aws Social Responsibility and Impact

The Food Value Chain x Cloud Technology

A LANDSCAPE ANALYSIS – NORTH AMERICA

2024

Deloitte.

Introduction & Acknowledgements

The Food Value Chain x Cloud Technology A Landscape Analysis – North America explores how cloud technology can optimize the food value chain for individuals and communities in North America (NAMER)– which, for the purposes of this report, includes the United States, Canada, and Puerto Rico. A review of related publications, reports, studies, and public commitments from leading food value chain and cloud technology landscape players informed the current thinking in this report. Also represented are the voices of innovators who leverage Amazon Web Services (AWS) to advance food equity through the development and deployment of cloud technology solutions. This analysis reflects both cross-sector and AWS commitment, investments, and efforts.

The landscape analysis is a collaboration, commissioned by AWS Social Responsibility & Impact (SRI) and executed by Deloitte Consulting LLP. It also includes engagement from Amazon enterprise leaders and an industry advisory group:

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Table of Contents

Executive Summary

Approximately 2.4 billion people worldwide struggle to obtain the food they need.[1] Americans, including Puerto Ricans, and Canadians are among the individuals facing this issue every day. Nearly 47 million Americans, 8.7 million Canadians, and more than one-third of Puerto Ricans are food insecure,[2,3,4] lacking regular access to safe and nutritious food to sustain normal growth, development, and an active and healthy life.[5] Food insecurity increases the likelihood of chronic mental and physical health conditions resulting in hundreds of thousands of deaths annually. Some 85% of healthcare spending in the United States is focused on managing diet-related chronic conditions.[6]

The food value chain is a complex and evolving system of public, private, and philanthropic entities and plays an integral role in the health of individuals, society, the economy, and the environment.

Cloud technology has the potential to drive impact at scale with use cases such as inventory management for food banks, smart farming technologies, e-government solutions, and supply chain coordination. This report seeks to understand the role technology can play in developing solutions for food insecurity, including, but not limited to, efficient food production, processing, aggregation, distribution, consumption, and waste management.

Food Value Chain Framework & Approach

The five components of the food value chain in this report were informed and developed in relation to the U.S. Department of Agriculture's (USDA's) framework. Each component is a necessary step to address food and nutritional needs for populations in NAMER.[7] Other external factors that impact the food value chain include: government regulations, macroeconomic conditions, industry trends, environmental factors, and the food value chain's impact on the environment, communities, and the workforce.

Key Insights

Within this framework, four key insights emerged across each of the geographic regions through analysis and interviews with subject matter leaders: 1) Food value chain volatility; 2) End-to-end suboptimal supply chain; 3) Inequitable systemic impact on individuals, communities, and workforce; and 4) Data interoperability deficiency. These key insights include relevant examples of current interventions and investments across public, private, and philanthropic sectors for technology-enabled investments, initiatives,

efforts, and use cases and non-technology-enabled investments, initiatives, efforts, and use cases.

Within these insights, significant needs, gaps, and opportunities were identified across the food value chain and further explored where cloud technology can be applied.

Optimizing the Food Value Chain

Four types of cloud technology (and other investments, initiatives, and efforts) can address current and future needs and gaps across the food value chain: 1) Data management & storage; 2) Internet of Things (IoT); 3) Artificial Intelligence (AI)/Machine Learning (ML); and 4) Predictive analytics. Seven prioritized calls to action were made to players across the food value chain on ways to consider cloud technology implementation.[8]

Calls to Action

Advancing data interoperability, analytics, & insights

- Build and implement systems that allow seamless communication, real-time data sharing, and coordination between institutions across public, private, and philanthropic sectors. Implement and facilitate interoperable datasets for greater analysis and actionable insights to address the causes, and develop solutions for food insecurity.
- Integrate data systems among organizations in the form of cloud-enabled closed-loop systems. Leverage these systems to deliver real-time data and analytics to identify opportunities for food rescue and waste reduction, and to create a more sustainable and responsive supply chain.

Connecting & communicating across the value chain to break silos and generate greater insights

- Facilitate collaborative opportunities rather than competition through a community synergy fund for like-minded entities, like community-based organizations and donors.
- Devise strategies with food value chain players in health and healthcare programs to incentivize quality and nutrient density (i.e., plant forward sustainable products) over quantity in food production with a measured impact of increased nutritional quality on health outcomes.
- Leverage cloud technology and services (e.g., IoT) to consistently measure food quality, aggregate data, and share insights to promote higher quality food and support food-as-medicine programs.

Centering on customers & enabling community co-creation

- Prioritize the voices of individuals to understand which food they require, how they wish to receive it, and how they prefer to engage with community-based organizations. Accelerate data collection through culturally appropriate user experience (UX) and user interface (UI) design, data processing capabilities, storage, and insight generation to amplify community voices within the food value chain.
- Prioritize the preferences and needs of the customer in procurement and inventory management strategies to lead with a customer-centric approach to product assortment and retail. Through cloud technology enablement, invest in interoperable datasets for upstream customer preferences and needs, and share and support interoperability to provide organizations with first-party data on customer insights.

Engaging and integrating the collective voice of individuals and communities can add greater value across the end-to-end food value chain.

Food Value Chain Definition & Framework

The commercial food value chain framework is informed by the USDA's framework.

PRODUCTION	The ***growing of crops and raising of livestock***, including all aspects of agriculture and aquaculture
PROCESSING	The ***transformation of raw agricultural products*** into forms suitable for consumption, storage, or further manufacturing
AGGREGATION & DISTRIBUTION	The ***logistics*** of getting food from manufacturers and producers to points of sale or directly to consumers
CONSUMERS	The ***end-user interaction*** with food products, encompassing buying, preparing, and eating food
WASTE MANAGEMENT	The handling of food and ***organic waste generated*** at each stage of the food value chain

SECTION ONE

Key Insights

The evaluation of key insights across the NAMER food value chain are defined as four interwoven themes: 1) food value chain volatility; 2) end-to-end suboptimal supply chain; 3) systemic inequities impact communities & the workforce; and 4) data interoperability deficiency.

Food value chain volatility	End-to-end suboptimal supply chain
The global context of the food value chain (i.e., how macro-level forces influence the food industry and supply).	How businesses respond to these forces and align across the ecosystem and require more adaptive and resilient strategies.
Systemic inequities impact communities & the workforce	**Data interoperability deficiency**
The food value chain's impact on communities and individuals, (i.e., how underlying structural forces exacerbate instability, inefficiency, and inequity in the food value chain).	The greatest point of leverage among the other challenges. As stakeholders address these themes, data and technology are integral to creating effective, scalable, and lasting solutions.

1. Food Value Chain Volatility

Volatility tends to disrupt the food value chain so it cannot operate at an optimal level. Geopolitical tensions and fluctuating interest rates can reshape global trade patterns that impact the cost of capital, which, in turn, can influence investment decisions that impact operations (e.g., increasing operational capacity). Shifting crop prices, driven by weather patterns and commodities speculation through futures, tend to add uncertainty. Fatal food safety outbreaks introduce another layer of volatility.

Industry development and implementation of strategies to mitigate the impacts of economic instability should be prioritized, along with establishing coordinated systems that permit efficient traceability, safety monitoring, and accurate labeling. Such strategies involve streamlined stakeholder collaboration across the entire food value chain (i.e., producers, processors, retailers, policy makers, and government agencies) to help ensure economic resilience and regulatory adherence.

Higher than average prices on imported food & high poverty rate

- Puerto Rico imports 80% of its food.[9]
- Complex shipping regulations generally drive up import costs.
- More than one-third of Puerto Ricans reported experiencing food insecurity.[10]

"Our population is around 3 million people, and 1.3 million to 1.4 million people are on the food stamp program. Over 50% of our children live in households that are below the poverty level."

