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Scientific article

Digital technology management for sustainable development of emerging economies

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In the changing world order, emerging countries have gone through a lot of challenges, with a direct impact on the economies, especially on a significant number of small and large-scale businesses. COVID-19 pandemic introduced a huge disruption in the supply chain, which largely contributed to consumer panic buying, inflation, profiteering activities, disruptions leading to economy drop, insufficient income and resultant hunger. Advantages of technological innovations have never been more relevant to attain efficiency, employ more local companies, and develop a more accurate business model, which can help industry stakeholders determine blockers in their business processes. In this paper, the impact of technological innovations on the global sustainable development goal 2, hunger eradication has been specifically analysed. Key common challenges regarding supply chain and lack of strong policies are delved into in order to assess the struggles in capitalizing the industrialization and technology, the relationship between the producers and the market that can be improved, as well as the process of modernizing the distribution cycle. When stakeholder relationships, industrialization, and supply chain management are evolved, this can be considered as the starting points that can contribute significantly towards achieving zero hunger societies across the world.
***Keywords**:* technological innovation, global sustainability agenda, hunger eradication, blockchain, AI, IoT, supply chain.

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Научная статья

Управление цифровыми технологиями для обеспечения устойчивого развития экономики развивающихся стран

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В меняющемся мировом порядке развивающиеся страны столкнулись с множеством проблем, которые оказали непосредственное влияние на экономику, особенно на значительное количество малых и крупных предприятий. Пандемия COVID-19 привела к огромным сбоям в цепочке поставок, что в значительной степени способствовало паническим покупкам потребителей, инфляции, спекулятивной деятельности, сбоям, ведущим к падению экономики, недостатку доходов и, как следствие, голоду. Преимущества технологических инноваций как никогда важны для достижения эффективности, привлечения большего количества местных компаний и разработки более точной бизнес-модели, которая может помочь заинтересованным сторонам в отрасли определить препятствия в своих бизнес-процессах. В этой работе было особым образом проанализировано влияние технологических инноваций на глобальную цель устойчивого развития 2, искоренение голода. Основные общие проблемы, связанные с цепочкой поставок и отсутствием сильной политики, рассматриваются для того, чтобы оценить трудности в капитализации индустриализации и технологий, отношения между производителями и рынком, которые могут быть улучшены, а также процесс модернизации цикла распределения. Когда отношения с заинтересованными сторонами, индустриализация и управление цепочками поставок развились, их можно рассматривать как отправные точки, которые могут внести значительный вклад в достижение обществ нулевого голода во всем мире.
***Ключевые слова**:* технологические инновации, глобальная повестка дня в области устойчивого развития, искоренение голода, блокчейн, ИИ, интернет вещей, цепочка поставок.

Introduction

There is a great recognition that utilization of information and communication technology is at the heart of achieving sustainable development goals. “Technology plays a critical role in transforming societies and economies through enhancing efficiency, connectivity and access to resources and services” (Al-Jayyousi, 2017). The industry value chains are no exception and are primed for transformation. Increased supplier collaboration, transparency, alternate labour practices and automation, stricter quality control and agility for the last mile pivot are some of the key determinants. Now is the optimal time for clients to invest in their business and adapt to the forces in the long-term trends below in spite of the uncertainty of their magnitude. According to Industry Career Guide released by the Department of Labour and Employment, process standardization and harmonization, the manufacturing and distribution of equipment and supplies, the processing, storage, and distribution of commodities are critical in determining the success. It has a wide scope constituting design inputs, operations and management, product processing, equipment and supplies manufacturing, trading and retailing.

The current industry value chain is inherently dependent on technological innovations to measure its chances of survival in the ever-changing world. Sustainability is at the core of it to drive the future operating model with an objective to demonstrate progress across all ESG initiatives and create long-term commitment to ensure sustainable development for all. Furthermore, the industry will need to create synergies between producers and consumers, adapt to changing consumer needs and focus on cost reduction throughout the value chain to be able to deliver on its promises.

One of the key challenges that the industry is facing amid various dependent and independent variables impacting the sustainability outcomes, is to correctly measure the performance. Companies have traditionally focused on financials and shareholder returns, but the current tipping point is being driven by customers, brands, employees, investors and regulators. Consumers are more gravitated towards sustainable products and bands are more inclined to market sustainable products. Manufacturing is also in turn shifting towards ESG value-driven productivity. The interplay of Governments, Regulators and Investors are putting additional pressure on technological innovation landscape thus driving investment decisions, accountability and reporting. Key sustainability KPIs include metrics for tracking impact on the topics below across the product lifecycle:

- ***Environmental*** **–** Key KPIs are Carbon emission, Resource Intensity, Water Usage, Waste Management and Biodiversity
- ***Social*** **–** Community wellbeing, Economic impact, Food Security, Job creation, Safety and Trust.
- ***Governance*** **–** Diversity and Inclusion, Labour practices.

