this overall figure, the study found that the NCRIS had the potential to boost GDP by $46 million, and directly support 300-350 scientific and technical services FTE workers, and indirectly support 1,400 FTE workers across the supply-chain.

This report estimated the economic value of NCRIS by the contribution that it makes to Australia's GDP. It did not attempt to quantify the enhancement of core scientific knowledge, or other non-market benefits as has been done in this report.

Scope of impact: national versus global

This economic valuation represents a global view of the value of GBIF to data users, providers and the global society. However, given the broad ranging benefits of GBIF, from its support of biodiversity data digitisation to its provision of digital infrastructure, the value proposition of GBIF at the national level is also of great interest.

Stakeholders may benefit from country or region-specific valuations which highlight the value of GBIF to those regions. This could be particularly beneficial for institutions seeking greater funding and wishing to use more contextually relevant figures as evidence of the importance of GBIF.

Contact Us

Claire Ibrahim

Partner

Deloitte Access Economics

cibrahim@deloitte.com.au

Josh Appleton-Miles

Manager

Deloitte Access Economics

jappleton-miles@deloitte.com.au

Appendix A Economic valuation methodology

Economic valuation methodology

To estimate the economic value of GBIF, we use multiple valuation methods that consider an increasingly wide scope of the value that GBIF generates.

While these methods are not all necessarily additive, comparisons between these methods yields some insight into the total value that GBIF creates. Our analysis primarily focuses on users and impact benefits related to the application of GBIF-mediated data.

Four categories of economic value are quantified:

1. **Investment value:** the direct cost of producing GBIF's network, infrastructure and services. This also includes the opportunity cost of GBIF volunteer time spent on mentoring and training, and translating per annum.
2. **Access value:** the direct non-market value that users place on having access to GBIF-mediated data.
3. **Time-saved value:** the value of users' time that is saved by having access to GBIF-mediated data.
4. **Research impact value:** the flow-on value to society of R&D activity that occurs with the support of GBIF-mediated data.

Investment value

The most direct indicator of GBIF's value is the direct expenditure on the production and consumption of its goods and services. As an open access platform, the data users do not pay at the point of use; rather, GBIF relies on donations from government organisations to continue to operate. Also referred to as its investment value, this category captures the direct expenditure by the GBIF Secretariat in providing its network, infrastructure and services. Although this conception of value is narrow, it 'creates' the other categories of value.

Data and assumptions

Deloitte Access Economics received and analysed financial information from between 2017 and 2021, provided by the GBIF Secretariat. We have adopted the average of expenditure over this period in our estimation, which reflects the funding of the Secretariat and global Work Programme. Under this analysis, the investment value of GBIF is estimated to be €4.5 million per year.

This estimate does include the investment of national nodes in GBIF-related activities that are separate from contributions made to the GBIF Secretariat. These are estimated to total €10.9 million per year. These values are captured through a national node level survey distributed in January 2023.

Non-respondent nodes

The national node survey received 41 responses. For greater information regarding this survey, see Appendix B.

This did not cover all nodes in the GBIF network. As such, investment data provided by respondents was categorised from very low to very high, and the average spend per category was estimated.

GBIF then provided estimates for the category of investment spend per national node which had not responded to the survey, and the average spend per category was utilised to estimate a value for those non-respondents. The below table indicates this estimation.

Table A.1 Demographic survey questions

	Survey respondents			Non-respondents	
Investment size	**Count of national nodes**	**Average spend**	**Total spend**	**Count of national nodes**	**Estimated total spend**
Very low investment	1	€275	€275	7	€1,925
Low investment	5	€5,484	€27,419	18	€98,708
Medium investment	16	€21,446	€323,578	23	€493,262
High investment	15	€223,448	€3,351,724	7	€1,564,138
Very high investment	4	€721,079	€2,884,317	3	€2,163,238
	41		**€6,587,313**	**58**	**€4,321,271**

However, these figures do not include investments made by data contributors in producing the information that is hosted on GBIF. This expenditure is considered as a part of the research process or would have occurred in the absence of GBIF and are therefore treated as 'sunk costs' (i.e., excluded).

Access value

The access value of GBIF denotes the value that users place on being able to access GBIF data and analytical tools. The most common method of assessing this value is by using a contingent valuation method, a direct survey method where respondents are asked to place a value on their access to GBIF.

