International Journal of Multidisciplinary Research and Growth Evaluation.

Artificial Intelligence in Agricultural Supply Chains: Lessons from the US for Nigeria

Babatunde Bamidele Oyeyemi
Federal Polytechnic Offa, Nigeria

* Corresponding Author: **Babatunde Bamidele Oyeyemi**

Article Info

ISSN (online): 2582-7138
Volume: 03
Issue: 01
January-February 2022
Received: 02-01-2022
Accepted: 04-02-2022
Page No: 1064-1074

Abstract
Artificial Intelligence (AI) is increasingly transforming global agricultural supply chains by enhancing productivity, reducing inefficiencies, and improving decision-making across all stages of the value chain. In the United States, the integration of AI technologies ranging from precision agriculture and automated logistics to predictive market analytics has led to significant improvements in agricultural performance, sustainability, and food distribution efficiency. These developments are supported by robust digital infrastructure, research and development investments, and strong public-private partnerships. Conversely, Nigeria's agricultural sector, which employs a large portion of the population and contributes significantly to GDP, faces numerous structural challenges. These include inadequate infrastructure, limited technological adoption, fragmented value chains, and data scarcity, all of which hinder the effective deployment of AI. This explores the application of AI in U.S. agricultural supply chains and extracts practical lessons that could guide Nigeria in modernizing its agri-food system. It identifies key success factors such as policy support, digital literacy programs, and scalable technologies that can be adapted to Nigeria's socio-economic and agricultural context. Moreover, the review emphasizes the importance of tailored AI solutions, mobile-based applications, and cloud computing as viable entry points for countries with limited infrastructure. Strategic recommendations are proposed, including fostering industry-academia collaboration, creating enabling environments for startups, and establishing data governance frameworks. By drawing on U.S. experiences, Nigeria will not only bridge its agricultural technology gap but also enhance food security, reduce post-harvest losses, and support smallholder farmers. The review concludes that while AI holds transformative potential for Nigeria's agricultural sector, its success hinges on a coordinated approach involving government, academia, the private sector, and international partners.

DOI: https://doi.org/10.54660/.IJMRGE.2022.3.1.1064-1074

Keywords: Artificial intelligence, Agricultural, Supply chains, U.S., Nigeria

Introduction

Global agricultural supply chains are increasingly under pressure due to a combination of rising population demands, climate change, market volatility, and logistical inefficiencies (Oruma, Misra & Fernandez-Sanz, 2021; Sutcliffe, Knox & Hess, 2021). In both developing and developed nations, these challenges affect the timely delivery, quality, and affordability of food products. Critical issues include unpredictable weather patterns disrupting harvests, inadequate infrastructure leading to post-harvest losses, lack of real-time data for informed decision-making, and fragmented distribution networks that hinder market access. These systemic inefficiencies not only threaten food security but also limit income potential for farmers and increase environmental burdens through resource wastage (Arakpogun, *et al*., 2021; Dong, 2021).

Artificial Intelligence (AI) is becoming a key tool for agricultural supply chains' modernization and optimization in response to

these issues (Ghadge, Wurtmann & Seuring, 2020). A wide range of innovations are included in AI applications in agriculture, including predictive analytics that aid in demand forecasting, spoilage reduction, and inventory management; AI-powered logistics systems that optimize the flow of goods from farm to market; and precision farming, which employs data-driven insights to increase crop yields (Jarrahi, 2018; Terziyan, Gryshko & Golovianko, 2018). AI has a revolutionary chance to boost productivity, save expenses, and enhance sustainability throughout the agricultural value chain by automating decision-making and facilitating real-time monitoring (Benjamin & Foye, V2022; Halecki & Bedla, 2022).

The United States provides a valuable standard in this regard. It has made great progress in incorporating AI across agricultural supply chains, underpinned by strong digital infrastructure, investment in research and development, and a broad network of public and commercial stakeholders. AI-powered crop disease detection tools, blockchain-integrated tracking systems, and driverless tractors and drones are just a few examples of how AI is being used in the United States (Omo-Ojugo, 2018; Sjah & Zainuri, 2020). Environmental management, supply chain resilience, and productivity have all significantly increased as a result of these innovations.

The agricultural sector in Nigeria, on the other hand, remains plagued by low technological penetration, supply chain inefficiencies, and traditional practices, despite being the backbone of the country's economy and employing the majority of its workforce. Nigeria also faces high post-harvest losses, limited access to market data, poor rural connectivity, and a lack of investment in agricultural innovation (Duan, Edwards & Dwivedi, 2019; Korteling, *et al*., 2021; Tien, 2017). The adoption rate of AI is low, and when it does exist, it is usually restricted to donor-funded initiatives or pilot projects with no long-term scalability (Borodin, *et al*., 2016; Nwankwo, Nwankwo & Wilfred, 2022).

Nigeria's agricultural transformation can benefit greatly from a comparison of the U.S. and Nigerian experiences (Effoduh, 2021; Khan, *et al*., 2022). The fundamental ideas of using AI to optimize supply chains are flexible, despite the fact that the contexts vary greatly in terms of infrastructure, economic scale, and institutional capability. Even in complex, large-scale systems, the U.S. model shows how focused investments, enabling regulations, and cross-sector collaboration may make AI integration easier (Adewusi, Chiekezie & Eyo-Udo, 2022 Baldwin & Freeman, 2022). These findings can help Nigeria create localized AI strategies that focus on opportunities like cellphone penetration and young populations while taking into consideration current limitations.

This review aims to explore how Nigeria can benefit from the lessons of the U.S. in deploying AI technologies to address supply chain challenges. By examining key enablers, barriers, and contextual adaptations. It highlight pathways through which Nigeria can modernize its agricultural sector and move towards greater food security, economic diversification, and sustainable development (Javaid, *et al*., 2022; Lu, 2019; Zhang & Lu, 2021).

Methodology

This study employed a systematic literature review methodology guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. The aim was to examine how artificial intelligence (AI) technologies have been utilized in the agricultural supply chains of the United States and how these lessons can inform AI integration in Nigeria's agricultural sector. A comprehensive search was conducted across multiple academic databases, including Scopus, Web of Science, IEEE Xplore, SpringerLink, ScienceDirect, and Google Scholar. The keywords used for the search included "Artificial Intelligence in agriculture," "AI in agricultural supply chains," "smart farming in the U.S.," "AI applications in Nigerian agriculture," and "digital agriculture in developing countries." Boolean operators such as "AND," "OR," and "NOT" were used to refine search queries and ensure relevance.

The inclusion criteria were peer-reviewed journal articles, conference proceedings, and credible reports published in English from 2010 to 2022. Publications were selected based on their relevance to AI applications in agriculture, specific examples from the U.S., and contextual analyses applicable to Nigeria. Exclusion criteria included articles not focused on agricultural supply chains, those without empirical or theoretical grounding, and studies limited to non-AI-based digital technologies.