–FOOD DISTRIBUTION COMPANY FORMER PRESIDENT

2. End-To-End Suboptimal Supply Chain

Inefficiencies and inaccuracies impact the supply chain (e.g., system failures can lead to inaccurate demand prediction and overproduction or misalignment). The high volume of supply chain handoffs tends to slow the movement of products to consumers and can create costly inefficiencies. Improper storage and handling tend to cause spoilage before points of sale, with high administrative and transportation costs that limit efficient distribution. Furthermore, poor retail inventory planning can create a supply surplus, or supply may fail to meet demand where it is needed most.

In response, it is important that industry leaders implement solutions for greater efficiency and generate cost savings across the food value chain to optimize distribution and align supply with demand.

Poor inventory planning & transportation

- 40% of waste occurs before food reaches the consumer.
- Retailers account for around 8 million tons of waste.
- The United States spends $218 billion annually to grow, process, transport, and dispose of wasted food.[11] Causes of food waste include inadequate refrigeration and customs delays during transportation, and retailers over-ordering to fully stock shelves.

"We're spending a lot of time rescuing food, but the better idea is not to have created that food at any point."

–FOOD MANUFACTURING COMPANY FORMER GROUP PRESIDENT

3. Systemic Inequities Impact Communities & the Workforce

Inequities affecting food access and food value chain workers tend to be interconnected. Communities face challenges with the availability of nutritious and affordable food. Destabilizing policies and the inequitable distribution of food resources generally make communities vulnerable to food supply disruptions. These structural obstacles also impact the food value chain workforce and result in low wages, poor working conditions, and job insecurity. Seasonal, migratory, and undocumented workers tend to be particularly vulnerable to exploitation, which can diminish their well-being and potentially destabilize food supply chain sustainability and efficiency.

It is critical for organizations to implement equitable policies, structural changes, and resource distribution. They help give communities consistent access—with dignity—to nutritious and affordable food that aligns with their preferences and addresses vulnerabilities of food value chain workers.[12]

Inadequate working conditions & low wages

Producing and processing fruits, vegetables, meats, and poultry can be labor intensive. In the United States, immigrants—often undocumented and working in poor conditions—make up most of the agricultural workforce.[13] Despite legal protections, workers endure low wages and dangerous conditions.[14] Moreover, in "agricultural exceptionalism," farm workers are frequently excluded from labor standards that protect workers in other industries.[15] Given the harsh conditions workers face, seasonal variability, and low wages, it is difficult to attract and retain an agricultural workforce.[16] According to the Columbia Center on Sustainable Investment, there is a dire need for better labor practices and protections.[17]

"No matter what era you look at, farm laborers have had a real challenge being in control of their work schedules and their free time…Farmworkers have very little political power or political voice."

–NON-PROFIT ORGANIZATION EXECUTIVE DIRECTOR

Acquiring food and other assistance with ease and dignity

Dignity and accessibility for people and communities are a significant part of food assistance, particularly for families who rely on charitable food support.

- In a U.S. Hunger survey of more than 100,000 respondents, 43% couldn't access transportation to visit grocery stores with fresh and healthy foods.[18]
- Feeding America reported 84% of its 2024 survey respondents say anti-hunger policies should support people's dignity and choices in what they feed their families.[19]
- With US food insecurity steadily increasing,[20] programs like the Supplemental Nutrition Assistance Program (SNAP) are crucial to feeding families. But SNAP help may not be able to keep up: 65% of people who received charitable food assistance and/or experienced food insecurity in the past two years want to see an increase in SNAP funding."[21]
- The cost of food and access to everyday needs impact food security.[22] The rate of severe food insecurity has increased since 2021, likely due to the end of pandemic relief efforts, inflation, and increases in the cost of living.[23] In 2023, 5.1% of US households (6.8 million) experienced very low food security.[24]

"Food on the table was like reaching for the stars. Many times, there wasn't anything to eat."

– INDIVIDUAL INTERVIEWED BY A NON-PROFIT ORGANIZATION[25]

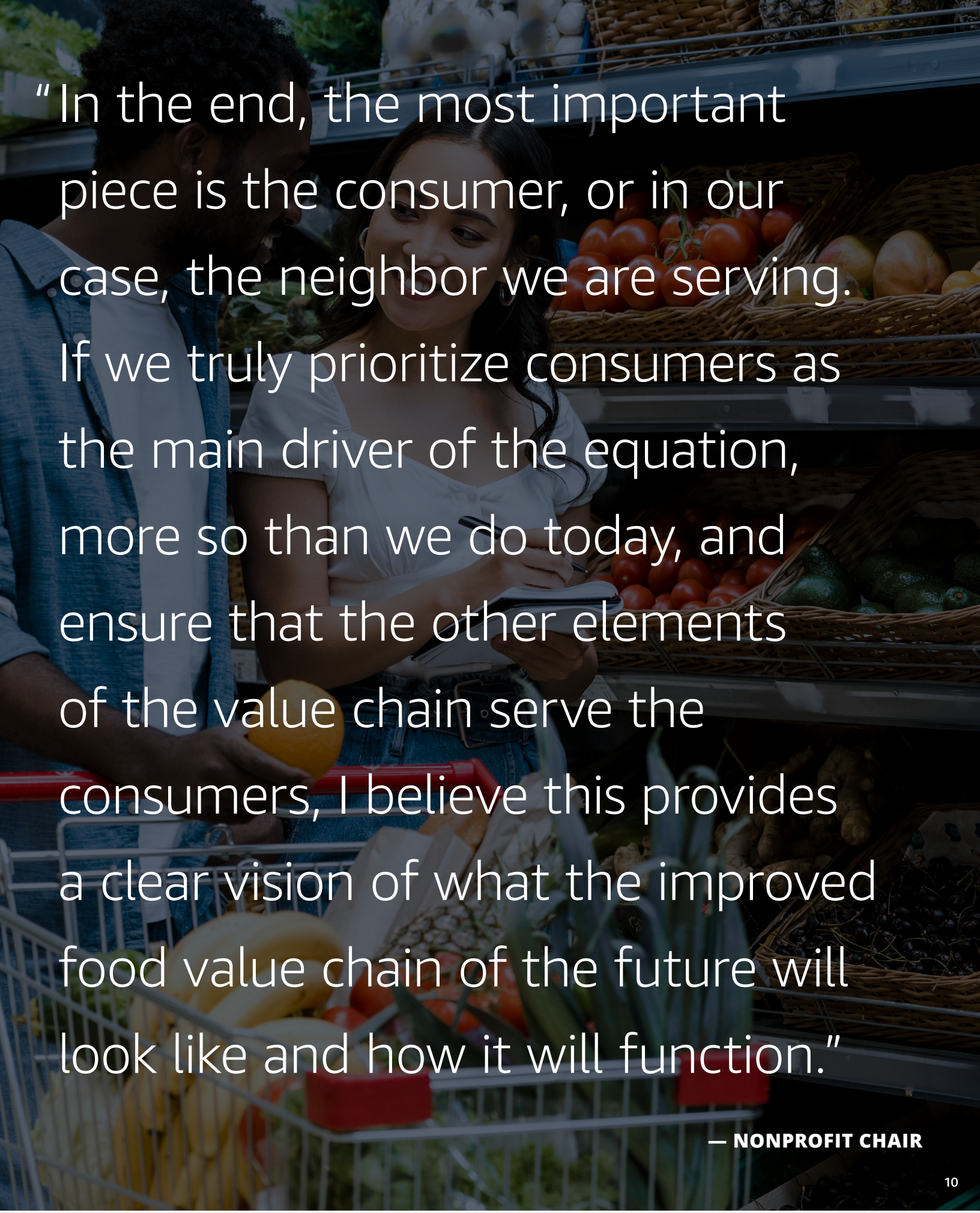
"I cannot buy organic foods free of antibiotics or toxins in my children's food."