To estimate the access value per region, we used the equation below.

$$\text{Access value} = \sum_{i=1}^{k_{Regions}} \frac{N_i}{n_i} \sum_{j=1}^{n_i} WTP_{i,j}$$

Here, $k_{Regions}$ denotes the number of regions, N_i and n_i denote the number of data downloads and respondents, respectively, in region i, $WTP_{i,j}$ is the willingness to pay for respondent j in region i. With over 253,000 data downloads in 2021, we estimate that GBIF generates €13 million of total economic value to users to access GBIF per year.

Data and assumptions

To find individual willingness to pay (WTP) values, we conducted a survey of GBIF users (detailed in Appendix B), with each survey respondent providing their WTP for access to the data they would ordinarily receive through GBIF. This survey asked respondents to select the amount they would pay (in euros) for one-time access to GBIF, out of a list of provided values, as well as an optional free text input. The results of this survey, segmented by region, is provided in Table A.2.

Table A.2 Summary of survey WTP responses

Region	Average WTP (€)
North America	16.10
Europe	91.40
Latin America	26.22
Asia	69.73
Africa	52.01
Oceania	10.52

Source: Survey of GBIF users.

To allow our final access value to be weighted by region, we used data provided by the GBIF Secretariat for the number of downloads, by region, in 2021. This is provided in Table A.4.

Table A.4 Summary of data downloads by region, 2021

Region	Number of downloads
North America	41,675
Europe	69,127
Latin America	73,812
Asia	56,907
Africa	7,059
Oceania	4,438
Total	253,029

Source: GBIF Analytics Archive <https://analytics-files.gbif.org/>.
Note: Mexico, the Caribbean, and Central America are considered part of Latin America.

We assumed that our samples in each region were representative of the user population of each region. This allowed us to extrapolate the average WTP for each region, as estimated by our survey, across the population of GBIF users to find the total WTP by all data users.

An important caveat to note is that the results of surveys may be biased, due to respondent self-selection, and the limited time that the survey was live, which may encourage a higher response rate from users who access GBIF data more frequently. We were unable to verify the population-level characteristics of users confirm whether the characteristics of survey respondents, such as organisation type, field of research and the primary use of GBIF data, were representative. However, although this data was not available, we monitored the characteristics of respondents and validated approximate shares with the GBIF Secretariat.

Time-saved value

Open access to a globally aggregated source of biodiversity data saves users, and organisations, time and allows this time to be put towards more productive uses. Interviews with stakeholders highlighted that this was a significant source of value for users. The time-saved value is an estimation of the total value of the time saved by having access to GBIF, compared to locating the relevant data elsewhere, in trying to achieve an equivalent research outcome.

To calculate the time-saved value, we used the equation below.

$$\text{Time saved value} = \frac{N}{n}\sum_{i=1}^{n} \text{Time taken to complete work without GBIF} \cdot \text{Reported value of time} \cdot \text{Share of respondents who required significantly more time to find and access data}$$

Here, N and n denote the number of GBIF researchers and survey respondents respectively, the time taken to complete work without GBIF is reported in hours, and the reported value of time is reported in euros per hours. The share of respondents who required significantly more time to find and access data was 41% in the survey, which is assumed to hold for the wider GBIF user population.

The researchers who use GBIF-mediated data saved an estimated 845,000 hours of total time in 2021 that would have been spent searching for and accessing data required for their work by other means. This time is valued at **€35 million**, according to the reported time values of GBIF users.

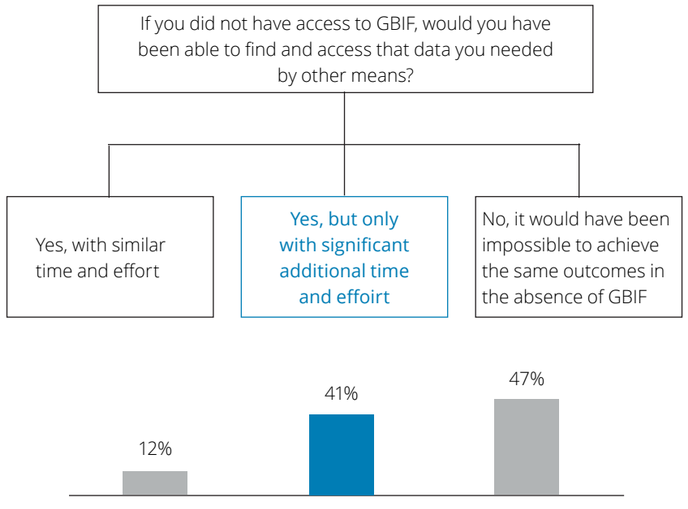
Data and assumptions

The time-saved value was derived from the user survey.