By looking at the recent technological innovations, key insights and information can be drawn that focuses primarily on solutions leveraging IoT, blockchain, and AI-driven platforms to collect, integrate and analyse data to monitor and help companies address a range of issued operational challenges including reducing resource intensity and emissions and integrating data for improved operational intelligence.

The paper does not analyse the impact of sustainable development goals, but rather accentuate the role of information and communication technology in addressing critical challenge from pre- and post-Covid world. The paper, firstly, presents definition and concept of ICTs and its link to sustainable development goals related to zero hunger. In details, the paper gives an overview of SDGs and discusses the role and impact of information communication technology in sustainable development goals of agribusiness industry sector, followed by the method used. Consequently, the paper discusses utilization of technological innovation in key economies of the world to achieve sustainability goals while illustrating major challenges and opportunities in those contexts.

Role of current technology innovations to address sustainable economic development

Modern innovations are mostly concentrated in operational sustainability areas, where they are most applicable across key sustainability issues. This is especially more relevant to areas, where population residing in emerging economies, and underprivileged countries are directly impacted. Blockchain and IoT technologies are used to address select sustainability issues, while AI sees broader applicability.

- ***Blockchain:*** Blockchain technology is one of many emerging technologies that has the potential to help solve some of the environmental problems that we face today. Usage of blockchain applications for tackling environmental challenges revolve around: supply chain monitoring and tracking, innovative financial instruments, peer-to-peer trading of tokenized values, enabling decentralized systems of energy, and common-pool resources. Applications of blockchain technology could be useful when monitoring actors’ compliance to Multilateral Environmental Agreements (MEAs) and progress with Sustainable Development Goals (SDGs) implementation (weds UN). Blockchain is most commonly used in sustainability technology to create end-to-end visibility, transparency and traceability across the supply chain. This approach seeks to create trust in manufacturing and sourcing processes as well as compliance. A key challenge that blockchain helps the companies to overcome is data integration, support circularity initiatives and footprint management.

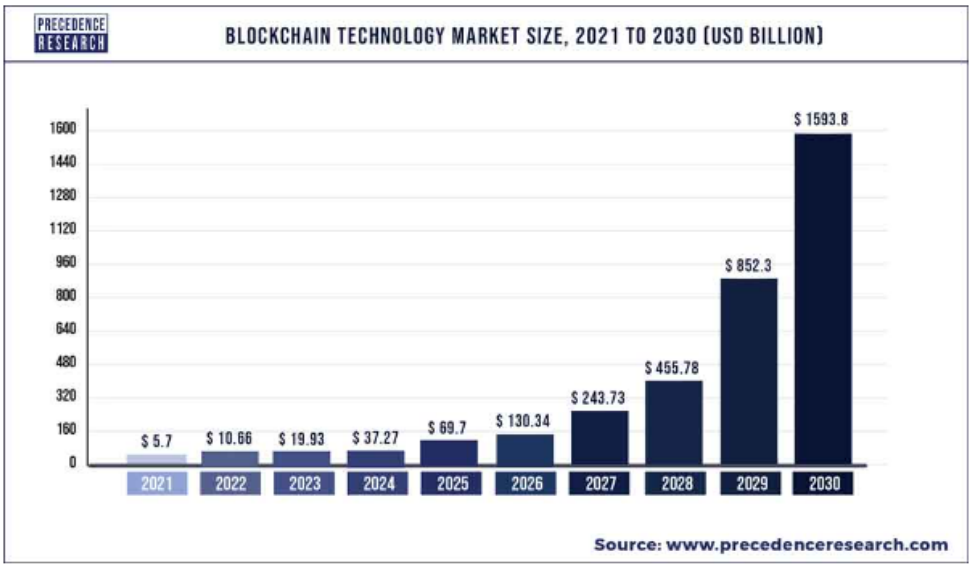

Figure 1. Blockchain Technology Market Size forecast
Source: Precedence Research

As evident from Figure 1, rapid demand for blockchain-powered technologies in developing countries has pushed the market to new heights, resulting in wider customer base and recording significant revenue during this period. Significant opportunities include data usage control, data decentralization, and encryption, which find use cases across the industry value chain. Decentralized Ledger Technology (DLT) has attracted investors from different fields, and various industries are choosing to integrate it into their infrastructure.

- ***Internet of Things (IoT):*** Internet of Things (IoT) technologies have started to impact society as a whole and have become a key enabler for sustainable development. The role of IoT in sustainability research is vast, with scientific research in many industries. It is used in farming, water management, recycling and has the potential to play a vital role in community management and stability (Rosca et. al., 2021). Internet of Things (IoT) applications can bring benefits to the environment (Maheswar and Kanagachidambaresan, 2020; Araral, 2020). The beneficial relationship between IoT and sustainability has been studied lately (Laine, 2014). Internet of Things (IoT) technology use is highly concentrated within operational sustainability, particularly when tracking resource intensity. It is leveraged to gather and exchange data across a range of devices to monitor, track and provide insights for resource usage. Currently IoT is starting to be used in smart manufacturing and supply chains optimization.