–INDIVIDUAL SURVEYED BY A NON-PROFIT ORGANIZATION ON THE IMPACT OF HIGH FOOD PRICES IN THEIR HOUSEHOLD[26]

4. Data Interoperability Deficiency

Without quality data collection, management/governance, security, and interoperability, stakeholders lack the ability to enhance supply-and-demand forecasting, supply chain optimization, and reduce costs and food waste.[27] High implementation costs and complexity, not enough data interoperability, and inadequate infrastructure can weaken productivity and threaten efficiency throughout the system. Implementing user-friendly systems for robust data collection, management, and interoperability can provide enhanced productivity, optimized logistics, and accurately forecast supply and demand to reduce costs and waste.

Rapidly changing industry expectations	**Marketing of unhealthy foods and beverages to racially and ethnically diverse communities**
Within the food retail industry, consumer diversity has increased dramatically, and preferences have become more specific and differentiated.[28] Technology gives consumers more choice. However, integrating diverse technologies (e.g., GenAI and app-guided shopping) into a cohesive system is complex and challenging. Moving from the once mass-market approach of grocery retail to a hyper-personalized one involves managing and analyzing vast amounts of data, and leveraging advanced analytics and machine intelligence. • Nearly eight in 10 grocery retail executives believe that more third-party data could be needed to know their customers better.[29]	An important component of data management is the ethical and productive use of data by those who own and act on it. However, research finds that the disproportionate marketing of unhealthy foods and beverages to Black and Latino consumers results from a business model that promotes an unhealthy product mix that helps contribute to health disparities.[30] • In 2021, candy, sugary drinks, snacks, and cereal made up 73% of food and beverage ad spending on Black-targeted and Spanish-language TV.[31]



"In the end, the most important piece is the consumer, or in our case, the neighbor we are serving. If we truly prioritize consumers as the main driver of the equation, more so than we do today, and ensure that the other elements of the value chain serve the consumers, I believe this provides a clear vision of what the improved food value chain of the future will look like and how it will function."

— NONPROFIT CHAIR

SECTION TWO

Sample Investments & Interventions

Across the NAMER region, current investments and innovations aimed at optimizing the food value chain are summarized as a "snapshot" across three categories: non-technology-enabled, technology-enabled, and cloud technology-enabled. These categories also note the private, public, and philanthropic sectors driving current investments and interventions.

Investments & Interventions

- **Non-technology-enabled:** Interventions not directly creating, investing in, or improving technology. These include policy changes, government investment to support the food industry (e.g., farmer payment programs), and other strategies within the public and private sector not explicitly leveraging technology integral to intervention.
- **Technology-enabled:** Interventions related to creating, investing in, or improving technology but are not explicitly connected to cloud technology.[32] These include mobile applications, the digitization of formerly manual processes (e.g., digital processing of food assistance applications), and in some instances, applications of technology like AI that are not expressly linked to cloud technology.
- **Cloud technology-enabled:** Interventions that use cloud technology (e.g., Generative AI tools for insight generation and ML tools to monitor crop disease).

Non-technology-enabled interventions to address challenges/needs include providing grants/investments (e.g., USDA American Rescue Plan Act's Meat & Poultry Processing Expansion program[33] and USDA investment in conservation agriculture[34]), enabling interest-free payments (e.g., Canadian Minister of Agriculture and Agri-Food Advanced Payment Program for 2024[35]), expanding food assistance programs (e.g., The Healthy Canadians & Communities Fund to provide prepaid cards for food assistance[36]), and establishing research centers (e.g., Kaiser Permanente launched the Food Is Medicine Center of Excellence[37]).

Examples of technology-enabled and cloud technology-enabled interventions & investments

TECHNOLOGY-ENABLED	CLOUD TECHNOLOGY-ENABLED
FOOD VALUE CHAIN VOLATILITY	
Opportunity: Reliable food traceability during recalls and outbreaks **Intervention/Investment:** ***Private sector – all stages (US) –*** IBM's Food Trust® solution built on blockchain creates a shared record of food provenance, transactions, and processing details to make product tracing easier.[38]	**Opportunity:** Production/distribution complexities **Intervention/Investment:** ***Public sector – aggregation & distribution (US) –*** The Web-Based Supply Chain Management (WBSCM) system is an integrated, online commodity ordering, acquisition, distribution, and tracking system. It supports domestic and international food aid and nutrition assistance programs, and marketing programs for US-produced and processed commodities. WBSCM supports the order, procurement, and delivery of 6.5+ billion pounds of farm food commodities worth $4+ billion.[39]
END-TO-END SUBOPTIMAL SUPPLY CHAIN	
Opportunity: Inadequate food preservation during crises and natural disasters **Intervention/Investment:** ***Private sector – aggregation & distribution (PR) –*** Viking Cold Solutions (VCS) – Thermal Energy Storage (TES) technology increases refrigeration system efficiency, cutting energy costs up to 50% while better protecting products. Energy efficiency maintains temperature control during crises and natural disasters. VCS's technology helped Isla Frio, a food storage/distributor, maintain safe temperatures in cold storage facilities during Hurricane Fiona. VCS helped decrease diesel consumption by 50% and extend generator life to double food preservation time.[40]	**Opportunity:** Gaps in cold chain creating food spoilage and damage **Intervention/Investment:** ***Private sector – aggregation & distribution (US) –*** Carrier, a provider of healthy, safe, and sustainable building and cold chain solutions, is working with AWS to co-develop Lynx to create an efficient and intelligent cold supply chain. Lynx is designed to provide customers greater flexibility, visibility, and intelligence across the cold chain, offering proactive recommendations to reduce food spoilage, and increase sustainability and efficiency.[41]

TECHNOLOGY-ENABLED	CLOUD TECHNOLOGY-ENABLED
END-TO-END SUBOPTIMAL SUPPLY CHAIN	
Opportunity: Not enough affordable and accessible food across communities **Intervention/Investment:** ***Public/private/philanthropic sector – consumers (US) –*** As a part of the $1.7 billion in new commitments announced in February 2024 through the *White House Challenge to End Hunger and Build Healthy Communities,* Homeplate Solutions developed an AI-enabled technology and integrated dietary management tool. It will assist 20,000 community-based nutrition providers in 600 jurisdictions in addressing food affordability and accessibility challenges. This solution brings together companies across the food, healthcare, and technology sectors to increase food security. Homeplate has a 5-year, $174 million investment from stakeholders.[42]	**Opportunity:** Inefficient donated food distribution **Intervention/Investment:** ***Private/philanthropic sector – aggregation & distribution (US) –*** Project Delta developed an intelligent food distribution system on Google Cloud. It integrated donated food data with real-time needs from Feeding America food banks and coordinated with grocers to distribute food donations.[43]
Opportunity: Insufficient real-time data on waste forecasts **Intervention/Investment:** ***Public/private/philanthropic sector – waste management (CAN) –*** Compass Group Canada, Canada's leading food service provider, launched "Waste Not 2.0" cloud-based waste reduction software. The software is part of their aim to cut food waste by 50% by 2030. It is a tablet-based food waste tracking program designed by Compass Group and rolled out across 12 countries in nine languages. It offers intuitive tools to promptly analyze data, and measure and report the carbon impact of kitchen waste to develop long-lasting solutions to food waste. The software is also equipped with resources to train employees to utilize better practices to avoid food waste.[44,45]	**Opportunity:** Siloed data hinders the ability to forecast demand **Intervention/Investment:** ***Private sector – consumers (US) –*** ButcherBox transitioned to Databricks Data Intelligence, leveraging cloud-based data analytics and visualization to address data silos and enhance customer insights. This tool helped ButcherBox rapidly query large datasets, reducing query time from hours to minutes and supporting enhanced inventory management and demand forecasting. This transformation increased data visibility and facilitated decision making, addressed logistical and delivery issues, and ensured high-quality, personalized customer experiences.[46]

Additional AWS Use Cases

Children's Hospital of Orange County (CHOC)

Opportunity: There is some visibility into which populations are at the highest risk for poor health outcomes related to the drivers of health. But there is also a need for predictive modeling, real-time tracking, and interventions to support children who are at risk for poor health outcomes.