The respondents who would have been able to find and access their required data from an alternative source to GBIF with 'significant time and effort' would have saved an average 64 hours. Based on their reported time value, this search cost is valued at €2,551 per respondent.

For certain users (12%), a lack of access to GBIF would have had little time cost on them. Conversely, a plurality of users (47%) would have found it impossible to 'achieve the same outcome in the absence of GBIF'. For the remaining users (41%), the availability of GBIF provides a quantifiable saving of time.

Estimating the time-saved value assumes that 41% of the current user population (31,131 in 2021) save a similar average amount of time due to the availability of GBIF than the survey respondents.



We found, particularly in respondents' estimates of the hours spent to find suitable replacements for GBIF data, that there were a number of outliers (potentially protest responses). For completeness, we've truncated our calculation of this time-saved value to exclude some of these outliers, as shown0020in the Table A.5.

Table A.5 Time-saved value calculations, with truncation

Cut-off value (hours)	Total respondents (n)	Per-user value (€)	Total annual value (€)
No cut-off	118	10,892	143,488,049
< 1,000	111	2,551	34,923,505
< 500	110	2,266	29,851,627
< 250	109	1,846	24,318,669
< 100	87	678	8,931,775

Source: Survey of GBIF users, Deloitte Access Economics analysis.

Due to the presence of potential protest responses in the survey, we elected to use 1,000 hours as the cut-off for our analysis.

Research impact value

GBIF improves both the access and quality of biodiversity data. This service allows researchers to use GBIF data to undertake ground-breaking research across a wide range of disciplines. GBIF data has been leveraged by organisations to combat the impacts of climate change, improve agricultural productivity and food security, and provide new ways of understanding and fostering biodiversity. The research impact value (or R&D value) of GBIF captures the total value of this research and development undertaken by institutions that use GBIF data.

Beagrie et al (2021) estimated a research impact value of a molecular biology informatics institute to the wider economy. The time that researchers spend conducting research with GBIF data serves as a proxy for R&D spend. This investment is then assumed to have macroeconomic benefits to society, beyond those that accrue privately to the research organisation (Table A.6).

We calculate the research impact value of GBIF using a similar approach. The equation is as below.

$$\begin{aligned}\text{Research impact value} &= \text{Average hours spent working with GBIF data per year} \\ &\cdot \text{Average hourly value of GBIF researcher time } \left(\frac{€}{\text{hour}}\right) \\ &\cdot \text{Number of GBIF users utilising GBIF data for research per year} \cdot r_{R\&D}\end{aligned}$$

Here, the average hourly value of GBIF user time is reported in euros per hour and rR&D denotes the social rate of return to R&D (Table A.6).

With this method we estimated that GBIF facilitates **€185 million** of economic value per year through enabled R&D.

Data and assumptions

Survey responses were used to determine the average number of hours per working week that researchers spent using GBIF data in their work, and the average hourly value of users' time.

The value of the time spent, per researcher, per week, working with GBIF-mediated data serves as a proxy for weekly R&D expenditure, following Beagrie et al (2021). On average, researchers spent up to 6.0 hours per work week working with GBIF data, and the average hourly value of this time is €42.97. Adjusting for frequency of use, researchers spent up to 313 hours per year working with GBIF data.

While there are a wide range of estimates, there is a significant body of established literature around social rates of return to R&D expenditure, particularly with publicly available data. A summary of methodologies can be found in Hall, 2010.[38] A recent paper by Jones & Summers found that, allowing for a variation in the social discount rate of between 3.5% and 10%, the social rate of return to R&D is between 20% and 67%.[39] A 2009 paper by Houghton and Sheehan[40] employed a social rate of return to R&D of between 20% and 60%. Similarly, Houghton et al., 2009[41], compiled a list of social rates of return to R&D found in the literature, which is outlined in Table A.6

Table A.6 social rates of return on R&D expenditure literature scan

Study	Social rate of return (%)
Nadiri (1993)	50
Mansfield (1977)	56
Terleckyj (1974)	48-78
Sveikauskas (1981)	50
Goto & Suzuki (1989)	80
Mohnen & Lepine (1988)	28
Bernstein & Nadiri (1988)	10-160
Scherer (1982, 1984)	64-147
Bernstein & Nadiri (1991)	20-110

Source: Houghton et al. (2009)

Given the wide range of social rates of return to R&D expenditure throughout the literature, our choice of value for this becomes a point of sensitivity for our analysis. We elect to use the relatively conservative value of 40%, including sensitivity analysis of 20% and 60%.