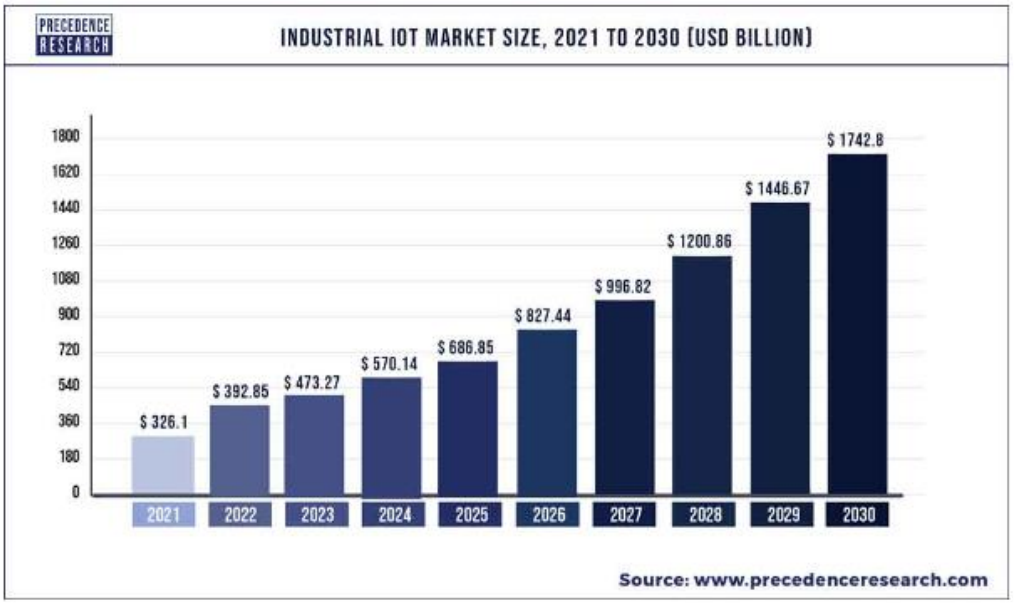

Figure 2. IoT Market Size forecast
Source: Precedence Research

Figure 2 shows that the manufacturing industry leverages IoT functionalities as the most followed by logistics and transportation segment over the years. Several governments and research organizations are developing new potential usage of Industrial IoT for increasing productivity in operations. Additionally, involving operation technology on the internet opens up many opportunities for the convergence of IT and OT within the technological framework of Industry 4.0.

- ***Artificial Intelligence (AI):*** AI is currently being utilized for a wide range of activities including medical diagnosis, electronic trading platforms, robot control, and remote sensing. It has been used to develop and advance numerous fields and industries, including finance, healthcare, education, transportation, and robotics (Kayid, 2020). Artificial intelligence (AI) will transform business practices and industries and has the potential to address major societal problems, including sustainability (Rohit et.al, 2020). AI sees applications across all sustainability issues, but it is mostly concentrated within operational sustainability. Another use case of AI-driven platforms is for helping DEI initiatives which allows companies attract from diverse talent pools and monitor their talent demographics.

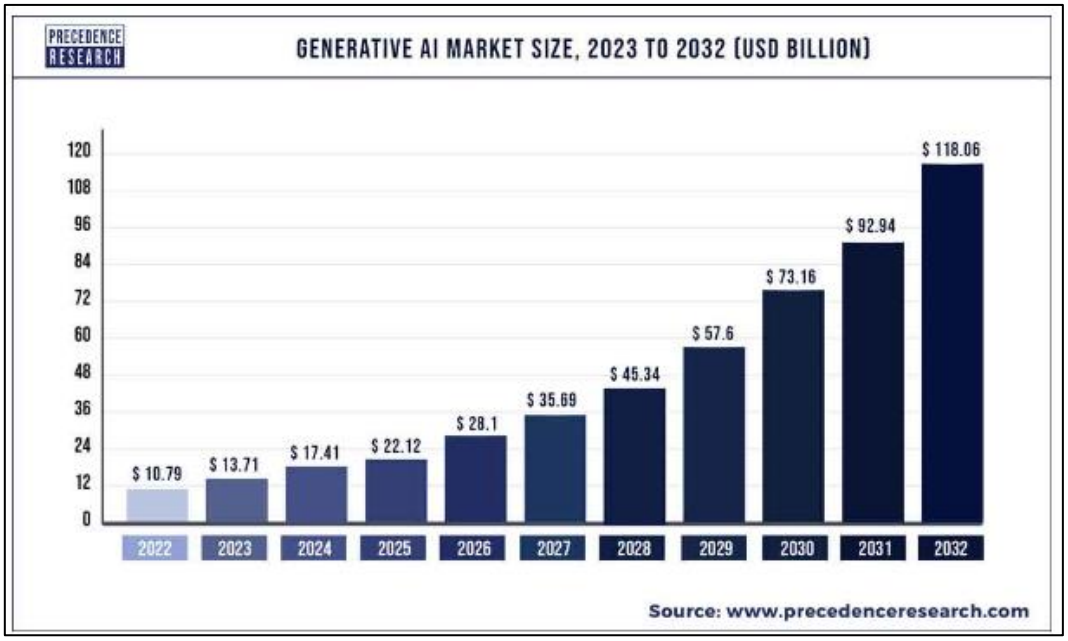

Figure 3. Artificial Intelligence Market Size forecast
Source: Precedence Research