Solution: CHOC is partnering with AdvanceOC and AWS to determine how to use a Youth Vulnerability Index tool (which aggregates data points from across the care system and partners like local schools) to generate an index that combines CHOC's clinical data and community-based drivers of health data to improve the lives of families in need. Integrated with electronic medical records, this index can inform healthcare providers about the risk to their patients and the factors behind that risk (e.g., low school attendance and hunger), allowing providers to personalize care plans in real time.

Impact: The integrated Youth Vulnerability Index can create opportunities for conversations and interventions that may have never occurred without these risk insights. For example, in the ideal future state, a family with food insecurity will be able to request healthy and accessible meals delivered to their home through their myCHOC patient portal. Long-term demonstrated improvements in health outcomes from this index may motivate policymakers to invest in addressing the drivers of health that strongly influence children's well-being.

Houston Food Bank

Opportunity: A Houston food bank needed support scaling delivery operations during the COVID-19 pandemic to meet many of those in need at their locations.

Solution: An AWS-supported tool was created to centralize data under one stack and create a mobile application that helps people in need access food banks near them. The app provides users with a map of pantry locations, multilingual support, push notifications by geography, general information about the food bank, and user analytics to help improve the food bank.

Impact: Pantries can support delivery and client pickup for their locations. Volunteers can also sign up digitally to be delivery drivers or to help with order preparation. Increased automation allows the application to process all divisions and stores data daily and share it in real time with a third-party delivery partner.

SECTION THREE

Gaps & Opportunities

Despite current interventions addressing the four food value chain insights (see Section 1), gaps remain. Stakeholder collaboration, which itself is an outstanding gap for the end-to-end suboptimal supply chain, is critical to addressing data and technology concerns. Technology and investment alone will not sufficiently solve for challenges across the food value chain; a gap also remains in policy intervention and resource allocation—specifically for systemic inequity insights that impact communities and the workforce.

Data & Technology Gaps

Data and technology gaps contribute to the current suboptimal food value chain across all components.

- **Food value chain volatility:** Factors including climate change and global shocks lessen the use of predictive models to navigate uncertainty. An absence of predictive models can hinder effective assessment and mitigation of risks, producing margin pressures and inefficiencies in yield and pricing. A lack of real-time scalable insights prevents the timely implementation of responsive policy and subsidy interventions, leaving the system vulnerable to shocks and slower adaptation. Gaps in data management and integration also hinder compliance with evolving food safety regulations and system functions, which involve additional funding and wider technology adoption.

  Without such investments, stakeholders struggle to navigate regulatory complexities and operational modernization, potentially further destabilizing the food value chain that relies on security and predictability to help maintain optimal function.

- **End-to-end suboptimal supply chain:** Gaps in data collection and sharing, and fragmentation tend to compound inefficiencies. Specifically, consumer insights collected at the brand or store level are often not shared with upstream stakeholders, leading to inconsistent and missing information across production, processing, and distribution. As a result, ineffective supply and demand management is likely to ensue, exacerbated by a deficiency in standardized datasets for food security, ultimately impeding real-time distribution. Despite greater AI and automation investment to enhance forecasting and inventory management, fragmented data management often results in siloed technologies.

- **Systemic inequities impact communities & workforce:** Implementing technology infrastructure, real-time predictive insights, and integrated data management can help non-profits that operate across the philanthropic food value chain better interact with commercial food value chain organizations. For example, the ability to track data and use predictive analytics help grocers and retailers identify food that is nearing the end of its shelf life and unlikely to be sold in a commercial market (based on historical buying patterns). This food, which would have otherwise expired and been wasted, can be redirected to food banks. Additionally, having better data on the types of food that the individuals and community prefer can more effectively match donated food to the communities and individuals who prefer that food. This could help non-profits to serve their communities in a culturally responsive and intelligent way. Further, public and private funding for data infrastructure and analytics could be used to help scale and increase efficiency across the charitable value chain to get food to people through channels at the time that they need it.

- **Data interoperability deficiency:** Effective interoperability is limited across the food value chain often with the same challenges that impact organizations in other industries including: technical gaps, such as poorly defined data standards, outdated legacy systems that don't support modern data exchange protocols, and differences in how data sets are structured. Additionally, semantic gaps arise from terminology differences across organizations and inconsistent or incomplete data. Within an organization, siloed data can result in ineffective or limited sharing, while varying regulatory requirements across regions add complexity. Data governance and secure controls within an organization give the appropriate people access to data needed at the appropriate time for successful, reliable data interoperability. As data is exchanged across systems, the risk of data breaches can increase, potentially exposing sensitive customer data and leading to negative consequences for the company. Given the rapid pace of technological innovation, cybersecurity may be underinvested in, particularly by businesses with scarce resources. Therefore, investing in and defining robust data governance, aggregating data to eliminate silos, and driving standardization for effective, efficient data-sharing should be priorities for organizations operating across the food value chain. Industry players should strive to keep pace with technological advancements to mitigate these risks. Interoperable data holds the potential to streamline data management, make organizations more productive through reduced human manipulation and transformation steps, and promote sharing data at scale.

Stakeholder Collaboration

Stakeholder collaboration and investment are important for addressing needs across the value chain, especially for the end-to-end suboptimal supply chain.

- Different food value chain players operate with individual profit motives and different systems (i.e., new vs. legacy). Inadequate collaboration between food producers and distributors can create mismatched supply and demand, which can affect the appropriate foods getting to people and increase waste. Collaborative efforts, such as joint planning between large manufacturers and retailers, are valuable but involve significant trust and willingness to share information. Cross organizational collaboration and investment helps to mitigate fragmentation across the food value chain to positively impact supply and demand for food distribution.

Policy Intervention & Resource Allocation Gaps

Gaps related to policy intervention and resource allocation across the food value chain are key to addressing systemic inequities impacting communities & the workforce, including:

- The agricultural industry is an important component of the production phase of the food value chain. Agricultural workers play an essential role in growing and harvesting the food that travels along the food value chain to feed the population of the United States, Puerto Rico, and Canada. However, the agricultural industry is a low-wage, high-violation industry[47]—a classification by the US Department of Labor's Wage and Hour Division that indicates an industry that predominantly employs low-wage workers, has a greater probability of violations of labor standards, and where workers are more vulnerable and less likely to file a complaint.[48] There are ongoing efforts to address this issue through new protections for farmworkers,[49] robust investigations, and education.[50]

- The prevalence[51] of labor standard violations can create an inequitable system where worker safety may be undermined, perpetuating structural forces that allow discrimination. There is a constant need for holistic services that address challenges identified among migrant and seasonal farmworkers, such as a missing flexibility in their work schedules, poor access to and assistance with transportation, and a lack of coordination of assistance to access educational development opportunities.[52] These services, in addition to vital legal and safety compliance support, can help address broader workforce well-being.[53]

- Inflexible food assistance benefits can further compound existing structural issues. Many individuals who do not qualify for food assistance requirements remain food insecure, and healthcare subsidies often cannot be used for food. While private sector efforts increase food accessibility and improve health outcomes, they often involve public and private partnerships to scale effectively.

SECTION FOUR

Cloud Readiness

Cloud Technology Defined

Cloud technology is the online delivery of convenient, on-demand, configurable, and shared computing services (i.e., storage, databases, and AI/ML).[54] Organizations using cloud technology can easily control and scale without having to own, operate, and manage physical data centers on premise.[55]

Essential Characteristics

On-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service

Service models

Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS)

Deployment models

Private cloud, community cloud, public cloud, and hybrid cloud

Signals of Cloud Readiness in NAMER

Worldwide public cloud end-user spending is expected to surpass US$675 billion in 2024, which is a YoY growth rate of more than 20%, as investments in cloud technology infrastructure and applications continue to remain strategic focus areas for cross-sector organizations.[56] This section explores the growth of cloud technology investments and presence across each region of NAMER, which highlights organizations moving toward modernizing existing digital systems and leveraging cloud-based solutions at a wider scale.

