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Emerging Technologies in Agriculture: Youth's Challenges and Prospects in Utilization for Sustainable Food Production in Kwara State, Nigeria.

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Abstract
This study explores emerging technologies for sustainable food production among youths in Kwara State, Nigeria, amidst widespread malnutrition and food insecurity. To address these challenges, three research questions guided the study: identifying available emerging agricultural technologies, challenges faced by youths, and prospects for sustainable food production. The study found emerging technologies in crop production and animal husbandry, including drones, big data, robots, and artificial intelligence, increase productivity and profitability. However, challenges persist, including limited access to finance and technical expertise. Using the PRISMA flow chart, 100 articles were reviewed, revealing that emerging technologies enhance agricultural production and sustainability. The study concludes that youth farmers require training and recommends access to loans and technical experts for technology maintenance. Artificial intelligence supplements human labor, rather than replacing it.

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Introduction

The global advancement of technology is vital for economic growth, food production, and sustainable development. Achieving food sustainability poses significant challenges, emphasizing the critical role of emerging agricultural technologies in ensuring sustainable food production in Kwara state. As Vågsholm et al. (2020) highlight, strategic production development mitigates losses throughout the agricultural cycle, boosting productivity. Agriculture plays a pivotal role in human livelihoods, providing food for consumption and contributing significantly to the economic sector, particularly to the Gross Domestic Product (GDP) in most countries (Abioye et al., 2020). By leveraging emerging agricultural technologies, youth can increase food availability, enhancing food security in Kwara state and beyond. Insufficient food production in the state creates worry for reviewing relevant literature to curb this menaced.

Emerging technologies are technologies that simplify production processes, increase profitability, and improve efficiency (Klerkx & Begemann, 2020; Liu et al., 2020). Emerging technologies in agriculture are adopted alternatives to increase productivity in agriculture (Boursianis et al., 2020), such as Artificial Intelligence (AI), Big Data, the Internet of Things (IoT), drones, and gene editing (Rose et al., 2021). These emerging technologies also include the following; Precision Agriculture, Solar-powered systems, Sensor networks, Variable rate technology, Predictive analytics, Automated systems, Smart irrigation, Blockchain and Supply Chain Management among others. The utilization of these technologies enhances cultural practices from the beginning to the end of production cycle for sustainability (Saiz-Rubio & Rovira-Más, 2020). Farmers in general may not be able to utilize these emerging technologies maximally because of their low literacy levels. However, youth are at the vantage position of utilizing it for sustainable food production in the state because of their exposure, education, and ability to adapt to the use of technologies of this era. The adoption and utilization rates of technologies decline significantly among farmers aged 50 and above (Tamirat et al., 2018). This means that youth have the greatest opportunities in utilizing these technologies. Youth are inquisitive and are willing to learn new things, most especially these new tools that are released in agriculture. They demonstrate an ability to utilize emerging technologies as a result of their familiarity with technologies (Kaňovská, 2021).

Moreover, the rural or aged farmer usually rejects advanced agricultural tools integration into their farming practices (Da Silveira et al., 2023). This is one of the factors limiting sustainable food production. In other words, the study tends to present that if youth engage in the utilization of emerging technology with the necessary support, food sustainability is a possibility in the state. The youth are key in agricultural production. Because the aged rigidly follow old methods of cultural practices (Das et al., 2019). In addition, they are technophobes (Marescotti et al., 2021). Consequently, older farmers may struggle to fully exploit the potential benefits of utilization of emerging technologies.

The prospects in the utilization of the fourth industrial revolution (4.0IR or emerging technologies) for youth in agriculture are enormous and can enhance food sustainability. This is because digital skills have a significant impact on production worldwide. Information communication technology (ICT) helps farmers create a safe, sustainable way of monitoring their farming activities for a sustainable food option. The 4.0IR of agriculture is a nexus between Sustainable Development Goals (SDGs) outlined in Agenda 2030. 4.0IR optimises natural resources, and water management, reduces food waste, and improves biodiversity (FAO, 2022). Help farmers' to effectively increase food production while respecting environmental impact (Finger, 2023). This is what sustainability is all about, improving resilience in production. The 4.0IR can help to boost SDGs, such as Zero Hunger (SDG 2), Clean Water and Sanitation (SDG 6), Responsible Production and Consumption (SDG 12), Life Below Water (SDG 14), and Life on Land (SDG 15) (Independent Group of Scientists Appointed by the Secretary-General Global. Sustainable Development Report, 2023). Considering the enormous advantages of emerging technologies, it also presents some pressing challenges.