The selection process involved four phases: identification, screening, eligibility, and inclusion. Initially, 312 records were identified. After removing duplicates and irrelevant titles, 210 articles were screened. Following abstract and full-text review, 85 studies met the eligibility criteria. Finally, 52 publications were selected for in-depth analysis, including comparative studies, implementation frameworks, case studies, and policy reviews.

Data extraction focused on identifying AI technologies employed, implementation strategies, outcomes, challenges, and enabling factors. The extracted data were synthesized thematically to highlight the mechanisms through which AI enhances agricultural supply chain transparency, efficiency, and productivity. Comparative insights were drawn between the U.S. and Nigerian contexts to inform practical recommendations for AI adoption in Nigeria.

The role of ai in agricultural supply chains

Global agriculture is undergoing a revolution thanks to artificial intelligence (AI), which is improving food supply systems' resilience, sustainability, and efficiency (Grote, *et al*., 2021; Songol, Awuor & Maake, 2021). Artificial Intelligence (AI), which includes machine learning, computer vision, natural language processing, and robotics, is defined as the simulation of human intelligence processes by machines. From cultivation and harvesting to processing, distribution, and transportation, artificial intelligence (AI) in agriculture enables data-driven decision-making at every level of the supply chain (Cook & O'Neill, 2020: Lund, DC & Manyika, 2020). The integration of AI into agriculture promises not only to boost productivity and efficiency but also to address systemic issues like food insecurity, supply chain fragmentation, and environmental degradation as shown in figure 1.

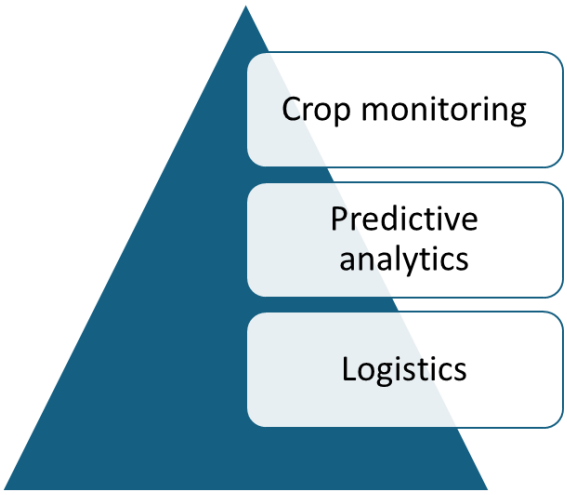

Fig 1: The Role of AI in Agricultural Supply Chains

Important uses of AI in agriculture are found in many different fields. Precision farming, which uses data from sensors, drones, and satellite imaging to track crop health, soil conditions, and weather patterns, uses AI technology during the production phase (Gwagwa, *et al*., 2021). Real-time crop monitoring, early disease identification, and tailored input application including water, fertilizer, and pesticides are made possible by these tools.

In the field of predictive analytics, artificial intelligence (AI) algorithms forecast crop yields, market demand, and supply chain disruptions using both historical and real-time data. With the use of these insights, farmers, dealers, and legislators may decide on planting dates, inventory control, and pricing schemes with knowledge (Dong, *et al*., 2020; Tien, *et al*., 2019). Artificial Intelligence (AI) lowers uncertainty and aids in resource allocation optimization by predicting weather-related hazards or supply constraints. By maximizing transportation routes, lowering post-harvest losses, and enhancing supply chain traceability, AI-driven platforms are also essential to logistics and distribution (Ly, 2021; Tzachor, *et al*., 2022).

Additionally, by automating warehousing, boosting cold chain monitoring, and enhancing inventory forecasting, AI in logistics simplifies agricultural supply chains. These features are crucial for reducing food loss and guaranteeing fresh produce is delivered on time, especially in remote and difficult-to-reach locations. By following agricultural products from farm to fork, AI applications in blockchain-based traceability systems further guarantee their safety and integrity, boosting consumer confidence and adherence to food safety laws (Umar, *et al*., 2022).

The usefulness of AI in tackling inefficiencies in agricultural supply chains cannot be emphasized. Many developing countries, like Nigeria, deal with fragmented markets, poor infrastructure, and lack of accurate data, which contribute to high post-harvest losses and low profitability for farmers. By incorporating AI technology, these issues can be reduced through greater coordination, predictive maintenance of farm machinery, and enhanced access to market information (Ajayi & Laseinde, 2022). Through scenario modeling and customized recommendations, AI helps farmers adjust to climatic variability, which further advances climate-smart agriculture.

AI also has the potential to make a big difference on food security. By 2050, there will likely be 9.7 billion people on the planet, meaning that agricultural systems would need to produce more food with fewer resources. AI can increase total food supply and accessibility by optimizing input use, improving yield prediction accuracy, and promoting sustainable farming methods. AI is a revolutionary tool for creating more equitable and efficient agricultural value chains in areas like sub-Saharan Africa, where poverty and malnutrition are common (Jellason, Robinson & Ogbaga, 2021).

AI is revolutionizing agricultural supply chains by providing creative answers to persistent issues with waste, inefficiency, and food insecurity. AI improves agricultural productivity, sustainability, and resilience through applications in logistics, predictive analytics, and crop monitoring. Lessons learned from the adoption of AI in developed economies like the US can offer a roadmap for utilizing technology to enhance food systems and accomplish long-term development objectives as nations like Nigeria seek to modernize their agricultural sectors (Krishnan, Banga & Mendez-Parra, 2020; Songol *et al*., 2021).

Challenges in Nigerian agricultural supply chains

Approximately 25% of Nigeria's GDP comes from the agricultural sector, which employs more than 70% of the country's rural labor (Rufai *et al*., 2021; Shaikh, Rasool & Lone, 2022)). Despite its importance, the industry continues to perform poorly because of a number of issues that affect the whole agricultural supply chain. (Mwangi, 2019; Zohuri & Moghaddam, 2020) These issues exacerbate food insecurity and economic vulnerability by limiting market access, increasing post-harvest losses, and impeding production as shown in figure 2. Implementing cutting-edge technologies like artificial intelligence (AI), which depend on a strong foundation of infrastructure, data systems, and institutional support to be successful, requires an understanding of these challenges.