Appendix B Survey development

National node Survey

A national node survey was developed and distributed in order to capture node level investment in the GBIF infrastructure. This was ultimately used to supplement GBIF secretariat expenditure data, and derive a total investment value figure.

The survey was distributed to national nodes across the globe, through GBIF's established contacts. Open between 23 January and 20 February 2023, the survey had a total of 24 responses.

This survey was prepared acknowledging the high level of variety in terms of operation and resourcing across the national nodes. As such, in developing the survey, a previous GBIF developed survey was leveraged to inform lines of enquiry. Following the structure of the previous survey, this survey was split into whether or not the responding national node had an annual budget for GBIF-related activities, and whether the node had joined GBIF recently. The following tables have been split in line with the structure of the survey.

Table B.1 General questions

Question	Response options
What is your full name	Open response
What is the name of the node you represent? (please also include host institution if different)	Open response
Where is your node headquarters located?	List of countries
Does your node have an annual budget to support GBIF-related activities?	Yes
	No

The following questions were only shown to those who have an annual budget for GBIF-related activities.

Table B.2 National node with annual budget questions

Question	Response options
Please specify which currency your responses will be in.	EUR
	Other [open response]
What is the annual budget figure for the node you represent? (approximate answers are fine, please write only the numbers in full)	Open response
Does this annual budget also cover activities outside of GBIF-related activities?	Yes
	No
What is your best estimate of the portion of this annual budget figure that was spent on GBIF-related activities?	0-100% sliding scale
Do paid staff at your organisation on GBIF-related activities that are not funded through the annual budget referred in the previous question?	Yes
	No
How much does your organisation spend annually on paid staff who work on GBIF-related activities? (Only include monetary value of time spent on GBIF-related activities, which could include your and other paid staff)	Open response
Please provide an estimation of the total number of hours per working week that your node staff contributed in-kind to global GBIF-related activities. This includes time dedicated by your staff to activities benefitting the GBIF community beyond your home country, for example acting as volunteer mentors, trainers translators, reviewers, regional representatives or GBIF committee members, excluding cases where salary time is covered by project funds. (assume max 40 hours per week per volunteer)	Open response
Please provide an estimation of annual external (project) funding that your node receives for GBIF-related activities.	Open response
When was your node established?	List of years

The following questions were only shown to those who did not have an annual budget for GBIF-related activities.

Table B.3 National node without annual budget questions

Question	Response options
Please specify which currency your responses will be in.	EUR
	Other [open response]
Please provide an estimation of the payments (anything that has an invoice) made by your node on GBIF-related activities.	Open response
Do these payments cover paid staff who work on GBIF-related activities?	Yes
	No
How much does your organisation spend annually on paid staff who work on GBIF-related activities? (Only include monetary value of time spent on GBIF-related activities, which could include your and other paid staff)	Open response
Please provide an estimation of the total number of hours per working week that your node staff contributed in-kind to global GBIF-related activities. This includes time dedicated by your staff to activities benefitting the GBIF community beyond your home country, for example acting as volunteer mentors, trainers translators, reviewers, regional representatives or GBIF committee members, excluding cases where salary time is covered by project funds. (assume max 40 hours per week per volunteer)	Open response
Please provide an estimation of annual external (project) funding that your node receives for GBIF-related activities.	Open response
When was your node established?	List of years

The following survey questions were only showed to national nodes who were established between 2012 and 2022. They were included in order to get a sense of the extent to which GBIF enables improved data digitisation, mobilisation and curation compared to the organisations previous operations.

Table B.4 National node without annual budget questions

Question	Response options
Prior to joining GBIF, did your organisation engage in any of the following GBIF-related activities?	Coordinating the landscape of biodiversity-related initiatives, including participating in the GBIF network
	Supporting biodiversity data mobilisation
	Supporting biodiversity data analysis and use
	Supporting biodiversity data management and curation
After joining GBIF, did your organisation receive new funding and/or resources to support these GBIF-related activites?	Yes
	No
How has your organisation changed its operations to support the GBIF-related activities as a node?	Open response

Appendix C Case study/ interview approach

To gain a greater understanding of GBIF's usage and reach, Deloitte Access Economics conducted eight interviews with select GBIF node representatives from across the world.