The challenges in technologies in agriculture production as impacted food sustainability in the state. According to FAO (2022) and FAO (2023), inadequate adoption rates of emerging technologies is evident among farmers between developed and developing countries. The challenges of utilizing these digital technologies in agriculture include the following; age, insufficient capital, lack of technical know-how, small farm size, lack of digital skills among others. Furthermore, mismanagement of technologies in agricultural production series (Baributsa & Njoroge, 2020; Bendinelli et al., 2020). These are some of the key factors affecting the utilization of the emerging technologies in the state and globally by the youth. The research questions guiding this reviewed are:

1. What are the emerging technologies in agriculture available for sustainable food production in Kwara State, Nigeria?
2. What are the challenges faced by youth in utilizing emerging agricultural technologies?
3. What are the prospects of emerging agricultural technologies for youth in sustainable food production?

These research questions provide a guide for reviewing relevant literature, ensuring a focused and systematic examination of the existing knowledge on emerging technologies in agriculture for a sustainable food production.

Methods

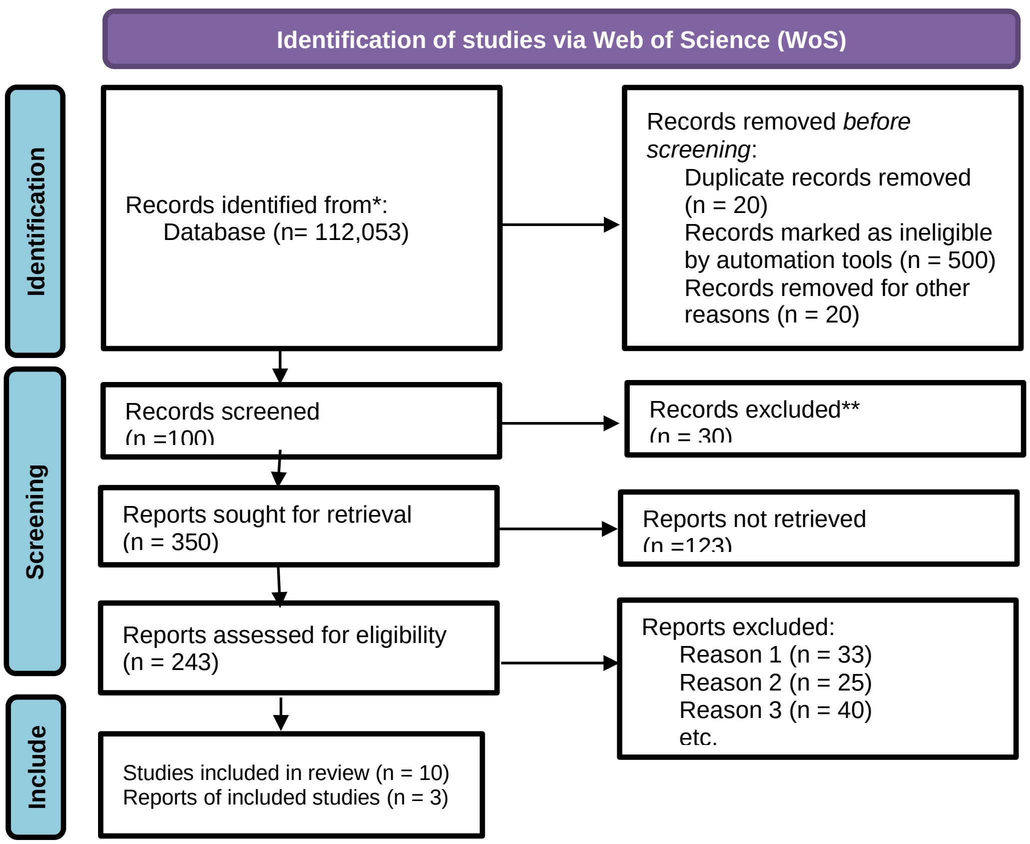
This study utilized a systematic review methodology, adhering to the revised PRISMA 2020 guidelines, to achieve its research objectives.