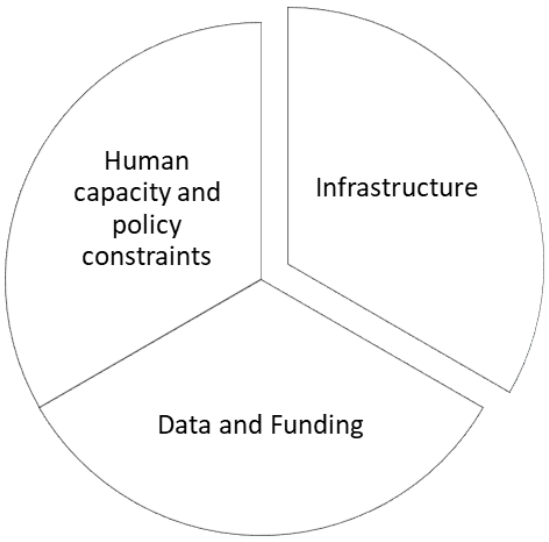

Fig 2: Challenges in Nigerian Agricultural Supply Chains

The fragmented and informal character of Nigerian agricultural supply networks is one of the main problems. Lack of coordination and uniformity throughout the supply chain, from manufacturers and input suppliers to processors and distributors, leads to inefficiencies and irregularities in the availability and quality of the final product (Groot *et al*.,

2021; Mhlanga, 2021). Farmers frequently work alone and have little access to finance facilities, agricultural extension services, or market knowledge. They consequently depend on manual labor and conventional farming methods, which reduces production and makes them more vulnerable to shocks brought on by climate change (Qrunfleh & Tarafdar, 2014; Wang, *et al*., 2016).

These difficulties are made even more difficult by structural and technological constraints. The transportation and preservation of agricultural products are hampered by deficiencies in infrastructure, such as inadequate storage facilities, bad road networks, and unstable electricity. The lack of silos, cold chains, and contemporary transportation methods is the main cause of Nigeria's estimated 30–50% post-harvest losses (Richey, *et al*., 2022; Simchi-Levi, Wang & Wei, 2018). Regarding the adoption of technology, many farmers do not have access to digital tools, sensors, or mobile platforms that could offer market pricing, weather forecasts, and real-time agricultural data (Ancín, Pindado & Sánchez, 2022). Furthermore, there is little data gathering and integration throughout the supply chain, which makes it challenging to follow production patterns, keep an eye on quality, or make data-driven choices.

Another major factor impeding supply chain efficiency is funding limitations. Financial institutions frequently view the agriculture industry as high-risk, which limits their ability to provide loans and investment opportunities. Due to their lack of collateral and financial knowledge, smallholder farmers—who make up the majority of the sector—are especially disadvantaged (Vyas, *et al*., 2022). The purchasing of contemporary farming products, machinery, and technology required to increase output and supply chain efficiency is hampered by this financial gap.

Another major obstacle to Nigeria's agricultural development is human capacity limitations. Professionals with expertise in fields like agronomy, supply chain management, logistics, and agri-tech are in short supply. Furthermore, many stakeholders—from farmers to extension agents—are ill-prepared to adopt or handle cutting-edge technologies like artificial intelligence (AI) due to a lack of training and capacity-building programs (Danese, Romano & Formentini, 2013). In addition to limiting output, this skills gap makes it more difficult to successfully incorporate creative alternatives into current agricultural systems.

Weaknesses in regulations and policies also present significant difficulties. Nigeria has implemented a number of agricultural policies and programs, including the Anchor Borrowers' Program and the Agricultural Transformation Agenda, although their execution has frequently been haphazard or ill-coordinated. Supportive regulatory frameworks that safeguard farmer interests, stimulate technical innovation, and encourage private sector participation are lacking (Negi, 2021). The efficacy of public initiatives is diminished and stakeholder trust is further undermined by bureaucratic inefficiency and corruption.

A wide range of intricate issues impede the resilience, sustainability, and efficiency of Nigeria's agricultural supply networks. Progress is nonetheless hampered by structural problems including inadequate infrastructure and underdeveloped technology, as well as by funding constraints and shoddy policy execution. A diversified strategy is needed to overcome these obstacles, one that includes large infrastructure investments, digital transformation, human capital development, and institutional reforms. Nigeria can only fully realize the potential of its agriculture sector and establish a favorable climate for incorporating revolutionary technologies like AI by addressing these fundamental concerns (Qi, *et al*., 2017).

Lessons from the U.S. for Nigeria

When it comes to using technology to increase agricultural output, especially in the area of artificial intelligence (AI), the US has long been a global leader (Ijeomah, 2020). Nigeria may learn a number of important lessons from the U.S. experience as it attempts to modernize its agricultural supply chains. Nigeria can improve its agricultural sector and solve its problems with food security, inefficiencies, and market access by implementing key elements like data collection systems, government policies, private sector engagement in promoting AI adoption, and foundational digital infrastructure.

Establishing a strong digital infrastructure and data gathering systems is one of the most important things Nigeria can learn from the American agriculture model. From satellite-based monitoring systems to farm management software, digital tools and platforms are integrated across the agricultural supply chain in the United States. Farmers may make well-informed, data-driven decisions thanks to these technologies, which gather and evaluate real-time data on weather patterns, soil conditions, crop health, and market prices (Khalifa, Abd Elghany & Abd Elghany, 2021). On the other hand, the adoption of technology and data collecting remain major obstacles in Nigeria's agriculture sector. Investing in digital infrastructure that facilitates data gathering, storage, and analysis would be a crucial first step in revolutionizing Nigerian agriculture. In the end, this would increase productivity and decrease waste by allowing farmers to better estimate harvests, track their produce, and maximize resources. Furthermore, farmers' access to information and markets would be improved by enabling technology like Geographic Information Systems (GIS), Internet of Things (IoT) gadgets, and mobile applications.

The role of the government in fostering AI adoption inside agricultural supply chains cannot be emphasized. In the U.S., federal and state governments have created regulations to encourage the adoption of AI and other innovative technology in agriculture. The expense of sophisticated equipment and data-driven agricultural techniques has been partially covered by programs like the U.S. Department of Agriculture's (USDA) effort to promote precision agriculture through grants and subsidies (Ochinanwata, 2019). In a similar vein, the government has funded AI-related training initiatives to develop a workforce with the necessary skills to support agricultural technology improvements. Nigeria can learn from these instances by creating laws that encourage the use of AI in farming. These might include tax breaks for companies investing in agricultural technologies, grants for research and development, and subsidies for farmers implementing AI-powered technologies. Furthermore, the Nigerian government can collaborate with academic institutions and global organizations to develop customized training programs that give farmers and agribusinesses the know-how to successfully embrace and use AI solutions.

Additionally, aggressive promotion of private sector participation should be combined with governmental sector backing for AI adoption. The private sector is a major force behind agricultural technology innovation in the United States. From logistics optimization software to precision

agricultural tools, big agribusinesses, tech firms, and startups work with farmers to offer AI-powered solutions (Otokiti, *et al*., 2022). Technological developments in the agricultural industry have been greatly expedited by private enterprises' involvement in the development and implementation of AI solutions. The government should think about providing tax breaks or other financial incentives to companies that are developing AI-based solutions for the agricultural sector (Krishnan, Banga & Mendez-Parra, 2020; Raja Santhi & Muthuswamy, 2022). Nigeria can gain from promoting private sector investment and collaboration in its agricultural supply chains through public-private partnerships (PPPs) that encourage innovation, create incentives for private companies to invest in agri-tech, and ensure that technology reaches smallholder farmers who are often excluded from technological advancements (Ezenwa, 2019; Otokiti, *et al*., 2022).