The demand for AI applications is increasing across industries over the years due to expanding applications of technologies using it. Growth factors in industry sectors are creating various products utilizing AI standalone and in conjunction with other technologies. In agribusiness sector, key sustainability related issues impacted by Innovation and Research are directly related to Carbon Emissions (Scope 3), Regenerative Agriculture and Biodiversity, and Waste Management.

- ***Reduction of Emissions:*** Primary technology solutions enable organizations to calculate and account for their GHG emissions. Many primary solutions offer the ability to report their impact across a range of standards as well as identify opportunities to reduce their impact. Footprint management technology enables companies to assess, track and offset their carbon footprints. Mature technology solutions focus on supply chain footprints as well as enable companies to do carbon modeling to understand impact and potential tax implications. Emerging technologies help companies assess, track, manage and report on Scope 3 emissions. Currently they have a strong focus on reducing supply chain Scope 3 emissions
- ***Regenerative Agriculture and Biodiversity:*** Primary solutions focus on efficient water use in agriculture. The technologies are a combination of low-cost hardware for sensing, with AI and data analytics that integrates field data and external factors to minimize waste. Wireless communications are common-place with most solutions not requiring network on the field. New use cases are emerging for detecting water abnormalities such as leaks and runoff during production. Most technology applications fall under the umbrella of precision agriculture. Precision agriculture leverages a multilayer system of hardware – predominately IoT-based – and software components. The integration of information and communication technologies into the agricultural production process yields sustainability benefits, e.g., resource optimization. New use cases for AI-driven technologies e.g., drones and robotic machinery, are being commercialized in precision agriculture, and are well-positioned to drive sustainability improvements for adopters. Biotechnology applications

– researchers are developing crops that are more resilient to disease, pests and drought conditions. Solutions focus on silent monitoring of energy use, mainly only software based, while some require IoT. The key piece of the technologies is the use of AI and data analysis to map out energy use and a strong visualization platform to drive decision making. Certain tools purely focus on reporting energy use levels. A new set of technologies are being developed to help small and medium businesses make better decisions around their energy use. The area of Biodiversity protection is very nascent, solutions are emerging around reforesting and monitoring biodiversity through AI and satellite data. The carbon offsetting projects created by carbon credits market have been a large contributor to the emergence of this space.

- ***Waste Management:*** Established waste reduction technology solutions have a heavy focus on food waste. Technology software helps track and optimize the food supply chain. Moreover, automation helps to drive consistency across measuring systems for reporting accuracy. Artificial Intelligence increasingly helps digest a vast amount of data across the supply chain and detect where food is lost. Low-cost RFID or cameras are being used to increase data volume and quality and support intelligent systems. Primary solutions offer secure platforms for visibility across the supply chain and tracking KPIs. Established software platforms integrate data with suppliers as well as aggregate data into the cloud, enabling system-level analytics and insights. End-to-end platforms are emerging to show consumers the product footprint. New technology provides real-time data on inventory levels, costs, production usage and accurate COGS numbers for products. Primary platforms leverage blockchain to provide supply chain transparency and integrate supply chain processes across ecosystem partners. Satellite imaging and computer vision are being used to automate data capture. Plug-and-play APIs easily help to connect sourcing data from suppliers. Emerging solutions feature machine learning powered software to accelerate material discovery and optimization for sustainable packaging. Digital watermarking and RFID low-cost solutions are being used to track products after product sell & use.

Methodology and data analysis

The objective of this review is to look at one of the most critical goals for sustainability agenda, which is related to eradication of hunger for a large swath of global population. This study provides a qualitative insight into one of the most critical industries impacting human lives, which is Agribusiness. It is illustrated by examples from multiple literature sources and research articles. After initial scoping searches of the literature, it draws on the theory and practice of reviews in multifarious channels used in the published literature, research documents and other source materials. The purpose was to outline the industry overview, challenges posed, and future prospects driven by the technological innovations using a Search, Appraisal, Synthesis and Analysis (SALSA) framework. Each review type was analysed, its characteristics were described, and its perceived strengths and weaknesses were factored in to lead to discussion and conclusions without applying any judgement of quality.