The interviewees were chosen from a shortlist of 15 potential stakeholders provided by GBIF. Deloitte Access Economics, in discussion with GBIF, narrowed this initial list to nine following a set of criteria:

1. Geographic diversity: given GBIF's global remit, with nodes located across every continent (excluding Antarctica), it was deemed important that the limited number of interviews captured views from every continent.
2. Institution type: ensuring that the institutions represented were diverse and representative of the variety of institutions that contribute to, and utilise, GBIF-mediated data. As such, a range of museums, universities, research institutes and government departments were chosen.
3. Perspectives on GBIF's economic value: for each stakeholder, a summary of the expected perspective or contribution was identified to ensure that each interview was likely provide a distinct perspective in understanding the economic value of GBIF. For example, the Institut de Recherche pour le Développement was identified for its involvement with institutional engagement across multiple countries, and provide examples of GBIF-mediated data supporting sustainable and human development. Alternatively, the Atlas of Living Australia collaborate with GBIF's informatics teams to improve infrastructures and resources, reducing duplicated effort.

The following stakeholders participated in the interviews.

Table C.5 List of stakeholders who participated in interviews

Country	Institution	Representative
Australia	Atlas of Living Australia	Andre Zerger and Hamish Holewa
Benin	University of Abomey-Calavi	Jean Ganglo
Colombia	Instituto de Investigación de Recursos Biológicos Alexander von Humboldt	Dario Escobar
France	Institut de Recherche pour le Développement	Eric Chenin and Anne-Sophie Archambeau
Japan	National Museum of Nature and Science, and Ministry of Environment	Tsuyoshi Hosoya and Mari Takehara
South Africa	South African National Biodiversity Institute	Fatima Parker
United Kingdom	Natural History Museum	Vince Smith and Sandra Knapp
USA	United States Geological Survey	Abby Benson and Sky Bristol

Interview approach

All interviews were conducted virtually over a two-week period in August 2022 and lasted 30 minutes each. Prior to each interview, the interviewees were sent a briefing note, detailing the purpose of the interview, the general scope of the project and provided a proposed question set in order for the interviewees to prepare. The proposed question set is listed below.

1. Could you give an overview of the types of key stakeholders and users of GBIF-mediated data in your network?
2. Are there functions or services provided by GBIF's infrastructure that would have otherwise required your organisation to:
   a. employ more staff? If so, could you estimate the number of staff and/or costs to your organisation?
   b. spend more on capital (e.g., data storage) or operating expenditure (e.g., energy costs)? If so, could you estimate these costs to your organisation?
3. Are there functions or services provided by GBIF that allow you to expand the scope of your work? If so, could you estimate the cost of pursuing that scope in the absence of GBIF?
4. Could you give some examples of how your organisation has used GBIF services to create economic, social or environmental benefits?

These questions were used to guide the conversation and help reveal the benefits of GBIF to these institutions. These interviews were, with permission, recorded in order to facilitate the use of quotes in this report and ensure accurate representation of discussions.

Appendix D Volunteer valuation approach

Volunteer effort value

GBIF volunteers support the key priorities set out in GBIF's implementation plans by addressing a range of challenges which include, but are not limited to, language barriers, data incompatibility, data publishing, data management, data capturing, and limited helpdesk support. There are two main types of GBIF volunteers; mentors and trainers, and translators who support the GBIF community of practice by sharing their expertise in biodiversity informatics, data publishing, analysis and use, and language.

This volunteer time plays a crucial role in the production of GBIF services, among other research infrastructures and biodiversity knowledge products.[42]

In many instances (if not most), because it was not an official requirement in project management, volunteer time invested had not even been accounted for or was not consistently recorded, making it difficult to apply a valid method. For these reasons we are likely to have underestimated substantially the total extent of volunteer time invested. We acknowledge that our estimates are uncertain, do not necessarily reflect the variation in any given process, and in some instances they may only capture a small subset of the input invested into the creation of GBIF's network.

These range from individuals compiling information to experts participating in workshops, reviewing assessments, providing data, and contributing to technical committees or governing bodies.

One of the accepted methods by which volunteer services can be valued is the opportunity cost of time method.[43] This is a value-based method which assumes that the time an individual spends volunteering for GBIF-related activities comes at the cost of the next best alternative use of that individual's time – paid employment in their usual occupation. This is based on the premise that if an individual chooses to spend their time volunteering, then they must receive at least as much benefit from doing so as they would from a salary. Based on this assumption, the benefit that GBIF receives from volunteer effort is estimated by valuing the hours that volunteers contribute, using a relevant hourly wage rate.