Nigeria could gain by encouraging cooperation between domestic and foreign parties in the agricultural technology sector in addition to public-private partnerships. Collaborations with global organizations, academic institutions, and non-governmental groups that focus on AI and agriculture may offer much-needed financial support and technological know-how. These collaborations may play a key role in removing the infrastructure and technical obstacles preventing AI from being widely used in Nigeria's agriculture industry. Successful pilot programs and innovations that tackle important issues like waste reduction, enhanced yield prediction, and supply chain inefficiencies could also be scaled with the support of collaborative initiatives (Belot, 2020; Füller *et al*., 2021).

Furthermore, for AI to be successfully implemented in Nigeria's agricultural supply chains, education and training are essential. With specific courses and certificates that teach students about the relationship between AI and agriculture, the United States has made great progress in incorporating AI into agricultural education. Nigeria might adopt a similar strategy by creating educational initiatives that are specifically suited to the demands of the agriculture industry (Akang, *et al*., 2019; Oyewola, *et al*., 2022). Predictive analytics for logistics, machine learning for demand forecasting, and hands-on training programs for farmers on AI applications in crop management are a few examples. Nigeria may learn a lot from the United States as it looks to use artificial intelligence to improve its agricultural supply networks (Das Nair & Landani, 2020; Lin, Lin & Wang, 2022). Nigeria can overcome its agricultural challenges through the implementation of foundational digital infrastructure, the promotion of government policies that facilitate the adoption of AI, the encouragement of private sector involvement, and the development of partnerships with international stakeholders (West, Kraut & Ei Chew, 2019). When correctly implemented, these programs would improve food security, create jobs, and promote sustainable economic growth over time, in addition to increasing productivity and transparency in Nigeria's agricultural sector.

Strategic opportunities for Nigeria

With more than 60% of the workforce employed and a sizeable GDP contribution, Nigeria's agriculture sector is vital to the nation's economy. Nonetheless, the industry has a number of difficulties, such as poor productivity, ineffective supply chain management, and restricted access to contemporary technologies. Artificial Intelligence (AI) has become a viable remedy for many problems in recent years. Nigeria has to take advantage of several strategic opportunities in order to fully utilize AI's promise in agriculture as shown in figure 3. These include developing capacity through training programs for farmers and agribusinesses, utilizing mobile and cloud-based AI solutions for scalability, and testing region-specific AI solutions in rural and peri-urban locations (Alam, *et al*., 2022; Kumar, *et al*., 2022; Misra, *et al*., 2020).

Using mobile and cloud-based AI solutions is one of Nigeria's most important strategic opportunities. Given how common mobile phones are in Nigeria, mobile platforms have a special chance to widely distribute AI technologies. Without the need for costly on-premise equipment, cloud computing and artificial intelligence (AI) can give farmers access to strong tools for data analysis, crop management, and market insights (Mustapha *et al*., 2021; Ramdoo, *et al*., 2021). These cloud-based and mobile technologies can improve supply chain efficiency by giving real-time data on market prices, pest outbreaks, soil health, and weather patterns. Smallholder farmers who might lack the funds to purchase pricey gear or on-site computer resources will particularly benefit from cloud-based systems. Cloud infrastructure may be used to make AI solutions more scalable and inexpensive, giving farmers in Nigeria's most distant regions access to state-of-the-art farming equipment. Moreover, cloud-based solutions can provide increased data exchange and cooperation between farmers, distributors, and governmental organizations, which can enhance resource allocation and decision-making throughout the agricultural supply chain (Babatunde, 2019; Nahr, Nozari & Sadeghi, 2021; Olukunle, 2013).

Building capacity represents yet another important strategic opportunity. Only until farmers and agribusinesses possess the requisite digital literacy skills will AI be able to be widely adopted in agriculture. Many Nigerian farmers, especially smallholders in rural areas, lack the fundamental skills necessary to apply technology to enhance their farming methods. To close this knowledge gap, capacity-building initiatives that teach farmers digital literacy, AI technologies, and data analytics are essential (Coalition, *et al*., 2019). These courses can teach farmers how to apply AI tools for resource management, crop monitoring, and predictive analytics. Nigeria can establish a workforce that can use digital technology to increase agricultural productivity and sustainability by incorporating AI training into rural development initiatives and agricultural extension services. Training on how to incorporate AI technologies into current operations will also help agribusinesses and farmers, which will increase the adoption of technology throughout the supply chain (Chaudhuri, *et al*., 2018; Stathers & Mvumi, 2020).

Fig 3: Strategic Opportunities for Nigeria

Another significant strategic opportunity is to pilot region-specific AI solutions in rural and peri-urban areas in addition to increasing capacity. Nigeria's numerous areas have very distinct agricultural needs, and a one-size-fits-all strategy might not be sufficient to meet the issues that various people face. The distinct circumstances of every location, including different soil types, crop preferences, and climate variables, can be accommodated by region-specific AI systems. On the other hand, AI applications in crop rotation, disease control, and soil fertility may be advantageous in the southern regions, which are more humid and supportive of crop diversification (Toledano, *et al*., 2021). Nigeria can customize its interventions to meet the needs of regional farmers by testing AI solutions in certain areas, guaranteeing that the solutions are applicable, efficient, and scalable. These pilot projects can also be educational opportunities, offering insightful information about the difficulties of implementing AI in various agricultural contexts. Adoption across the country can be facilitated by scaling up successful experiments to new areas (Jagtap, *et al*., 2020; Sibanda & Workneh, 2020).

Furthermore, by offering the required financing, incentives, and policies, the Nigerian government may significantly contribute to the support of these strategic prospects. Innovation in the agricultural technology industry can be boosted by policies that incentivize private sector investment in AI solutions, such as tax cuts or subsidies for AI-related technologies (Ahiaba, 2019; Hodges, Buzby & Bennett, 2011). Additionally, when private businesses contribute their resources and experience to government programs aimed at revolutionizing agriculture, public-private partnerships can play a significant role in scaling AI solutions throughout the nation. Furthermore, regional AI solutions and research on the particular difficulties Nigeria's agriculture sector faces can be developed by collaborating with local universities and research organizations (Heinonen, Ruotsalainen & Karjalainen, 2017)).

Furthermore, advancements in digital infrastructure would be necessary for the incorporation of AI into Nigeria's agricultural supply networks. Nigeria, a nation with a rapidly increasing internet penetration rate, can improve connectivity in rural areas by taking use of mobile networks' rising reach. To guarantee that AI solutions can reach even the most remote places, internet connectivity should be strengthened and access to digital tools increased (Amadio, *et al*., 2015).