Overall, there is advanced cloud technology maturity across NAMER, with the primary obstacles appearing to be unequal access to connectivity and a need for cloud technology skilling and upskilling across the workforce. Despite these concerns, cloud readiness does not appear to pose a challenge to cloud-enabled food value chain optimization in the United States, Puerto Rico, and Canada.

UNITED STATES	PUERTO RICO	CANADA
CLOUD-RELATED POLICIES		
In 2018, the United States introduced its Cloud Smart strategy, which aims to expedite cloud-based solutions by emphasizing three vital areas: security, procurement, and workforce. Unlike the 2011 Cloud First[57] initiative, which mandated federal cloud adoption without detailed guidance, Cloud Smart[58] offers specific directions to ensure secure, efficient, and skilled implementation of cloud technology. The policy seeks to accelerate adoption of cloud technology within the federal government, promoting operational efficiencies through a "light touch" and shared-services model. However, this strategy is primarily tailored for federal agencies and may not be applied across all industries.	In 2017, Puerto Rico established the Puerto Rico Innovation and Technology Service (PRITS),[59] which is responsible for centralizing and standardizing government IT and innovation efforts. It focuses on establishing consistent technology and data policies, developing modern infrastructure, optimizing government processes, and ensuring effective project management. PRITS operates across three strategic priority areas: IT Strategy and Management, IT Infrastructure, and Innovation. The IT infrastructure optimization priorities include connectivity, cloud services, data center consolidation, and legacy modernization.	In 2018, Canada renewed its Cloud Adoption Strategy,[60] transitioning from a Cloud First to a Cloud Smart[61] approach, which encourages departments to modernize applications using public cloud technology services or migrate to Enterprise Data Centers. Cloud Smart principles focus on rationalizing application portfolios, enhancing agility, ensuring security through zero-trust architectures, incentivizing cloud technology optimization, and investing in talent. The strategy emphasizes agility, rapid deployment, and continuous improvement, aligning adoption of cloud technology with business value and modernization efforts.
CLOUD PRESENCE[62]		
The United States boasts some of the most mature cloud technology providers, with widespread adoption across various sectors. In 2023, spend on cloud technology was estimated to surpass US$380 billion and is projected to exceed US$800 billion by 2030.[63] The private cloud technology growth trajectory is expected to rise from US$124.8 billion in 2024 to US$190.9 billion by 2029.[64] Major cloud technology providers, such as AWS, Google Cloud Platform (GCP), Microsoft Azure and Oracle, have established more than 50 US availability zones, including California, Ohio, and Oregon.[65,66,67,68]	Puerto Rico's cloud technology providers operate on a smaller scale than the United States and Canada but feature a variety of cloud technology industry players (e.g., colocation providers, hosting and cloud technology providers, and managed service providers). Puerto Rico's cloud technology infrastructure is comprised of local regions, which are subsets of availability zones, including 19 colocation data centers, 23 cloud technology providers, data center providers, and network operators.	Canada's cloud technology adoption, while mature and widely available in public and private sectors, remains significantly smaller than the United States.[69] Major cloud technology providers, including AWS, GCP, Microsoft Azure, and Oracle, each have two availability zones in Canada, primarily located in Quebec, Toronto, and Montreal.[70,71,72,73]

UNITED STATES	PUERTO RICO	CANADA
CLOUD-ADOPTION CHALLENGES		
Cloud-skills gap: Too few professionals with cloud technology skills is a top business concern. A survey of IT professionals responsible for cloud technology infrastructure investments found that 22% of respondents lacked cloud technology operation skills and experience which impacted the companies' ability to meet business goals.[74]	**Lack of Infrastructure:** Puerto Rico's geography and experience with natural disasters exacerbate connectivity gaps and leave many residents without access to broadband. Recent natural disasters (e.g., Hurricanes Irma, Maria, and Fiona, and the 2020 earthquakes) caused widespread damage to the island's existing telecom infrastructure. Government initiatives to increase equitable access to broadband and build resilient infrastructure aim to bridge the connectivity gap, but Puerto Rico's geography and environmental struggles pose significant challenges.[78]	**Data regulation:** The Personal Information Protection and Electronic Documents Act (PIPEDA) governs private-sector data handling in Canada. However, Quebec, Alberta, and British Columbia have provincial laws that differ from PIPEDA. These multi-region intricacies and the continuous evolution of regulations can create challenges for cloud technology deployment.[80]
Connectivity gap: Many rural Americans (versus urbanites) face significant Internet connectivity issues. Dispersed rural housing increases costs and logistical challenges for Internet service providers (ISPs) to develop broadband infrastructure.[75] Despite federal initiatives, gaps persist even in urban low-income communities.[76] Broadband access is crucial for cloud computing services, and rural non-metropolitan counties exhibit the lowest adoption. Cloud computing use in the largest metropolitan counties is 15 percentage points higher than in rural non-metropolitan counties, demonstrating slower adoption from connectivity challenges.[77]	**Talent shortage in cloud technology:** A lack of experienced cloud technology professionals is a significant challenge for adoption and expansion of cloud technology. Educational institutions are working to train unemployed or underemployed Puerto Ricans to meet the rising demand of cloud roles.[79]	**Technology modernization:** Cloud technology adoption in Canada has progressed slowly, primarily due to funding constraints and a risk-averse culture. Government services still rely on outdated systems, which pose service disruption risks. Although a few provinces have detailed modernization plans, they lack sufficient funding.[81]

UNITED STATES	PUERTO RICO	CANADA
EXAMPLE INVESTMENTS IN CLOUD TECHNOLOGY[82]		
AWS launched a virtual Cloud Institute, which is a 9-month experiential learning program focused on training developers with little or no prior technology background. The program has several learning modalities, including hybrid-instructor led programs, self-paced courses, interactions with industry experts, and capstone projects. The program is currently offered in the United States and will begin to roll out globally.[83] Google is investing US$3 billion to scale its US data center locations. US$2 billion will be spent on a new Indiana site to enhance its services and AI training efforts, and US$1 billion will go to expand its three Virginia campuses. Additionally, it announced the formation of a US$75 million Google AI Opportunity Fund to deliver AI skills to 1 million Americans.[84] In May 2024, Microsoft announced a US$3.3 billion investment to expand its cloud technology and AI infrastructure with a data center campus in Wisconsin by 2026. This investment is intended to enable companies to utilize advanced cloud technology and AI applications, and train more than 1,000 students for IT jobs in a Data Center Academy with Gateway Technical College.[85]	In April 2022, AWS announced a new office in San Juan to drive rapid adoption of cloud computing in Puerto Rico and other Caribbean locations. AWS plans to support various organizations, including public entities, in cloud technology transition. AWS also collaborated with the Department of Economic Development and Commerce and Ana G. Mendez University to launch the free re/Start education program to prepare unemployed or underemployed people for careers in cloud, addressing the talent shortage within the industry.[86]	In December 2023, AWS announced the launch of the AWS Canada West (Calgary) Region, its second AWS Infrastructure. This region will provide startups, enterprises, developers, and public sector organizations with better options for delivering cloud technology applications. The region could boost access to advanced technologies like data analytics and AI/ML. AWS plans to invest ~US$17.9 billion in Canada through 2037 for the new and existing infrastructure region. This investment also aims to generate local jobs, enhance cloud technology skills, and support regional collaboration.[87] In November 2023, Microsoft announced an investment of US$500 million to expand its hyperscale cloud computing and AI capabilities in Quebec. This investment could lead to a 750% increase in Microsoft's Canadian cloud technology infrastructure within two years, and a 240% growth in its computing capacity in Quebec within three years. The investment includes the launch of the Operational Risk Skills Development Center to offer cybersecurity and GenAI training in the French language and the expansion of the Canadian Tech Talent Accelerator.[88]