For each country identified as housing GBIF volunteers, the average full-time hourly wage rate for employees across scientific industries was estimated.[44] Given the limitations of finding data for each country's average full-time wage across scientific industries, countries were separated into four income groups as determined by the World Bank.[45] These groups include high-income, upper-middle-income, lower-middle-income, and low-income countries. Available wage data for each country income group was utilised to determine an average hourly wage for countries with limited data availability. Using this method, an average hourly wage was derived for each country income grouping, which was then applied to each volunteer in the same income group. To calculate the total volunteer effort value, we used the equation below:

$$Total\ value\ of\ volunteer\ effort = \sum_{i=1}^{n} V_i \times H \times W_i$$

$V_i = number\ of\ volunteers\ in\ country\ income\ group\ i$
$H = average\ hours\ per\ annum\ per\ volunteer$
$W_i = average\ hourly\ full\ time\ science\ industry\ wage\ in\ country\ income\ group\ i$

Data and Assumptions

The average number of hours per annum given by each volunteer was estimated based on GBIF provided data regarding translation and review (average of 32 hours per volunteer per year), and workshop activities (average of 52 hours per volunteer per year). GBIF also has an up-to date list on their website of all volunteer mentors and trainers, and translators that provides information on volunteer names, short biographical statements and which GBIF region they represent. From this list, we separated countries by income and calculated the averages of country average available full-time wage data for employees across scientific industries. These averages then applied to each of the income groups and were used to determine value accordingly to the count of volunteers from each income group.

Table D.1 Summary of volunteer translators effort value calculations by income group

World Bank income grouping	Count of volunteer translators	Average hourly science industry wage in euros
High-Income	48	26.64
Upper-Middle-Income	22	5.88
Lower-Middle-Income	3	2.27
Low-Income	3	2.27
Total	**76**	

Source: World Bank, GBIF[46]

Table D.2 Summary of volunteer mentors and trainers effort value calculations by income group

World Bank income grouping	Count of volunteer mentors and trainers	Average hourly science industry wage in euros
High-Income	44	26.64
Upper-Middle-Income	33	5.88
Lower-Middle-Income	35	2.27
Low-Income	11	2.27
Total	**123**	

Endnotes

1 IPCC (2021), Valérie Masson-Delmotte et al., 'Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change' (Cambridge University Press, 2021); IPBES (2019), 'Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services'. S. Díaz, J. Settele, E. S. Brondízio, H. T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y. J. Shin, I. J. Visseren-Hamakers, K. J. Willis, and C. N. Zayas (eds.). IPBES secretariat, Bonn, Germany. 56 pages. <https://doi. org/10.5281/zenodo.3553579.>.

2 GBIF, accessed 17 August 2022 <https://www.gbif.org/>.

3 OECD, Enhancing Access to and Sharing of Data (Report, 26 November 2019) <https://www.oecd-ilibrary.org/science-and-technology/enhancing-access-to-and-sharing-of-data_276aaca8-en;jsessionid=kbtPFGJkhgEgvrS3o7_qNTxZw1BVk1eEO0Pik1HJ.ip-10-240-5-120; Open Data Institute (2022) 'Data's value: how and why we should measure it' <https://theodi.org/article/datas-value-how-and-why-should-we-measure-it/>.

4 GBIF financial information. This average value varies each year and grows with voting participant GDP.

5 CODATA, the Committee on Data of the International Science Council; Pfeiffenberger, Hans; Uhlir, Paul; Twenty-Year Review of GBIF (CODATA, Paris, 2020) <https://doi.org/10.35035/ctzm-hz97>, p122.

6 GBIF, accessed 17 August 2022 <https://www.gbif.org/>.

7 GBIF, accessed 17 August 2022 <https://www.gbif.org/>.

8 J Mason Heberling et al, 'Data Integration Enables Global Biodiversity Synthesis' (2021) 118(6) Proceedings of the National Academy of Sciences <https://doi.org/10.1073/pnas.2018093118>.

9 Rebecca K Runting et al, 'Opportunities for Big Data in Conservation and Sustainability' (2020) 11(1) Nature Communications 1 <https://doi.org/10.1038/s41467-020-15870-0>.