Nigeria's agriculture industry is at a turning point in its history, and artificial intelligence (AI) holds great promise for resolving issues of inefficiency, low productivity, and food shortages. Nigeria can greatly improve its agricultural supply chains by piloting region-specific AI applications, concentrating on capacity building for farmers and agribusinesses, and utilizing mobile and cloud-based AI solutions for scalability (Islam, 2022). To take advantage of these prospects, government assistance, the growth of digital infrastructure, and private sector participation will be essential. AI may assist Nigeria's agricultural sector reach its full potential with a coordinated and cooperative effort, guaranteeing a sustainable and profitable future for the country's farmers and agricultural industry (Akande & Diei-Ouadi, 2010; Morris, Kamarulzaman & Morris, 2019).

Policy Recommendations

Artificial Intelligence (AI) has enormous potential to improve food security, increase productivity, and eliminate inefficiencies in Nigeria's agricultural supply chains (Olanipekun, Ilori & Ibitoye, 2020). Policymakers must, however, adopt a thorough and strategic approach that includes creating AI-friendly agricultural regulations,

encouraging global collaboration for the transfer of knowledge and technology, and aiding agritech startups and research institutes in order to fully realize the advantages of AI in agriculture. In order to promote sustainable growth and better agricultural results, these policy recommendations seek to provide an environment that is conducive to the adoption and growth of AI technology in Nigeria's agricultural industry (Affognon, *et al*., 2015; Balana, Aghadi & Ogunniyi, 2022).

Developing AI-friendly agricultural policies that may offer a precise regulatory framework for the incorporation of AI technology into farming practices is one of the first stages in encouraging the deployment of AI in agriculture. Promoting innovation while safeguarding farmers' rights, data privacy, and security should be the main goals of these regulations. To promote the creation and use of AI-powered agricultural solutions, governments ought to put in place incentives like tax breaks, grants, and subsidies (Kolade, *et al*., 2021). Farmers who might otherwise find it prohibitively expensive to acquire AI-enabled products and technology can benefit from financial incentives. Additionally, rules must handle the legal and regulatory difficulties of data ownership, data sharing, and privacy, particularly when it comes to the collecting of data from farmers, suppliers, and other stakeholders in the supply chain. By developing an enabling regulatory environment, the government can incentivize the private sector to invest in AI research, development, and deployment in the agriculture sector (Ajibola & Olanipekun, 2019, Olanipekun & Ayotola, 2019). Building trust amongst stakeholders in the agricultural value chain, encouraging digital literacy initiatives, and creating frameworks for cooperation between the public and commercial sectors are all critical tasks for the government.

Another important policy measure that can speed up the deployment of AI in Nigerian agriculture is to promote international cooperation (Ilori & Olanipekun, 2020). Working together with top international agritech and AI innovation companies can hasten the dissemination of best practices, technology, and expertise to Nigeria's agricultural industry. Nigerian stakeholders can gain access to the newest AI technologies and resources that have been effectively implemented in other regions of the world through partnerships with commercial tech businesses, research institutes, and international organizations.

The Nigerian government should actively participate in global networks and conferences devoted to agricultural innovation and technology in order to promote this collaboration. These platforms offer beneficial chances to discover new trends, build technology transfer collaborations, and gain knowledge from successful case studies. Nigeria may also aid in the creation of international frameworks and standards that direct the moral and responsible application of AI technology in agriculture by advocating for a global perspective on AI and agriculture (Olanipekun, 2020). This partnership may result in the creation of AI-focused research centers or incubators where local stakeholders and international specialists may work together to address the particular difficulties Nigerian farmers experience.

Building local capacity for the adoption and development of AI-driven solutions requires fostering the expansion of agritech businesses and research institutes specializing in AI in agriculture. Nigeria may create an environment that promotes experimentation, technological development, and growth by giving startups—which are frequently in the front of innovation—finance, mentorship, and resource access. Agritech companies that concentrate on creating AI-powered solutions specifically suited to the requirements of Nigerian farmers might benefit from financial assistance in the form of venture capital, government grants, and innovation contests.

Furthermore, by studying crop optimization, precision farming, and AI-driven logistics, research institutes and universities contribute significantly to the advancement of AI in agriculture (Ogunyankinnu, *et al*., 2022, Kolade, *et al*., 2022). The government may make sure that research initiatives are in line with the practical requirements of Nigeria's agriculture industry by collaborating with academic institutions. Additionally, universities can be crucial in training the next generation of AI specialists who will help advance AI in agriculture.

Additionally, encouraging collaborations between big agribusinesses, universities, and startups can help commercialize AI research. These collaborations have the potential to produce AI solutions that are affordable, scalable, and appropriate for the various demands of Nigerian farmers (Francis Onotole, *et al*., 2022). Apart from financial assistance and infrastructure support, entrepreneurship and innovation-focused training programs can give local agritech businesses the tools they need to launch their products.

The creation of AI-friendly agricultural regulations, the promotion of global collaboration for the transfer of knowledge and technology, and the assistance of agritech startups and research institutes are all necessary for the effective integration of AI into Nigeria's agricultural supply chains. Nigeria can create the foundation for the broad use of AI in agriculture by establishing transparent regulatory frameworks, rewarding innovation, and fostering a cooperative atmosphere for research and technology exchange. Nigeria may harness AI's potential to revolutionize its agriculture industry and improve food security, sustainability, and productivity by implementing strategic policy initiatives (Olanipekun, Ilori & Ibitoye, 2020). Nigeria may take the lead in the AI-powered agricultural revolution if it makes the appropriate investments in research, infrastructure, and capacity building.

Conclusion

Long-standing issues including inefficiencies, low productivity, and food insecurity could be significantly addressed by integrating artificial intelligence (AI) into Nigeria's agricultural sector. Important takeaways from this conversation include how AI is revolutionizing fields including logistical optimization, predictive analytics, and agricultural monitoring. Nigeria can improve decision-making, supply chain management, and food security by implementing AI-driven solutions. The potential advantages are obvious: AI provides ways to minimize waste, maximize resource utilization, and anticipate and address problems before they become more serious.

But for AI to be successfully implemented, more than just technical developments are needed; cooperative, context-sensitive approaches that are adapted to the unique requirements of Nigeria's agriculture industry are also necessary. To build an environment that supports AI innovation and makes sure that solutions are available, reasonably priced, and efficient in tackling the various issues that Nigeria's agricultural community faces, policymakers, business sector stakeholders, and local farmers must

collaborate. This will entail creating AI-friendly regulations, forming knowledge-sharing alliances, and making a determined effort to increase local capability via training and education.