Importance of technological innovation and digital transformation in agricultural sector

Digitization has the potential to bring radical transformation to the agribusiness sector, which feeds a large section of world population directly, especially in the developing countries. Farming is becoming increasingly digital to bring about efficiency, inclusivity, variety and sustainability. That, in turn, is increasing its productivity with optimum utilization of resources, energy-efficient processes, while aligning with our environment and biodiversity. Key objective of digital farming is to be able to help our resource constrained farmers to make sustained profits with optimal exploitation of natural resources. Farmers are more aware of their role in operational aspects of this sector and how they impact the social, economic and environmental dimensions overall. With well-defined sustainability goals embedded in the agribusiness companies, it is vital how relevant technologies can fit into appropriate processes along with the value chain to realize efficiency, accuracy and transformation of the all-encompassing food production.

Recent technological developments have driven all sectors into rapid spiral of change, and agribusiness is no exception. Many institutions, organizations, and universities in different countries take various initiatives to drive this revolution enabled by smart technologies. As a result of these initiatives, many new terms and definitions are emerging and transforming. Different forms of digitalization in agriculture have been deployed under the guise of different terms such as "Digital Agriculture", "Precision Agriculture" "Precision Farming", "Smart Agriculture" and "Smart Farming". These terms are interchangeably used in the digitalization of agriculture and in parlance of literature around it. While Wolfert et al. (2017), Blok and Gremmen (2018), Rose and Chilvers (2018) use the term of smart farming in their studies; Gondchawar and Kawitkar (2016), Baz (2022), Kırkaya (2020) used the term of smart agriculture in their studies, Keogh and Henry (2016), Shepherd, et al. (2018) used the term of digital agriculture in their studies as well.

The chronology of technological developments in agribusiness industry are dominated by key concepts such as productivity, operational efficiency, ease of access to markets and overall profit quotient for the stakeholders.

- ***Agriculture 1.0*** - Low productivity and labour intensive.
- ***Agriculture 2.0*** - Green Revolution of 1950s characterized by synthetic pesticides, fertilizers, cheap inputs, new instruments leading to low cost and high volume.
- ***Agriculture 3.0*** - Precision Agriculture of 1990s with the advent of significant changes, such as manual guidance with GPS, Variable Rate Application (VRA) in harvesters, Fertilizers usage tracking, plot-specific tracking, animal specific tracking and herd tracking, which saw incremental cost seduction and more effective process management (Saygılı et al., 2019).
- ***Agriculture 4.0*** – By 2010, in parallel with the revolution in the industry with Industry 4.0 technologies, many technological aspects of the agribusiness value chain, such as computers, robots, UAVs (Drones), artificial intelligence, augmented reality, internet of things, sensors, internet, and automation, took the driver seat and redefined the perspective, with which it is approached. Agriculture 4.0 process has been given names such as Digital Agriculture, Precision Agriculture (1990), and Smart Agriculture (Ercan, et al., 2019; Güldal et al., 2019; Kirmikil & Ertaş, 2020).

Current challenges faced to address sustainable development goals

Climate change, leading to erratic weather conditions and increased crop infestation, is likely to impact crop yields across the globe. Tropical crops, livestock and fisheries are most affected by current climate change; regions of major exposure to climate change coincide with high prevalence of poverty and food insecurity. Uneven climate change effects in combination with differences in adaptation capacity may give rise to a growing divide between developed and developing countries. With climate change and intensive agriculture, arable land is decreasing, and the soil is degrading. Urban expansion will result in a 1.8–2.4% loss of global croplands by 2030 with 80% of the loss expected to be in Asia and Africa. The US alone lost 31m acres of farmlands in last the 20 years and more than 11m acres of best farmland, which was used to expand cities and towns (FAO, 2022).

Post pandemic, consumers have started focusing on healthier food alternatives. Consumer preference is shifting towards healthy, traceable and personalized food, and also demand for fresh, local, sustainable products with provenance creates an opportunity for new business models. As a result, consumers' expectations of what they want from products, how they shop and interact with brands is also changing. Customers are seeking authenticity, along with personalization – driving the need for LATTE (Local Authentic Traceable Transparent Ethical) products. In conjunction with those, the customers are getting more accustomed to 24/7, anywhere, anyhow shopping providing them with convenience and unique experiences. This need to digitally engage with consumers makes traditional marketing channels less relevant for companies.

With increasing population and stress on available natural resources, sustainability will be at the core of agribusiness. Regulatory support for carbon farming and initiatives by leading world economies can help develop a more sustainable value chain. Agribusiness leaders need to focus on sustainability and digital innovation to tackle regulatory and trade obstacles and develop business opportunities. Input costs have increased due to rising cost for active ingredient introductions and low labour availability. With low availability of labour during farming season, the agricultural machinery and agricultural machinery rental market are likely to witness growth. Increasing labour cost, increasing infestation and toxic impact of synthetic herbicides provide opportunities. The agribusiness industry needs to look at opportunities that reduce production costs and prices paid by the consumers.