SECTION FIVE

Applying Cloud Technology Across The Food Value Chain

Vision for a Cloud-Supported Food Value Chain

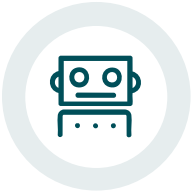
Harnessing the power of cloud across the food value chain to address current state needs and gaps is rooted in a set of cloud-based products and services: **data management and storage, IoT, AI, ML,** and **predictive analytics.**[89,90,91,92]

Data Management and Storage

These cloud technology products provide infrastructure to store, integrate, catalog and access data, and enable data processing, data integration, data storage, data interoperability (i.e., sharing data across institutions), and data governance.[93]

Internet of Things

The network of connected devices and technologies facilitates communication among devices, and between devices and the cloud.[94]



Artificial Intelligence, Machine Learning, and Predictive Analytics

AI encompasses the strategies and techniques that increase human characteristics of machines. ML, a branch of AI, develops algorithms and statistical models that systems use to perform complex tasks without explicit instructions. Predictive analytics involves applying advanced mathematical and statistical techniques to historical and current data to make future predictions.[95]

Cloud Technology Overview

- Cloud technology powers products and services providing the foundation for interoperability (i.e., how software systems, devices, applications, etc., connect with other entities without end-user effort).
- Cloud technology serves as building blocks for products and services (e.g., IoT devices generate volumes of real-time data saved in cloud storage and processed using database solutions).
- Real-time data collection helps AI/ML algorithms learn, adapt, predict, and make intelligent decisions.
- IoT generates data; cloud storage and data management offer the processing power; and AI/ML and predictive analytics can deliver intelligent analysis to ensure comprehensive and actionable future-focused outputs.[96]
- Interoperable data and infrastructure can maximize each building block's potential, driving efficiency, innovation, and informed decision making across applications.
- Interoperability is the successful exchange of secure data across applications and systems automatically, irrespective of geographical, political, or organizational boundaries.[97] Interoperability makes access, sharing, and transmittal of data across organizations fluid.

Core opportunities where cloud technology can address key needs and gaps across the food value chain (see Section 2) are defined as starting points.

Use Cases	Data management & storage	IoT	AI/ML and predictive analytics
A - Production (Global): ***Qaltivate*** developed an agribusiness tool bringing together functionalities like an agricultural marketplace with interactive dashboards for real-time pricing and industry trends, a remote satellite sensing hub to monitor weather patterns and crop health, calculations to determine potential integrations of solar energy systems in agriculture, and a data hub that uses advanced analytics to synthesize insights and visualize data.[98]			
B - Consumers (US) ***Kraft Heinz*** is leveraging Generative AI to drive innovation and efficiency across its supply chain, product development, and marketing efforts, aiming to create a responsive and adaptive business model. KraftGPT, an internal Generative AI application provides insights into product sales and operational queries. To predict factory line downtimes and make forecasting more accurate, they are using a digital twin of the supply chain, enabling autonomous decision making and rapid response to consumer demand changes. This approach has helped Kraft Heinz react quickly to changing consumer demands, enhancing operational efficiency and decision making, and creating end-to-end visibility from retail store shelves to farmers.[99]			
C - Waste Management (Global): ***Hitachi*** and ***OneThird's*** use of an AI/IoT-enabled waste monitoring system demonstrates the future potential of cloud technology in the food value chain—using near-infrared sensing and AI algorithms to analyze food at a molecular level, predicting shelf life, and providing real-time insights on food longevity. This advanced technology helps reduce food waste by at least 25% by optimizing distribution routes and redirecting products to the charitable food value chain.[100]			

	1	2	3	4
Emerging capabilities & impact on challenge themes	Food value chain volatility	End-to-end suboptimal supply chain	Impact of systemic inequities on communities & workforce	Data interoperability deficiency
Capability: Data management & storage Advances in cloud-based data management and storage have the potential to significantly reduce supply chain costs, make planning and forecasting more accurate, and provide better visibility into inventory management. Further advancements in data integration and user-friendly interfaces, along with the integration with other services like ML, could help expand impact. It is important to implement or upgrade computational infrastructure and develop intuitive user interfaces.				
Capability: IoT IoT-enabled sensor devices and data analysis tools can facilitate real-time monitoring and analysis of food quality and enhance precision agriculture through GPS satellite tracking tags. These advancements created more accurate analytics, immediate insights, and data-driven decision making.[101] Fostering collaboration between IoT technology providers and stakeholders across the food value chain could be important in maximizing the potential of these technologies in addressing these multifaceted challenges.				

	1	2	3	4
Emerging capabilities & impact on challenge themes	Food value chain volatility	End-to-end suboptimal supply chain	Impact of systemic inequities on communities & workforce	Data interoperability deficiency
Capability: AI/ML & predictive analytics AI/ML & predictive analytics can make quality control better, develop automation, and optimize logistics to help ensure timely delivery, reducing waste and boosting productivity. AI can also personalize experiences and predict demand trends, which can help to increase customer satisfaction as well as reduce overproduction. To fully realize these advancements, investment in research and development, access to high-quality data, a skilled workforce, robust computational infrastructure, and the implementation of regulatory and ethical frameworks are all important.	✓	✓	✓	

SECTION SIX

Calls to Action

Public, private, and philanthropic organizations can take actionable steps toward an equitable and optimized food value chain. These calls to action are based on input from the Advisory Group, interviewees, food value chain innovators, and the assessment of needs and gaps to address:

CTA 1

Advancing data interoperability, analytics, & insights

CTA 2

Connecting & communicating across the value chain to break silos that exist across components and generate greater insights to support community and health needs

CTA 3

Centering on the customer & enabling community co-creation

CALL TO ACTION 1: ADVANCING DATA INTEROPERABILITY, ANALYTICS, & INSIGHTS			
GENERAL ACTION	**EXAMPLE ACTION**	**OWNER(S)**	**POTENTIAL OUTCOME**
Develop and implement integrated systems that allow seamless communication, real-time data sharing, and coordination among institutions across public, private, and philanthropic sectors (e.g., community-based organizations, healthcare companies, and governments); recognizing that food insecurity is a symptom of deeper issues like housing insecurity and unemployment. **Cloud technology enablement:** Implement and facilitate interoperable datasets for analysis of actionable insights on root causes of food insecurity and effectiveness of change efforts.	**Implement an integrated social services data platform.** • Create a cloud-based system that integrates data from various sectors (e.g., housing, employment, and healthcare) to provide a comprehensive view of the root causes of food insecurity. • Implement and promote standardized data formats and APIs to ensure seamless data-sharing across CBOs, healthcare organizations, and governments. • Implement AI and ML algorithms to analyze integrated datasets and identify root causes of food insecurity.	• Cloud technology providers • Community-based organizations & partners • Government program (e.g., SNAP) directors	Identify targeted interventions to address the root causes of food insecurity, measure their effectiveness, and expand investment in scalable interventions that make an impact.