Looking ahead, Nigeria's agricultural innovation has a bright future thanks to the use of AI. Enhancing data gathering systems, increasing the scalability of AI technologies, and making AI solutions easier for smallholder farmers to utilize are probably the main goals of the next wave of AI developments. Nigeria may take the lead in utilizing AI technologies for sustainable agriculture, fostering innovation, raising living standards, and enhancing national food security as the field develops. Nigeria may change its agricultural environment into a model of creativity, efficiency, and sustainability by coordinating AI advancements with the requirements and capabilities of regional farmers.

References

1. Adewusi AO, Chiekezie NR, Eyo-Udo NL. Cybersecurity threats in agriculture supply chains: A comprehensive review. World Journal of Advanced Research and Reviews. 2022;15(3):490-500.
2. Affognon H, Mutungi C, Sanginga P, Borgemeister C. Unpacking postharvest losses in sub-Saharan Africa: a meta-analysis. World Development. 2015;66:49-68.
3. Ahiaba UV. The Role of Grain Storage Systems in Food Safety, Food Security and Rural Development in Northcentral Nigeria [dissertation]. Cheltenham: University of Gloucestershire; 2019.
4. Ajayi MO, Laseinde OT. Promoting viable supply chain management (SCM) in the Nigeria agro-allied industry using internet of things. In: Proceedings of Seventh International Congress on Information and Communication Technology: ICICT 2022, London, Volume 1. Singapore: Springer Nature Singapore; 2022. p. 389-399.
5. Ajibola KA, Olanipekun BA. Effect of access to finance on entrepreneurial growth and development in Nigeria among "YOU WIN" beneficiaries in SouthWest, Nigeria. Ife Journal of Entrepreneurship and Business Management. 2019;3(1):134-149.
6. Akande B, Diei-Ouadi Y. Post-harvest losses in small-scale fisheries. Rome: Food and Agriculture Organization of the United Nations; 2010.
7. Akang VI, Afolayan MO, Iorpenda MJ, Akang JV. Industrialization of the Nigerian Economy: The Imperatives Of Imbibing Artificial Intelligence And Robotics For National Growth And Development. In: Proceedings Of: 2nd International Conference of the IEEE Nigeria; 2019. p. 265.
8. Alam MA, Ahad A, Zafar S, Tripathi G. A neoteric smart and sustainable farming environment incorporating blockchain-based artificial intelligence approach. In: Cryptocurrencies and Blockchain Technology Applications. Hoboken: Wiley; 2020. p. 197-213.
9. Amadio JP, Beasley K, Rothstein BD, Selman WR, Riley J, Emery J. Intervening in the Brain: Ethics and Neurosurgery. Virtual Mentor. 2015;17:1.
10. Ancín M, Pindado E, Sánchez M. New trends in the global digital transformation process of the agri-food sector: An exploratory study based on Twitter. Agricultural Systems. 2022;203:103520.
11. Arakpogun EO, Elsahn Z, Olan F, Elsahn F. Artificial intelligence in Africa: Challenges and opportunities. In: The fourth industrial revolution: Implementation of artificial intelligence for growing business success. Cham: Springer; 2021. p. 375-388.
12. Babatunde AI. Impact of supply chain in reducing fruit post-harvest waste in agric value chain in Nigeria. Electronic Research Journal of Social Sciences and Humanities. 2019;1:150-163.
13. Balana BB, Aghadi CN, Ogunniyi AI. Improving livelihoods through postharvest loss management: evidence from Nigeria. Food Security. 2022;14(1):249-265.
14. Baldwin R, Freeman R. Risks and global supply chains: What we know and what we need to know. Annual Review of Economics. 2022;14(1):153-180.
15. Belot ST. The state and impact of the Fourth Industrial Revolution on economic development [dissertation]. Cape Town: Cape Peninsula University of Technology; 2020.
16. Benjamin OO, Foye VO. Inclusion, organizational resilience, and sustainable development in Nigeria: the role of digital innovations. Environmental Sciences Proceedings. 2022;15(1):27.
17. Borodin V, Bourtembourg J, Hnaien F, Labadie N. Handling uncertainty in agricultural supply chain management: A state of the art. European Journal of Operational Research. 2016;254(2):348-359.
18. Chaudhuri A, Dukovska-Popovska I, Subramanian N, Chan HK, Bai R. Decision-making in cold chain logistics using data analytics: a literature review. The International Journal of Logistics Management. 2018;29(3):839-861.
19. Coalition ES, West M, Kraut R, Ei CH. I'd blush if I could: closing gender divides in digital skills through education. Paris: UNESCO; 2019.
20. Cook P, O'Neill F. Artificial intelligence in agribusiness is growing in emerging markets. International Finance Corporation Note. 2020;82.
21. Danese P, Romano P, Formentini M. The impact of supply chain integration on responsiveness: The moderating effect of using an international supplier network. Transportation Research Part E: Logistics and Transportation Review. 2013;49(1):125-140.
22. Das Nair R, Landani N. Making agricultural value chains more inclusive through technology and innovation (No. 2020/38). WIDER Working Paper; 2020.
23. Dong L. Toward resilient agriculture value chains: challenges and opportunities. Production and Operations Management. 2021;30(3):666-675.
24. Dong Y, Hou J, Zhang N, Zhang M. Research on how human intelligence, consciousness, and cognitive computing affect the development of artificial intelligence. Complexity. 2020;1:1680845.
25. Duan Y, Edwards JS, Dwivedi YK. Artificial intelligence for decision making in the era of Big Data–evolution, challenges and research agenda. International Journal of Information Management. 2019;48:63-71.
26. Effoduh OJ. Stakeholder Mapping of AI Actors in Nigeria. Montreal: AI4D-Africa Network; 2021.
27. Ezenwa AE. Smart logistics diffusion strategies amongst supply chain networks in emerging markets: a case of Nigeria's micro/SMEs 3PLs [dissertation]. Leeds: University of Leeds; 2019.
28. Onotole EF, Ogunyankinnu T, Adeoye Y, Osunkanmibi AA, Aipoh G, Egbemhenghe J. The Role of Generative