The next wave of agribusiness requires investments across the ecosystem with focus on sustainability, innovation and new business models for agribusiness industry; measuring sustainability development starts with defining KPIs across each stage of the product lifecycle.

Table 1

Major KPIs to focus on in the Agribusiness Industry sector

Product Lifecycle	1. Innovation & Research	2. Product Design	3. Source	4. Manufacture	5. Package	6. Transport and Store	7. Sell and Use	8. Return and Dispose
Sustainability KPIs	1. % products meeting volatile organic compound (VOC) emissions standards (where applicable)	1. % of revenue from land meeting NRCS criteria	1. % Level 1 tier suppliers or other suppliers with full traceability	1. CO_2 emissions	1. % recycled materials or plastics (marine or PCR) used	1. % of carbon emissions from logistics process	1. % revenue from land with sustainable or regenerative agriculture practices	1. % food waste due to packaging
	2. % products made without hazardous chemicals or waste	2. % sustainably grown crops & animals employing eco-friendly practices	2. % source products certified through 3rd party environmental or social standard	2. Scope 1, 2 and 3 GHG emissions Total water withdrawn / total water consumed	2. % packaging made from biodegradable materials	2. % renewable fleet fuel consumed	2. $ losses to product safety issues (e.g., foodborne illness)	
			3. % of suppliers that do not use child labour or modern-day slave labour	3. % acres using best practice irrigation techniques		3. % energy efficient warehouse use	3. % of product recalls / total products	
			4. % water sourced from regions with High Baseline Water Stress	4. % products sourced from GFSI certified suppliers		4. % product lost in transit		
			5. % of land using regenerative ag practices	5. Tons of fertilizer & run-off per acre				
				6. Reused water/total water drawn				
				7. Tons of pesticide per acre				

Source: SASB Consumer Goods, Food and Beverage Sector metrics, 2022

The absence of a transparent value chain results in impacts, which are felt from farm to fork. The influence of the supply chain on sustainability initiatives is also a gap in terms of their influence on social sustainability actions. It has been pointed out that to ensure sustainability in the supply chain it is necessary to have sustainability action at each supply chain level (Govindan et al., 2021).

It is clear that the industry needs to clearly objectify their strategy for engaging in sustainability and planned actions to achieve them. It is also equally critical how do supply chain parties influence each other in adopting sustainability. Investments are being made in the digital agriculture space, and firms across the agricultural food value chain are investing and developing digital capabilities, however the opportunities to collaborate and consolidate to develop a connected value chain with a sustainable food ecosystem is still far from what is needed.

Discussions and future outlook

With the changing global scenario, evolving consumer needs, and increasing costs, players need to leverage digitization as a tool to transform the way they operate. Digital adoption in agribusiness sector has been slower compared to other sectors despite having promise of performance, efficiency, and profitability to farmers/growers. Data abundance across the value chain provides an opportunity to transform to unlock power of technology and value creation across their operations.

Recent technological innovations are helping the industry enhance efficiency and make the best of its digital transformation efforts. The objective to provide greater trust and transparency to customers by leveraging multiple data points from sourcing to production through distribution and making certifications from all parties available is the bedrock for the innovations. Creating a trusted relationship with ecosystem partners based on transparency and automated processes across operations is fast becoming the minimum denominator to measure success. Standardized data formats for better interoperability and enhancing data integrity and quality to support decision-making (supply chain optimization, sales cycle reporting, etc.) is crucial along the value chain to address market requirements and challenges. This is crucial to achieve the better connect with end consumers and enable greater personalization during the upstream and downstream lifecycle of the product.

The technological innovations are driving the sustainability strategy, which are being incorporated into future vison of organizations and countries alike. Various solutions and managed services are supporting industries and governments along their sustainability journey. Global sustainability goals sets the framework for multiple innovation opportunities to value for the stakeholders, reflected in their purpose, outcomes and roadmap for execution. An overview of the strategic initiatives is illustrated below:

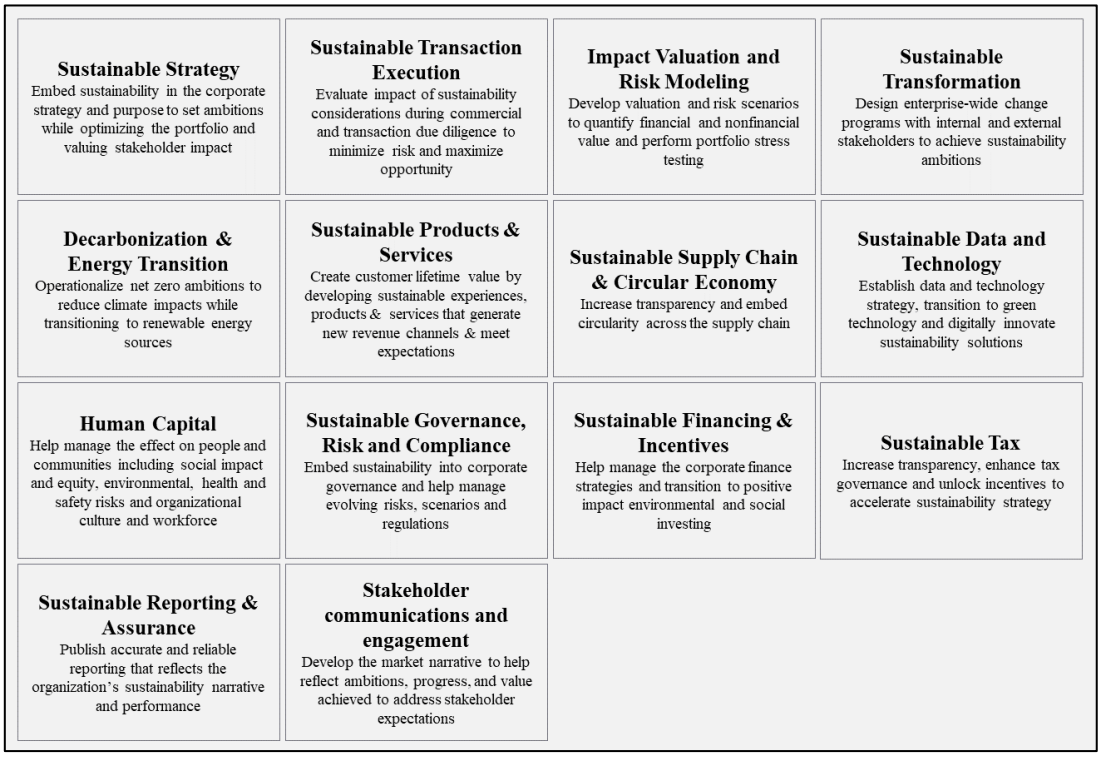

Figure 4. Integrated solution framework to solve issues across the sustainability journey

The technologies associated with the above-mentioned strategic initiatives are transforming the value chain and can be classified into 2 broad heads:

- ***Production:*** Pre-season planning and demand forecasting of relevant crops are aided by remote management, better soil analysis, access to information database and precise weather information. Crop forecasting models for visibility over supply chain are better supported by Geographic Information System (GIS) and Global Positioning Systems (GPS). In conjunction with precision agriculture, it helps price and output management to increase profitability and yield.
- ***Processing / Retailing / Consumption:*** On account of accurate forecasting, supply chain visibility and collaboration between producers and consumers, it is feasible to calculate real-time pricing data for arbitrage opportunities

within futures markets. Solutions for freshness and quality indications, especially in fresh produce, is tightly coupled along the food value chain for better quality

As a result, companies and government organizations are challenging substantial investments to deepen penetration of digital technologies in agribusiness and eventually drive efficiency and profits for stakeholders, which will in turn ensure supply of food to a large population that in past has been expensed due to inherent inefficiencies of the industry.