CALL TO ACTION 1: ADVANCING DATA INTEROPERABILITY, ANALYTICS, & INSIGHTS			
GENERAL ACTION	**EXAMPLE ACTION**	**OWNER(S)**	**POTENTIAL OUTCOME**
Integrate data systems with grassroots organizations, health and healthcare initiatives, policy frameworks, and food production companies to identify opportunities for food rescue and waste reduction to create a more sustainable and responsive supply chain. **Cloud technology enablement:** Provide support through cloud-enabled, closed-loop systems to deliver data and analytics on food assistance needs and potential food waste in real time.	**Establish a food rescue and waste reduction coalition.** • Implement a cloud-based system that integrates data from all stakeholders to provide a comprehensive view of food surplus and community needs. • Use AI and ML to predict food surplus and potential waste, and coordinate food rescue efforts for food assistance programs. • Use cloud-based tools to measure the impact of these initiatives on food waste reduction, community health outcomes, environmental harm reduction, and supply chain efficiency.	• Cloud technology providers • Food retail • Healthcare organizations	Reduce food waste in landfills, lowering the food value chain's greenhouse gas emissions while redirecting food to families in need, creating a healthier environment and more food secure communities through greater predictability and facilitation of food rescue.
Implement data systems that leverage predictive analytics to anticipate and mitigate the impacts of global shocks and economic volatility. **Cloud technology enablement:** Provide support through cloud-enabled platforms that integrate diverse data sources and leverage ML algorithms to deliver real-time data and advanced predictive analytics.	**Implement a predictive analytics tool for food value chain resilience.** • Create seamless integration of data from food value chain stakeholders and external sources, such as weather forecasts, global trends, and geopolitical events. • Implement ML models that predict potential disruptions and global supply chain shocks, price volatility, and climate impacts. • Provide real-time dashboards that visualize predictive insights and provide actionable recommendations.	• Cloud technology providers • Food distributors • Food processors • Food producers • Policymakers	More resilient and adaptive data-driven food value chain with collaborative efforts to reduce the impact of global disruption on food supply and security.

CALL TO ACTION 1: ADVANCING DATA INTEROPERABILITY, ANALYTICS, & INSIGHTS			
GENERAL ACTION	**EXAMPLE ACTION**	**OWNER(S)**	**POTENTIAL OUTCOME**
	• Deploy policy interventions in real time based on forecasted supply shocks.		
CALL TO ACTION 2: CONNECTING & COMMUNICATING ACROSS THE VALUE CHAIN TO BREAK SILOS			
GENERAL ACTION	**EXAMPLE ACTION**	**OWNER(S)**	**POTENTIAL OUTCOME**
Engage and activate historically excluded food value chain players, particularly those in food production like farmers, in health and healthcare and food assistance program development and evidence-building efforts. In collaboration with these partners closest to the source of food, devise strategies to incentivize quality and nutrient density (including plant forward sustainable products) over quantity in food production, and measure the impact of increased nutritional quality on health outcomes. This collaboration is important to support broader healthcare reimbursement of food assistance by demonstrating the positive impact food production can have on human health. **Cloud technology enablement:** Implement cloud-based systems and services like IoT to ensure consistent measurement of food quality, aggregate data, and share insights to promote higher quality food and to support health and healthcare programs.	**Launch a farm-to-health initiative.** • Create an initiative that integrates local farmers into the development and delivery of health and healthcare programs. • Establish direct partnerships with local farmers to source fresh produce for healthcare programs, ensuring fair compensation and support for sustainable farming practices. • Implement community health farmers' markets where farmers can sell their produce directly to community members involved in a healthcare-sponsored food prescription program. • Collect the data and evidence needed to support improvement in healthcare outcomes based on food assistance programs and the production of higher quality foods.	• Cloud technology providers • Community-based organizations & partners • Food producers • Healthcare organizations • Policymakers	Effective strategies with accountable milestones, metrics, and outcomes informed by agricultural insights and expertise, to create a food system that promotes health and well-being.

CALL TO ACTION 2: CONNECTING & COMMUNICATING ACROSS THE VALUE CHAIN TO BREAK SILOS			
GENERAL ACTION	**EXAMPLE ACTION**	**OWNER(S)**	**POTENTIAL OUTCOME**
Invest in and facilitate collaboration among like-minded organizations to amplify impact.	**Launch a community synergy fund.** • Create a fund specifically aimed at fostering collaboration among various community-based organizations. • Design a grant application process that incentivizes organizational partnership for funding. • Fund projects that address common community challenges through collaborative approaches (e.g., joint food distribution programs).	• Community-based organizations & donors/funders	Unified and powerful network of mission-driven initiatives with accountable milestones, metrics, and outcomes to serve and support communities.
CALL TO ACTION 3: CENTERING ON CUSTOMERS & ENABLING COMMUNITY CO-CREATION			
GENERAL ACTION	**EXAMPLE ACTION**	**OWNER(S)**	**POTENTIAL OUTCOME**
Continue and expand efforts to use design thinking and prioritize the voices of individuals by understanding what food they need, how they wish to receive it, and how they want to be engaged by community-based organizations. Partner with food leaders (e.g., local dieticians) who can accurately represent community needs. **Cloud technology enablement:** Accelerate data collection through culturally appropriate user experience (UX) and user interface (UI) design, data processing capabilities, storage, and insight generation to amplify community voices	**Create a community food innovation hub.** • Build and pilot new UI/UX in partnership with members of the community. • Offer workshops and training sessions to support community engagement with new technologies and build community capacity. • Use cloud-based tools to measure the impact of initiatives for rapid ideation.	• Cloud technology providers • Community-based organizations & partners • Food distributors • Food retail • Healthcare organizations	Responsive, inclusive, and dignified support system that addresses food insecurity while also enhancing community well-being.

CALL TO ACTION 3: CENTERING ON CUSTOMERS & ENABLING COMMUNITY CO-CREATION			
GENERAL ACTION	**EXAMPLE ACTION**	**OWNER(S)**	**POTENTIAL OUTCOME**
within the food value chain. Support the interoperability of these data elements across food value chain stakeholders.			
Prioritize preferences and needs of the customer in procurement and inventory management strategies to lead with a customer-centric (pull) approach to product assortment and retail rather than pushing products that may be misaligned with customer needs. **Cloud technology enablement:** Invest in interoperable datasets for upstream customer preferences and needs sharing, and support interoperability and the development of a system so that all organizations throughout the food value chain have first-party data on customer insights.	**Launch a customer-centric food value chain initiative.** • Implement a unified system where customer feedback is collected, analyzed, and shared with all stakeholders in real time. • Use cloud-based tools to measure the impact of these initiatives on customer satisfaction, sales, and inventory efficiency to support better predictive analytics.	• Cloud technology providers • Food distributors • Food processors	Unified and customer-centric system that more effectively matches supply and demand to reduce food insecurity and food waste.

The Future of a Cloud Technology-Enabled Food Value Chain

The food value chain of the future that uses cloud technology could transform how we navigate volatility, optimize the supply chain, implement data interoperability, and address systemic inequities. Envisioning the future, cloud technology has the potential to optimize the food value chain with increased efficiency, sustainability (i.e., reduced food waste and lower greenhouse gas emissions), and more equitable delivery systems to feed a population. However, realizing this potential involves an approach that incorporates stakeholder collaboration, strategic investments, policy interventions, and precise/reimagined resource allocation.

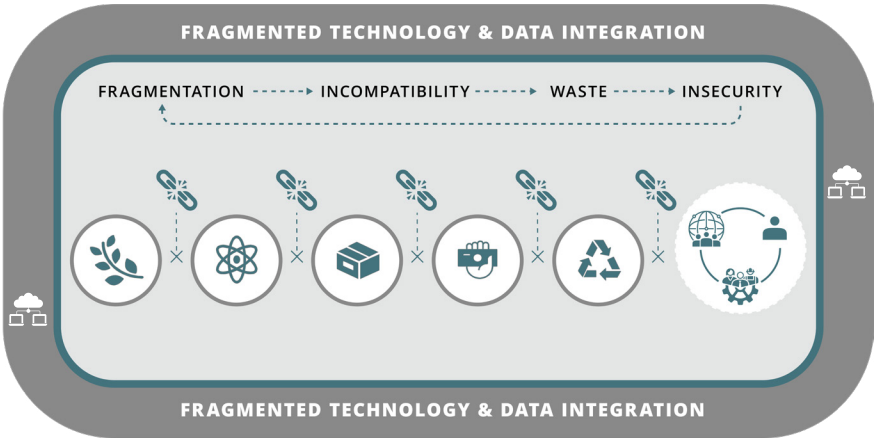
Optimizing the food value chain using cloud technology begins with seamless and secure data sharing across institutions to illuminate the root causes of food insecurity, such as a lack of transportation. Understanding these root causes through data allows for the deployment of targeted interventions, such as providing food delivery or access to transportation. Cloud-based infrastructure that integrates data on food surplus and assistance needs can expedite food rescue initiatives, reducing waste and increasing food security. Enhanced data interoperability and data management with cloud technology solutions can democratize access to advanced analytics for collaboration and innovation in food assistance programs. Through predictive analytics and automation, organizations can enhance risk mitigation and responses to global shocks, ensuring stability in production, processing, and waste management. Unified systems for customer feedback and community needs data can create more customer-centric distribution models and customer-driven procurement.