AI in developing new Supply Chain Strategies-Future Trends and Innovations. Journal of Supply Chain Management. 2022;58(4):3-17.
29. Ghadge A, Wurtmann H, Seuring S. Managing climate change risks in global supply chains: a review and research agenda. International Journal of Production Research. 2020;58(1):44-64.
30. Grote U, Fasse A, Nguyen TT, Erenstein O. Food security and the dynamics of wheat and maize value chains in Africa and Asia. Frontiers in Sustainable Food Systems. 2021;4:617009.
31. Gwagwa A, Kazim E, Kachidza P, Hilliard A, Siminyu K, Smith M, Shawe-Taylor J. Road map for research on responsible artificial intelligence for development (AI4D) in African countries: The case study of agriculture. Patterns. 2021;2(12):100381.
32. Halecki W, Bedla D. Global wheat production and threats to supply chains in a volatile climate change and energy crisis. Resources. 2022;11(12):118.
33. Heinonen S, Ruotsalainen J, Karjalainen J. Energy Futures 2050. Turku: Finland Futures Research Centre; 2017.
34. Hodges RJ, Buzby JC, Bennett B. Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. The Journal of Agricultural Science. 2011;149(S1):37-45.
35. Ijeomah S. Challenges of supply chain management in the oil & gas production in Nigeria (Shell Petroleum Development Company of Nigeria) [dissertation]. Dublin: National College of Ireland; 2020.
36. Ilori MO, Olanipekun SA. Effects of government policies and extent of its implementations on the foundry industry in Nigeria. IOSR Journal of Business Management. 2020;12(11):52-59.
37. Islam MZ. Digital Transformation Management. Dhaka: BRAC University; 2022.
38. Jagtap S, Bader F, Garcia-Garcia G, Trollman H, Fadiji T, Salonitis K. Food logistics 4.0: Opportunities and challenges. Logistics. 2020;5(1):2.
39. Jarrahi MH. Artificial intelligence and the future of work: Human-AI symbiosis in organizational decision making. Business Horizons. 2018;61(4):577-586.
40. Javaid M, Haleem A, Singh RP, Suman R. Artificial intelligence applications for industry 4.0: A literature-based study. Journal of Industrial Integration and Management. 2022;7(01):83-111.
41. Jellason NP, Robinson EJ, Ogbaga CC. Agriculture 4.0: Is sub-saharan africa ready?. Applied Sciences. 2021;11(12):5750.
42. Joudyian N, Doshmangir L, Mahdavi M, Tabrizi JS, Gordeev VS. Public-private partnerships in primary health care: a scoping review. BMC Health Services Research. 2021;21:1-18.
43. Khalifa N, Abd Elghany M, Abd Elghany M. Exploratory research on digitalization transformation practices within supply chain management context in developing countries specifically Egypt in the MENA region. Cogent Business & Management. 2021;8(1):1965459.
44. Khan SAR, Razzaq A, Yu Z, Shah A, Sharif A, Janjua L. Disruption in food supply chain and undernourishment challenges: An empirical study in the context of Asian countries. Socio-Economic Planning Sciences. 2022;82:101033.
45. Kolade O, Osabuohien E, Aremu A, Olanipekun KA, Osabohien R, Tunji-Olayeni P. Co-creation of entrepreneurship education: challenges and opportunities for university, industry and public sector collaboration in Nigeria. In: The Palgrave Handbook of African Entrepreneurship. Cham: Palgrave Macmillan; 2021. p. 239-265.
46. Kolade O, Rae D, Obembe D, Woldesenbet K, editors. The Palgrave handbook of African entrepreneurship. Cham: Palgrave Macmillan; 2022.
47. Korteling JH, van de Boer-Visschedijk GC, Blankendaal RA, Boonekamp RC, Eikelboom AR. Human-versus artificial intelligence. Frontiers in Artificial Intelligence. 2021;4:622364.
48. Krishnan A, Banga K, Mendez-Parra M. Disruptive technologies in agricultural value chains. Insights from East Africa. Working Paper, 576. London: ODI; 2020.
49. Kumar D, Singh RK, Mishra R, Wamba SF. Applications of the internet of things for optimizing warehousing and logistics operations: A systematic literature review and future research directions. Computers & Industrial Engineering. 2022;171:108455.
50. Leng K, Li S. Distribution path optimization for intelligent logistics vehicles of urban rail transportation using VRP optimization model. IEEE Transactions on Intelligent Transportation Systems. 2021;23(2):1661-1669.
51. Lin H, Lin J, Wang F. An innovative machine learning model for supply chain management. Journal of Innovation & Knowledge. 2022;7(4):100276.
52. Linaza MT, Posada J, Bund J, Eisert P, Quartulli M, Döllner J, Pagani A, G. Olaizola I, Barriguinha A, Moysiadis T, Lucat L. Data-driven artificial intelligence applications for sustainable precision agriculture. Agronomy. 2021;11(6):1227.
53. Lu Y. Artificial intelligence: a survey on evolution, models, applications and future trends. Journal of Management Analytics. 2019;6(1):1-29.
54. Lund S, DC W, Manyika J. Risk, resilience, and rebalancing in global value chains. McKinsey Global Institute; 2020.
55. Ly R. Machine learning challenges and opportunities in the african agricultural sector--A general perspective. arXiv preprint arXiv:2107.05101. 2021.
56. Majumdar P, Mitra S, Bhattacharya D. IoT for promoting agriculture 4.0: a review from the perspective of weather monitoring, yield prediction, security of WSN protocols, and hardware cost analysis. Journal of Biosystems Engineering. 2021;46(4):440-461.
57. Mhlanga D. Artificial intelligence in the industry 4.0, and its impact on poverty, innovation, infrastructure development, and the sustainable development goals: Lessons from emerging economies?. Sustainability. 2021;13(11):5788.
58. Misra NN, Dixit Y, Al-Mallahi A, Bhullar MS, Upadhyay R, Martynenko A. IoT, big data, and artificial intelligence in agriculture and food industry. IEEE Internet of Things Journal. 2020;9(9):6305-6324.
59. Morris KJ, Kamarulzaman NH, Morris KI. Small-scale postharvest practices among plantain farmers and traders: A potential for reducing losses in rivers state, Nigeria. Scientific African. 2019;4:e00086.
60. Mwangi NW. Influence of supply chain optimization on the performance of manufacturing firms in Kenya