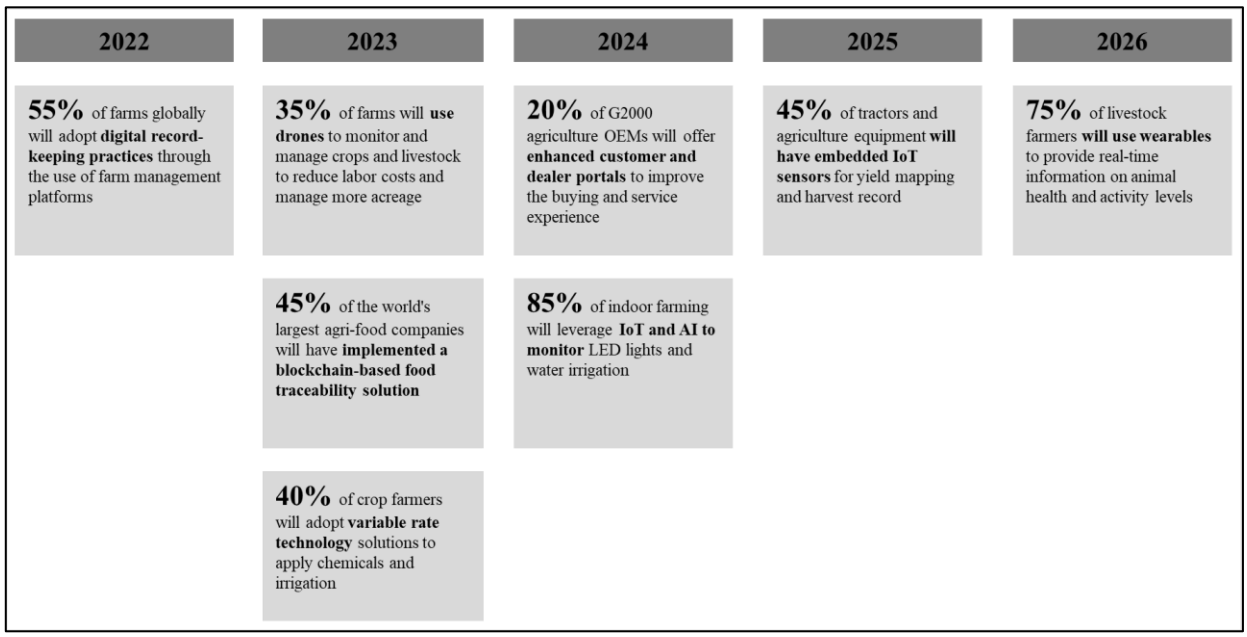

Figure 5. An overview of ongoing investments driving the innovation

Technological innovation and transformation in the industry will lead to a more connected value chain that supports a sustainable development. Consumer centric, efficient and regenerative food system driven by restructured supply chains with seamless connectivity and closer proximity between production and consumption will primarily drive sustainability.

- ***Digital transformation to reimagine food systems*** - With the changing global scenario, evolving consumer needs, and increasing costs, players need to leverage digitization as a tool to transform the way they operate. Digital adoption in agriculture and food has been slower compared to other sectors, however future of digital agriculture will hold promise of performance, efficiency and profitability to farmers/growers. Data abundance across the value chain provides an opportunity to transform the agribusiness value chain. To unlock power of technology and value creation out of data abundance, firms need to look at potential opportunity areas across their operations. The absence of food system transparency results in material impacts, which are felt from table to farm across all three trusts by transparency components. Blockchain can help the agricultural and food industry to enhance its efficiency and make the best of its digital transformation efforts.
- ***Increased relevance of ESG and sustainability*** – With increasing population and stress on available natural resources, ESG and sustainability will be at the core of agribusiness growth. The need to grow more on available land area will drive the need for sustainable solutions: climate change and intensive agriculture are leading to a decrease in arable land and a degradation of soil; climate change also leads to erratic weather conditions and increased crop infestation, which is likely to impact crop yields across the globe. These effects, coupled with rising food demand due to increasing population, urbanization and higher incomes, create a need for sustainable agriculture. Globally, public administrations are driving carbon farming initiatives to mitigate climate change and develop a sustainability driven society. The regulatory push for carbon farming creates business opportunities across regions, with Europe leading the way. Growth in biological fertilizers will be driven by increases in the organic area, awareness around yield improvement, and importance of soil conditioning.
- ***Changing Consumer Needs*** - The pandemic has accelerated the trend towards healthier food alternatives with increasing demand for whole foods that are organically sourced and fully traceable. Consumers are increasingly demanding healthy, fresh, local and sustainable products. These changes in consumer preferences lead to a higher demand for food transparency and traceability, creating an impetus for supply chain reinvention. Empowered consumers, primarily led by data driven decisions, are demanding personalized nutrition solutions. Opportunities are cropping up in adjacent spaces like alternative proteins. Products like hemp/cannabis can provide new opportunities for agriculture growth.

- ***Price Volatility and increasing costs*** **-** Agribusiness industry needs to look at holistic solutions that help reduce the production cost for farmers, thereby reducing the cost of purchase for the end consumers. Food commodities witnessed volatility due to supply concerns driven by poor weather, shipping snarls and higher fertilizer costs. Rapid urbanization has led to an increase in labour costs and decline in yields, thus creating a need for rapid mechanization across the farmlands. With low availability of labour during farming season, agricultural machinery and agricultural machinery rental market are likely to witness growth. Increasing labour cost, increasing infestation and toxic impact of synthetic herbicides provide opportunities in the bio-pesticide market. Increased compliance costs and delays related to the stringent regulatory environment have led to less new Active Ingredient (AI) introductions.

Conclusion

The impact of technological innovations across the ecosystem can be attributed to a mix of digital enablers, changing business operating models and embedded sustainability agenda. Traditional equipment is paving ways to modern concepts like Farming-as-a-Service, which capitalizes on big data, robots, drones, IoT devices and e-commerce channels to support advance breeding and Individual/Co-operative farming. Technologies to assess carbon footprint for emissions, identify ways to reduce emissions, set emissions reduction goals, customize carbon inventory calculation tools, prepare reporting and improve rating scores (e.g., CDP) are critical to activate decarbonization initiatives, throughout their supply chain, in an impactful and sustainable manner that enhances corporate value and streamlines operations. They are critical to ensure sustainable and diverse sourcing across the food value chain. Traceability and visibility allow the stakeholders to trace the origin of materials and products, providing assurance of adherence to quality and compliance standards. It will in turn reduce the complexity and costs of international trade compliance, which further supports the circular economy.

Next generation themes in Agribusiness sector are dominated by Software/ Equipment-as-a-service incorporating AI capabilities, digital equipment, 5G enabled virtualization to implement outcome-based business models to materialize Sustainable crops, desert & sea water farming, insect farming, carbon farming and synthetic seeds. All in all, the sustainability tipping point for the economic development is being driven by consumers, brands, employees, investors, regulators and governments.

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