Literature search

The researchers conducted a comprehensive literature search on November 2, 2024, to ensure the inclusion of recent literature. This search built upon an initial search performed on February 1, 2024, which was updated to incorporate the most current search strategies following peer review.

The search was conducted using Web of Science (WoS), a premier database for peer-reviewed articles. To identify relevant studies, I created targeted search strings through an iterative process, refining terms to optimize results. The search terms included "emerging technologies," "emerging technologies in agriculture," "sustainable food production," "challenges of emerging technologies," "challenges of emerging technologies in agriculture," and "prospects of emerging technologies in agriculture." The search parameters were set to include English-language papers published between 2021 and 2024. I searched titles, abstracts, and keywords within WoS. To supplement database searches, I also examined reference lists of included studies to identify relevant sources.

The search methodology adhered to the PRISMA 2020 guidelines, ensuring a systematic and transparent approach. A PRISMA flow chart outlining the search process is provided.



Source: Haddaway, et al. (2022).
Fig. 1 | PRISMA flow chart. The PRISMA flow chart shows the study identification procedure.

This comprehensive search strategy enabled the identification of the most relevant and up-to-date literature on emerging technologies in agriculture

Emerging Technologies in Agriculture for Sustainable Food Production

The agricultural sector has experienced a real transformation from the medieval stage to the adoption of new technologies. The population of the world is predicted to reach about 9 billion by 2050 (Despommier et al., 2013). Technologies utilization in agriculture is important as it improves food production and reduces food insecurity. These technologies are not limited to crop or animal production areas of agriculture but rather cut across all aspects that bring about a complete series of operations. Waste in agriculture could result in the incidence of climate change (Haile et al., 2019), and increased pests, pathogens, and weeds to the use of agricultural pesticides (Leeuwen et al.,2020; Leia et al., 2020). Due to this, it's very difficult to maximize profit without the use of these technologies. To increase the scale, speed, and productivity, leading to more efficient use of land, food production, reduction in the cost of production use of chemicals, drones, and farm machinery that makes farm operation seamless to do on the farm. Advancements in the use of emerging technologies or Precision Agriculture such as remote sensing, robots, and ICT support systems have created a broad transformation platform in farming and food production (Pedro & Gonzalez-Andujar, 2019). The high cost of foodstuff and insufficient food in the state is probably due to the inadequate utilization of emerging technologies by youth in farming, this is of great concern as the populace is increasing daily leading to malnutrition, and disease among the dwellers of the state and may finally result to death due to lack of food.

Agriculture is the main source through which humans can survive on earth to reduce the death rate and increase food production and accessibility to all and sundry. It becomes very paramount to categorically state that emerging technologies improve agricultural productivity and profitability. 4.0IR in agriculture increases profit and reduces the cost of production in agricultural processes (Rose et al., 2021).

The following are the emerging technologies; Cloud Computing, the Internet of Things, Big Data, Blockchain, Robotics, and Artificial Intelligence that can be used to curb food insecurities. Artificial Intelligence (AI) is important to knowledge model identification, service creation, and informed decisions that support different Agri-Food applications (Solemane et al., 2019. For instance, Convolutional Neural Networks (CNNs) utilize Internet of Things (IoT) data to predict and detect potential crop diseases at various scales (Chen, et al. 2020). Furthermore, Artificial Intelligence (AI) optimizes agricultural production by: automating harvest management, regulating greenhouse gases, implementing smart fertigation systems. These AI-driven solutions respond to changing external conditions, enhancing efficiency and sustainability in agriculture. The agricultural sector has witnessed significant transformation with the advent of robotic systems. Notably, drones (UAVs) have become indispensable for precision agriculture, offering aerial insights into plant health, soil conditions, and moisture levels across expansive farmlands (Sparrow & Howard 2021). In addition to these, robots can provide real-time updates to human operators, seek assistance when needed, and participate in decision-making processes through collaborative task voting (Kureshi, et al. 2023). By providing a real time action oriented process that makes farming activities faster and easier.