[dissertation]. Nairobi: Jomo Kenyatta University of Agriculture and Technology; 2019.
61. Nahr JG, Nozari H, Sadeghi ME. Green supply chain based on artificial intelligence of things (AIoT). International Journal of Innovation in Management, Economics and Social Sciences. 2021;1(2):56-63.
62. Negi S. Supply chain efficiency framework to improve business performance in a competitive era. Management Research Review. 2021;44(3):477-508.
63. Nwankwo W, Nwankwo CP, Wilfred A. Leveraging on Artificial Intelligence to Accelerate Sustainable Bioeconomy. IUP Journal of Knowledge Management. 2022;20(2):45-57.
64. Ochinanwata NH. Integrated business modelling for developing digital internationalising firms in Nigeria [dissertation]. Sheffield: Sheffield Hallam University; 2019.
65. Ogunyankinnu T, Onotole EF, Osunkanmibi AA, Adeoye Y, Aipoh G, Egbemhenghe J. Blockchain and AI synergies for effective supply chain management. International Journal of Production Research. 2022;60(8):2509-2528.
66. Olanipekun KA. Assessment of Factors Influencing the Development and Sustainability of Small Scale Foundry Enterprises in Nigeria: A Case Study of Lagos State. Asian Journal of Social Sciences and Management Studies. 2020;7(4):288-294.
67. Olanipekun KA, Ayotola A. Introduction to marketing. GES 301, Centre for General Studies (CGS). Ibadan: University of Ibadan; 2019.
68. Olanipekun KA, Ilori MO, Ibitoye SA. Effect of Government Policies and Extent of Its Implementation on the Foundry Industry in Nigeria. Journal of Policy and Development Studies. 2020;14(4):12-25.
69. Olukunle OT. Challenges and prospects of agriculture in Nigeria: the way forward. Journal of Economics and Sustainable Development. 2013;4(16):37-45.
70. Omo-Ojugo E. Relevance of big data analytics in agriculture: Focus on Nigeria agricultural sector. International Journal of Scientific Research. 2018;7:1-11.
71. Oruma SO, Misra S, Fernandez-Sanz L. Agriculture 4.0: an implementation framework for food security attainment in Nigeria's post-Covid-19 era. IEEE Access. 2021;9:83592-83627.
72. Otokiti BO, Igwe AN, Ewim CP, Ibeh AI, Sikhakhane-Nwokediegwu Z. A framework for developing resilient business models for Nigerian SMEs in response to economic disruptions. International Journal of Multidisciplinary Research and Growth Evaluation. 2022;3(1):647-659.
73. Otuoze SH, Hunt DV, Jefferson I. Neural network approach to modelling transport system resilience for major cities: case studies of lagos and kano (Nigeria). Sustainability. 2021;13(3):1371.
74. Oyewola DO, Dada EG, Omotehinwa TO, Emebo O, Oluwagbemi OO. Application of deep learning techniques and bayesian optimization with tree parzen estimator in the classification of supply chain pricing datasets of health medications. Applied Sciences. 2022;12(19):10166.
75. Picas S, Reis P, Pinto A, Abrantes JL. Does tax, financial, and government incentives impact long-term Portuguese SMEs' sustainable company performance?. Sustainability. 2021;13(21):11866.
76. Qi Y, Huo B, Wang Z, Yeung HYJ. The impact of operations and supply chain strategies on integration and performance. International Journal of Production Economics. 2017;185:162-174.
77. Qrunfleh S, Tarafdar M. Supply chain information systems strategy: Impacts on supply chain performance and firm performance. International Journal of Production Economics. 2014;147:340-350.
78. Raja Santhi A, Muthuswamy P. Pandemic, war, natural calamities, and sustainability: Industry 4.0 technologies to overcome traditional and contemporary supply chain challenges. Logistics. 2022;6(4):81.
79. Ramdoo I, Cosbey A, Geipel J, Toledano P. New Tech, New Deal: Mining policy options in the face of new technology. Winnipeg: International Institute for Sustainable Development; 2021.
80. Richey RG, Roath AS, Adams FG, Wieland A. A responsiveness view of logistics and supply chain management. Journal of Business Logistics. 2022;43(1):62-91.
81. Rufai AM, Ogunniyi AI, Salman KK, Salawu MB, Omotayo AO. Rural transformation and labor market outcomes among rural youths in Nigeria. Sustainability. 2021;13(24):13794.
82. Shaikh TA, Rasool T, Lone FR. Towards leveraging the role of machine learning and artificial intelligence in precision agriculture and smart farming. Computers and Electronics in Agriculture. 2022;198:107119.
83. Sibanda S, Workneh TS. Potential causes of postharvest losses, low-cost cooling technology for fresh produce farmers in Sub-Sahara Africa. African Journal of Agricultural Research. 2020;16(5):553-566.
84. Simchi-Levi D, Wang H, Wei Y. Increasing supply chain robustness through process flexibility and inventory. Production and Operations Management. 2018;27(8):1476-1491.
85. Sjah T, Zainuri Z. Agricultural supply chain and food security. In: Zero Hunger. Cham: Springer International Publishing; 2020. p. 79-88.
86. Sjödin D, Parida V, Palmié M, Wincent J. How AI capabilities enable business model innovation: Scaling AI through co-evolutionary processes and feedback loops. Journal of Business Research. 2021;134:574-587.
87. Songol M, Awuor F, Maake B. Adoption of artificial intelligence in agriculture in the developing nations: a review. Journal of Language, Technology & Entrepreneurship in Africa. 2021;12(2):208-229.
88. Stathers T, Mvumi B. Challenges and initiatives in reducing postharvest food losses and food waste: sub-Saharan Africa. In: Preventing food losses and waste to achieve food security and sustainability. Cambridge: Burleigh Dodds Science Publishing; 2020. p. 729-786.
89. Sutcliffe C, Knox J, Hess T. Managing irrigation under pressure: how supply chain demands and environmental objectives drive imbalance in agricultural resilience to water shortages. Agricultural Water Management. 2021;243:106484.
90. Terziyan V, Gryshko S, Golovianko M. Patented intelligence: Cloning human decision models for Industry 4.0. Journal of Manufacturing Systems. 2018;48:204-217.
91. Tien JM. Internet of things, real-time decision making, and artificial intelligence. Annals of Data Science.

2017;4:149-178.
92. Tien NH, Anh DBH, Thuc TD. Global supply chain and logistics management. Academic Publications; 2019.
93. Toledano P, Ramdoo I, Cosbey A, Geipel J. New Tech, New Deal: Mining Policy Options in the Face of New Technology. Winnipeg: International Institute for Sustainable Development; 2021.
94. Tzachor A, Devare M, King B, Avin S, Ó hÉigeartaigh S. Responsible artificial intelligence in agriculture requires systemic understanding of risks and externalities. Nature Machine Intelligence. 2022;4(2):104-109.
95. Umar MA, Sani BM, Suleiman U, Tijjani ML. An overview of machine and deep learning technologies application in agriculture: opportunities and challenges in Nigeria. SLU Journal of Science and Technology. 2022;4:84-96.
96. Uthmann T. Transition towards digital modernity in the Global South: The contribution of AI to sustainable development in Sub-Saharan African countries [bachelor's thesis]. Enschede: University of Twente; 2021.
97. Vyas S, Shabaz M, Pandit P, Parvathy LR, Ofori I. [Retracted] Integration of Artificial Intelligence and Blockchain Technology in Healthcare and Agriculture. Journal of Food Quality. 2022;2022:4228448.
98. Wang G, Gunasekaran A, Ngai EW, Papadopoulos T. Big data analytics in logistics and supply chain management: Certain investigations for research and applications. International Journal of Production Economics. 2016;176:98-110.
99. West M, Kraut R, Chew HE. I'd blush if I could: closing gender divides in digital skills through education. Paris: UNESCO; 2019.
100. Zhang C, Lu Y. Study on artificial intelligence: The state of the art and future prospects. Journal of Industrial Information Integration. 2021;23:100224.
101. Zohuri B, Moghaddam M. From business intelligence to artificial intelligence. Journal of Material Sciences & Manufacturing Research. 2020;1(1):1-10.