10 Beagrie and Houghton, 'Data-driven discovery: the value and impact of EMBL-EBI managed data resources' (report commissioned by the European Molecular Biology Laboratory's European Bioinformatics Institute) <https://www.embl.org/documents/wp-content/uploads/2021/10/ EMBL-EBI-impact-report-2021.pdf>

11 Interview with Atlas of Living Australia (2022).

12 Survey of GBIF Users, see Appendix B.

13 World Economic Forum, 'Global Risks Report 2022: What you need to know' (2022), <https://www.weforum.org/agenda/2022/01/global-risks-report-climate-change-covid19/>.

14 CSIRO, 'Making better biodiversity conservations decisions' (2022), <https://www.csiro.au/en/research/natural-environment/biodiversity/conservation-decisions>.

15 UNESCO, 'Policy Brief Biodiversity and Zoonotic Diseases: Lessons for Effective Biodiveristy Governance and Resilience to Pandemics in Africa' (2021) <https://unesdoc.unesco.org/ark:/48223/pf0000380038>.

16 UNEP, 'Assessing Environmental Impacts – A Global Review of Legislation' (2018), <https://europa.eu/capacity4dev/unep/documents/assess-ing-environmental-impacts-global-review-legislation>.

17 Foundational Biodiversity Information Programme (FBIP), 'BioGaps Project' (2022), <https://fbip.co.za/biogaps-project/>.

18 GBIF financial information. This average value varies each year and grows with voting participant GDP.

19 Does include some extrapolation to national nodes which did not respond to the survey, see Appendix B.

20 GBIF Secretariat, 'Establishing an Effective GBIF Participant node: Concepts and General Considerations' (2020) <https://docs.gbif.org/effective-nodes-guidance/1.0/en/establishing-an-effective-gbif-participant-node.en.pdf>.

21 Ibid.

22 Beagrie and Houghton, 'The Value and Impact of Data Sharing and Curation: A synthesis of three recent studies of UK research data centres' <https://commons.esipfed.org/sites/default/files/JISC%20report,%20The%20Value%20and%20Impact%20of%20Data%20Sharing%20and%20Curation,%202014.pdf>.

23 Beagrie and Houghton, 'Data-driven discovery: the value and impact of EMBL-EBI managed data resources' (report commissioned by the European Molecular Biology Laboratory's European Bioinformatics Institute) <https://www.embl.org/documents/wp-content/uploads/2021/10/ EMBL-EBI-impact-report-2021.pdf>.

24 Deloitte Access Economics, 'Cost benefit analysis of a mission to discover and document Australia's species' (report commissioned by the Australian. Academy of Science, October 2020), <https://www2.deloitte.com/au/en/pages/economics/articles/cost-benefit-analysis-mission-discover-document-australia-species.html>..

25 Beagrie and Houghton, 'The Value and Impact of Data Sharing and Curation: A synthesis of three recent studies of UK research data centres' (2014) <https://commons.esipfed.org/sites/default/files/JISC%20report,%20The%20Value%20and%20Impact%20of%20Data%20Sharing%20and%20Curation,%202014.pdf>..

26 Loomis et al., 'Valuing geospatial information: Using the contingent valuation method to estimate the economic benefits of Landsat satellite imagery' (2015) Photogrammetric Engineering & Remote Sensing 81(8): 647-656.

27 Deloitte Access Economics, 'Economic study into an Australian continuous launch small satellite program for Earth observation' (report commissioned by Geoscience Australia, 2021), < https://www2.deloitte.com/au/en/pages/economics/articles/economics-earth-observation.html>.

28 Deloitte Access Economics, 'The value of Australian seabed mapping data to the blue economy' (report commissioned by Geoscience Australia, October 2021), < https://www2.deloitte.com/au/en/pages/economics/articles/value-of-australian-seabed-mapping-data-to-blue-economy.html>.

29 Lateral Economics, 'National Collaborative Research Infrastructure (NCRIS) spending and economic growth', (report commissioned by the Population Health Research Network, June 2021) <https://www.phrn.org.au/media/82231/ncris-stimulus-report-updated-final-31-august-2021-002.pdf>.

30 Popov et al., 'The value of Digitising Natural History Collections' (2021) Research Ideas and Outcomes 7 <https://doi.org/10.3897/rio.7.e78844>.

31 Parker-Allie, Fatima et al, 'Towards a Post-Graduate Level Curriculum for Biodiversity Informatics. Perspectives from the Global Biodiversity Information Facility (GBIF) Community' (2021) 9 Biodiversity Data Journal e68010 <https://doi.org/10.3897/BDJ.9.e68010>.