This will make the state if utilized maximally by the youth increase sustainable food production. Youth are known to possess the necessary agility that can make them stand out since most of them are more educated and versatile in the use of technologies than adult rural farmers who might be skeptical about the usage. Therefore, the article tends to enlighten the youth on the emerging technologies to be used to increase food sustainability. Artificial intelligence, analytics, connected sensors, and other emerging technologies can increase yields, improve water use and other inputs, and build sustainability across crop cultivation and animal husbandry in particular. Therefore, for sustainable food production in terms of crop production, meat, milk, and eggs the adoption of emerging technologies is important to utilize in agriculture.

Prospects of Emerging Technologies in the Use of ICT on Animal Husbandry

The animal husbandry sector is an important aspect of agriculture that provides meat, milk, eggs, and other raw materials for personal and industrial purposes. A lot of prospects abound in the use of ICT. Various stages may include in raising the animal from the hatchery to the growth out section where they are raised to maturity. The technologies differ from the start of the production system to where they are raised to the grow-out section. Digital livestock farming is a set of solutions aimed at increasing production through the use of specialized systems that ensure targeted use of resources that control all processes (Chand et al., 2018; Kebebe, 2019; Martinez et al., 2020).

The following are some of the prospects of ICTs on farm animals; help to reduce or eliminate the daily routine of manual labor, create awareness of emerging malfunctions in farm animals, and ensure the microclimate. Farmers gain a holistic understanding of their farm landscapes through this technology. For instance, drone satellites provide continuous, global coverage, capturing data in a single image. This solution offers a cost-effective option for monitoring extensive farmland areas. The utilization of these technologies will lead to a decrease in the importation of the industry by 35-40%, an increase in quality and quantity of products by 25-30%, labor productivity in subsectors of livestock by 1.5-2 times, and contribute to the wellbeing and longevity of animals (Mahdavian et al., 2020; Alonso et al., 2020). These autonomous robots will only require the monitoring and evaluation of the digital technologies for effectiveness for maximum output. Feeds, and water sensors detecting the health status at a faster rate are used based on intelligent automation. The use of ICTs provides financial report indicators at a glance of the production for accurate management decision making by the farmers. It also forecasts of climate change that may affects animal production for planning.

Digital innovation in livestock presented in the figure below. This help to monitor the production, milking, feeding, climate control and efficient management on the farm. Scientists have been able to develop an RFID-based Mobile Monitoring System (RFID-MMS), which is used to manage the animals efficiently and retrieve necessary information at a distance such as detecting estruses and predicting calving-time in animals through a wireless sensor network.

Wireless network helps in reducing the production cost and animal health. The utilization of a wireless network is very useful as it saves the cost of operation and traveling in monitoring the animal health and behavior of the farm animals. Rafael, Becerra, Richard, and Fernando (2013) discussed a Computational Intelligence Automatic Body Conditioning algorithm specifically for cattle called Automatic Body Condition Assessment (ABiCA). This helps with remote monitoring, presentation of the status of the animal's health, breathing, vital signs, heart rate, and therapy measures that could be adopted using this smart device. The use of these technologies is very effective and efficient if integrated into farm activities with the necessary skills for productivity. The livestock industry is also very key to the nation's economy in the sense that it provides necessary protein substances that can improve the health status of the populace. Since transformation has changed many things in agriculture, the scale of production with the advent of emerging technologies will also impact the production in animal husbandry and increase the production of meat, milk, egg, and materials needed in the industry as a result of connected sensor, data, connectivity, artificial intelligence analytic in sustainable production. This brings about sustainable environmental impacts (Pittelkow et al., 2014)

The architecture of the animal monitoring system is made up of different sections collecting data from the farm animals and sending it to the data collection center through the gateway for analysis and visualization. The data collected are then analyzed and stored in data-based for retrieval and monitoring of the animal after processing.According to Ji-De and Han-Chuan (2013), the gateway is an embedded system with a wireless network using Internet of Things (IoT) sensors.Also, Anuj and Gerhard (2013) designed an Animal Health Monitoring System (AHMS) for monitoring the physiological state of farm animals. Animal monitoring system is projected (Chao et al.,2015) to have an increase in adoption rate in a good environment. This will bring about the effectiveness of the roles of ICTs in livestock farming.