Cloud technology providers have an opportunity to lay the foundation for a customer-centric food system that enhances community well-being and delivers greater value with more equitable and efficient supply chains. However, cloud technology providers cannot achieve this alone; it will involve public, private, and philanthropic leaders acting together to bring a cloud technology-enabled food value chain to life.

Food Value Chain Optimization

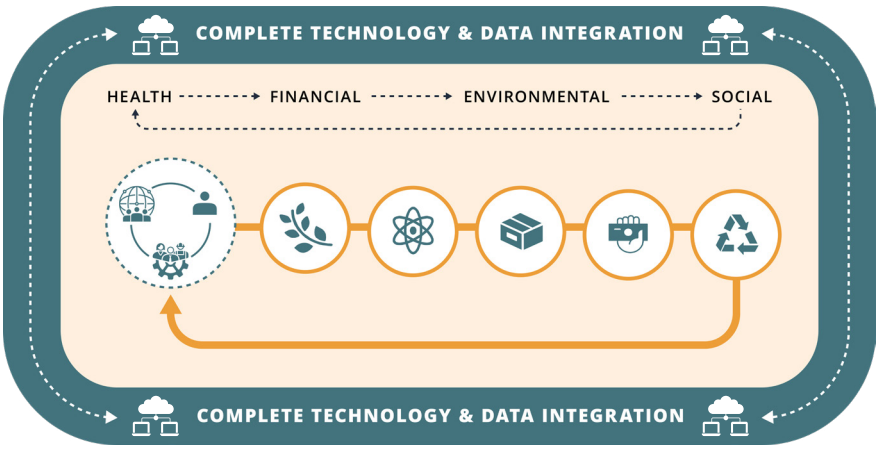
FROM

- **Communities, individuals, and the workforce** are recipients of the food value chain's output rather than being central to decision-making processes and actions. Their influence on the overall system is limited, indicating a need for a more inclusive approach.
- **Operational/process breakdowns** occur throughout the components of the food value chain that cause inconsistencies in process, disrupt workflow, and hinder knowledge sharing.
- **Technology & data** are used ad hoc in a nonstrategic capacity across the food value chain, contributing to process inefficiencies and inaccuracies.



TO

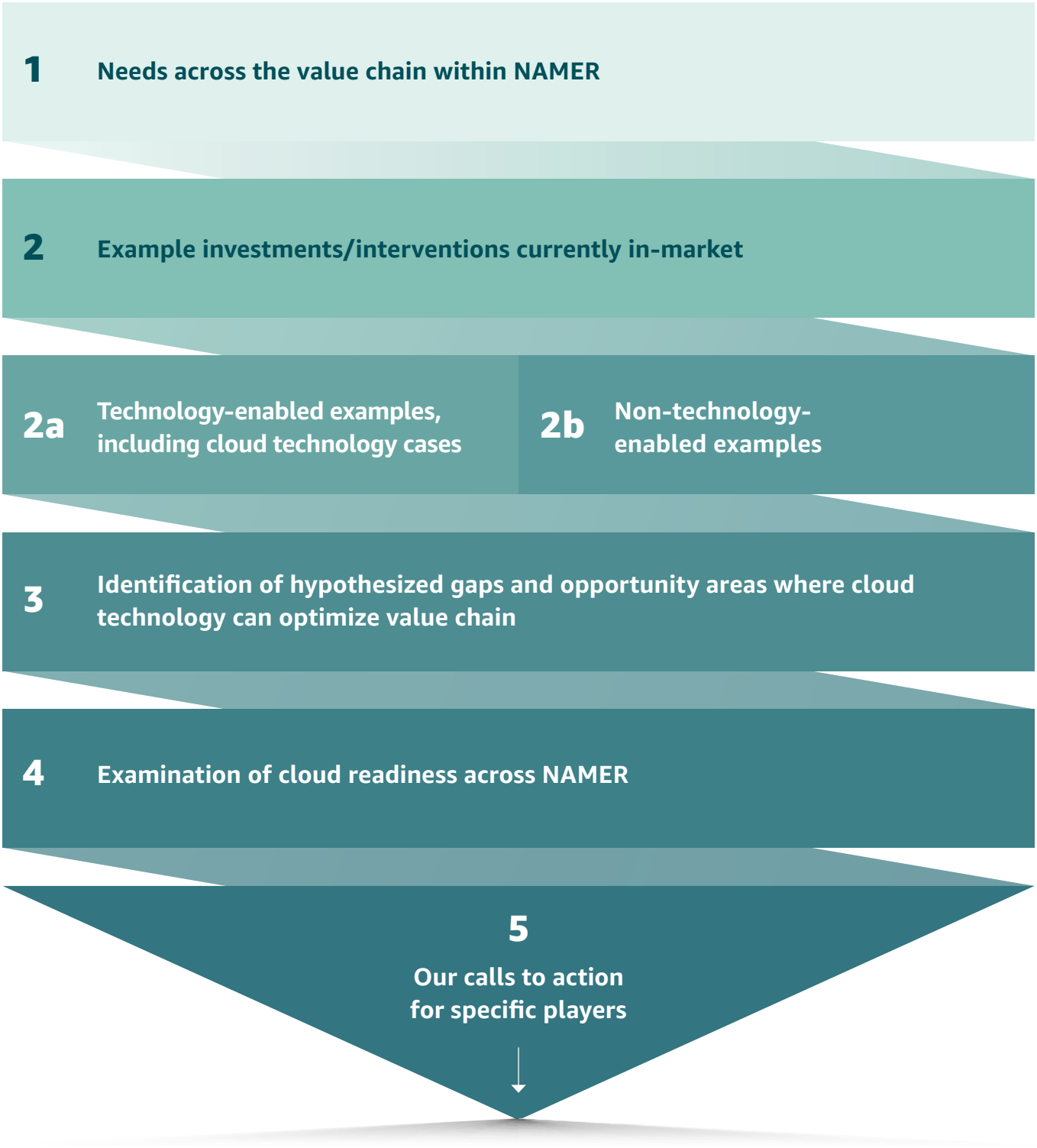
- **The voices of individuals, communities, and the workforce** inform choices and actions across the food value chain. Their needs, preferences, and actions are integrated across food value chain components.
- **Operational/process integration** occur within and across the food value chain, resulting in equitable, effective operations and a robust end-to-end continuous feedback loop for accurate, timely information sharing.
- **Technology & data** are integrated strategically across the food value chain to optimize process efficiency, inform decision making (e.g., optimizing food production quantities based on weather patterns to minimize waste, and determining the appropriate quantities of food to deliver to various neighborhoods to meet population needs), and drive equitable, proportionate supply and demand across all components.



KEY:

Production
Consumers
Technology & Data
Communities, Individuals, & Workforce
Processing
Waste Management
Broken Value Chain Link
Aggregation & Distribution

Our Research Approach



The potential impact of a future where cloud technology can address core needs across the food value chain and specific steps that key players can take to realize transformation in this space.

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