32 OECD, 'Economics and social benefits of data access and sharing' in Enhancing Access to and Sharing of Data: Reconciling Risks and Benefits for Data Re-use across Societies OECD Publishing, Paris (2019). <https://www.oecd-ilibrary.org/sites/90ebc73d-en/index.html?itemId=/content/component/90ebc73d-en>.

33 CODATA, the Committee on Data of the International Science Council; Pfeiffenberger, Hans; Uhlir, Paul; Twenty-Year Review of GBIF (CODATA, Paris, 2020) <https://doi.org/10.35035/ctzm-hz97>.

34 Parker-Allie, Fatima et al, 'Towards a Post-Graduate Level Curriculum for Biodiversity Informatics. Perspectives from the Global Biodiversity Information Facility (GBIF) Community' (2021) 9 Biodiversity Data Journal e68010 <https://doi.org/10.3897/BDJ.9.e68010>.

35 Popov et al., 'The value of Digitising Natural History Collections' Research Ideas and Outcomes 7 (2021). <https://doi.org/10.3897/rio.7.e78844>.

36 Beagrie and Houghton, 'Data-driven discovery: The value and impact of EMBL-EBI managed data resources', (report commissioned by the European Bioinformatics Institute, 2021) <https://www.embl.org/documents/wp-content/uploads/2021/10/EMBL-EBI-impact-report-2021.pdf>.

37 Lateral Economics, 'National Collaborative Research Infrastructure (NCRIS) spending and economic growth', (report commissioned by the Population Health Research Network, June 2021) <https://www.phrn.org.au/media/82231/ncris-stimulus-report-updated-final-31-august-2021-002.pdf>.

38 Hall, Bronwyn, Mairesse, Jacques, and Pierre Mohnen, 'Measuring the Returns to R&D,"
in Handbook of the Economics of Innovation' (2010) 1033–1082.

39 Jones & Summers, "A calculation of the social returns to innovation", NBER Working Paper 27863 (2020) < http://www.nber.org/papers/w27863NATIONAL>.

40 Houghton & Sheehan, 'Estimating the potential impacts of open access to research findings' (2009) Economic Analysis and Policy 39(1) <http://eap-journal.com/download.php?file=696>..

41 Houghton & Oppenheim, 'The economic implications of alternative publishing models' (2010) Prometheus, 28:1, 41-45 <https://doi.org/10.1080/08109021003676359>..

42 Juffe-Bignoli, Diego et al, 'Assessing the Cost of Global Biodiversity and Conservation Knowledge' (2016) PLOS ONE, 11(8) <https://doi.org/10.1371/journal.pone.0160640>.

43 Deloitte Access Economics, 'Economic contribution of the Australian charity sector' (report commissioned by the Australian Charities and Not-for-Profits Commission 2017) <https://www.acnc.gov.au/sites/default/files/documents/2021-07/Download%20the%20report%20for%20Economic%20contribution%20of%20the%20Australian%20charity%20sector%20%5BPDF%202MB%5D.pdf>.

44 GBIF, 'Mentors and trainers', accessed 10 February 2023, <https://www.gbif.org/mentors>; GBIF, 'Translators', accessed 20 February 2023, <https://www.gbif.org/translators>.

45 The World Bank, 'World Bank Country and Lending Groups', accessed 10 February 2023, <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>.

46 The World Bank, 'World Bank Country and Lending Groups', accessed 10 February 2023, <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>; GBIF, 'Translators', accessed 10 February 2023, < https://www.gbif.org/translators>.

Limitation of our work

General use restriction

This report is prepared solely for the internal use of The Global Biodiversity Information Facility Secretariat. This report is not intended to and should not be used or relied upon by anyone else and we accept no duty of care to any other person or entity. The report has been prepared for the purpose to perform an economic valuation and assessment of the impact of the GBIF network. You should not refer to or use our name or the advice for any other purpose.

Deloitte.

Deloitte Access Economics Pty Ltd
ACN 149 633 116
Brookfield Place, Tower 2,
123 Eagle St,
Brisbane, QLD, 4000,
Australia
Phone: +61 8 9365 7000

Deloitte Access Economics is Australia's pre-eminent economics advisory practice and a member of Deloitte's global economics group. For more information, please visit our website: www.deloitte.com/au/deloitte-access-economics