The role of ICTs in animal husbandry is crucial for effective communication and knowledge exchange among farmers, researchers, and extension agents. This will help to bridge the gap between the stakeholders and eventually lead to improvements in production (Food and Agriculture Organization, 2017). ICTs promote sustainable farming practices such as the adoption of climate-smart agriculture. Reduction in the cost of energy solutions with robustness and autonomy (Hugo, & Nuno, 2016). Sensor modules help to determine the temperature, heart rate, and rumination of animals (Anushka et al., 2015). ICTs help to record health status using an RFID-based web application platform (Ariff et al., 2014 & Yoshihiri et al., 2014). A cloud-based framework helps the healthcare industry by implementing IoT healthcare solutions(Sapna et al., 2016). The utilization of ICTs aids rural expansion particularly among women and youth, by increasing access and opportunities. This, in turn, leads to improving the overall quality of life. Among the main advantages of using the technologies is increased financial returns (Huh & Kim, 2018; Kodan et al., 2019).

4.0IR Technologies Utilization for Sustainable Crop Production

Crop sustainability is essential in this century of global warming affecting agricultural production, especially in crop production. The process is key in enhancing food crops for the state and other states. Technology in agriculture is the adoption of 4.0IR which is used interchangeably with emerging technologies such as IoT, based on cloud, robotics, and artificial intelligence (Rose & Chilvers, 2018). This enhances a more productive way of farming that increases food production. The existence of the National Center for Agricultural Mechanization in Kwara state is one of the major factors that can make food production sustainable for the states and even for exportation if the youth in farming are practically trained in the use of these modern technologies for farming practices. This is because some of the technical and agricultural engineering experts can provide their expert advice on the appropriate steps to utilizing farm machinery from scratch of the farming activities to the processing stage till it reaches the final consumers. Dissemination of necessary information to the youth is a possibility if the federal and state governments can involve them in the training. To start with, precision agriculture is adopted for a more accurate result in crop production. For agriculture to achieve the desired impact on the quantity and quality of food production, it is necessary to know how to adopt the use of precision agriculture (Boursianis et al., 2020; Singh & Singh, 2020; Rose et al., 2021). Precision agriculture makes use of technologies for proper crop management and optimization.

Key Technologies: GPS: Accurate field mapping and navigation. Sensors: Monitoring soil moisture, nutrient levels, and crop health. This AI can improve IoT through the development of applications that analyze data captured by the sensors with accuracy using a machine learning system (Reshma & Pillai, 2018). Variable Rate Technology (VRT): Adjusting inputs (fertilizers, pesticides) based on specific field conditions. Satellite Imagery: Assessing crop growth and identifying problem areas. Automated Machinery: Precise planting, spraying, and harvesting.

Challenges of Digital Technologies in Agricultural Production

The application of digital technologies in agriculture presents benefits that cannot be relegated to its utilization in agriculture. However, there are adverse effects of utilizing these digital tools in agriculture. Besides, the advantages of digital technologies various factors slow down its mastery, and these are challenges on its utilization for farmers. One major challenge of agriculture is increasing food production sustainably (Fu et al., 2020; Singh & Singh, 2020). The Agri Artificial Intelligence approach is defined as intelligent agricultural systems that incorporate AI to process data from sources with variability, such as natural pests, pathogens, and weeds due to climate change (Grieve et al., 2019). As such, it has the following challenges; Equipment for digitalization is often imported. High equipment prices make production too expensive. Acute shortage of IT specialists for agriculture for global digitalization. The problem with teaching how to work in a new system. It requires a large number of IT specialists; experts in machine learning, robotics, big data processing and analysis, etc. Industrialization may lead to a reduction in the number of people employed in the agricultural industry. Adopting of digitalization farm requires Internet and electricity that is stable on the farms. Understanding agricultural development in transforming the traditional food systems is imperative to know the visions of agriculture 4.0IR (Klerkx & Begemann, 2020; Liu et al., 2020), the limitations and risks for all countries to benefit from the new agriculture (Hinson et al., 2019). Another challenge is that the digital technological revolution in agriculture is not evenly shared (Rose & Chilvers, 2018; Whitfield et al., 2018; Rose et al., 2021). Despite its evolution, many are still ignorant of the 4.0IR in agriculture for sustainable food production.

Conclusion

Emerging technologies in agriculture simplify many production processes and increase the profitability of the business. Emerging technologies play a vital role in increasing food production such as in the area of animal and crop production. Major emerging technologies in animal and crop production were examined and discussed in this paper. The prospects that can be utilized by youth in farming to improve sustainable production while keeping the environment sustainable. The sub-headings in this paper also consider the technologies to be used in animal production. In the emerging technologies for animal production, some of the digital technologies were considered to help monitor the health status, feeding, and administration of drugs to farm animals. The utilization of (ICTs) has been observed to be key in covering all areas of farming activities to the farming communities. It promotes sustainable farming practices such as the adoption of climate-smart agriculture, provides early warning and disaster management through timely information to communities, reduction in the cost of energy solutions with robustness and autonomy, improves market access through marketing and trade of goods and services, and more importantly sensor modules helping to do determine temperature, heart rate and rumination of animals. However, despite the numerous advantages of emerging technologies that can be used; it has some adverse effects which may hinder or limit its utilization for sustainable food production. These include the age of the farmers, finance, education of the farmers, and technical know-how. If these are not taken care of by the individual, state, or the federal government the cry for food insecurity and malnutrition in the state will persist. The state having the National Center for Agricultural Mechanization was discovered as a center that can be utilized to train the youth in farming. Farm mechanization is what will draw most youth into farming and not the old methods of using crude tools. This will continue to make food production dwindle and will make youth not to be interested in farming but if youth are introduced to all these emerging technologies it will improve the food production in the state.The study therefore concludes if these issues are taken into consideration and the youth are trained, and provided with necessary assistance the state will be a center of food supply, to other states. In a nutshell, artificial intelligence can only serve as a supplement and not a substitute for farmers. No form of Artificial Intelligence can fully replace human experience, but it can enhance the ability to make decisions accurately. They can help the farmers carry out daily routines that do not require human assistance perfectly. Artificial intelligence is program activities to be carried out by machines that cannot manipulate themselves. It can render solutions to problems that have not been programmed on it. It must be noted that a ready-made solution kit to which human experience is added and utilized for efficiency and profitability cannot be isolated.

Recommendations

These recommendations aim to harness the potential of emerging technologies to transform agriculture, ensure sustainable food production, and promote youth engagement in farming in Kwara state. Below are the recommendations;

1. Establish Training Programs for Youth in Farming: Utilize the National Center for Agricultural Mechanization to train youth in emerging technologies, farm mechanization, and sustainable farming practices to increase food production and attract young farmers.

2. Address Barriers to Technology Adoption: Address the adverse challenges of emerging technologies, including age, finance, education, and technical know-how, by providing necessary assistance, funding, and education to farmers, particularly youth and women.

3. Promote Digital Technologies in Animal Production: Encourage the use of digital technologies, such as ICTs, sensor modules, and artificial intelligence, to monitor animal health, feeding, and administration, improving efficiency and reducing costs.

4. Support Climate-Smart Agriculture: Promote sustainable farming practices, such as climate-smart agriculture, to enhance resilience to climate change, improve market access, and reduce energy costs.

5. Integrate Human Experience with Artificial Intelligence: Recognize the limitations of artificial intelligence and emphasize the importance of human experience and decision-making in farming, using AI as a supplement to enhance accuracy and efficiency.

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