Chapter 4

Role Of Smart Agriculture Technologies For Enhancing Food Sustainability In Nigeria: An Overview

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Abstract

Smart agriculture can also be referred to as smart farming which involves managing farms using modern Information and Communication Technologies to increase the quantity and quality of products while optimizing the human labour required. This involves collecting data on crop production and analyzing them, especially during crop production season. For instance, a farmer growing cowpea can collect data on the produce, authenticate and analyze them. The analysis will give the farmer insights into how the inputs applied have influenced the growth or yield of the cowpea crop. Also, drones can be used to easily detect plant diseases or identify weeds and these can be used even in places where there is insurgency or high rate of rural-urban migration among youths which are factors that militate against agricultural productivity. Digital technology will increase the quantity and quality of crops produced by farmers thereby enhancing food sustainability in Nigeria.

Keywords: Smart agriculture, technologies, food security, food sustainability, profitability

1. Introduction

Agriculture in Nigeria is faced with current problems such as use of human labour, animals and simple tools, increase in population, urban migration, inadequate and scarcity of resources, inherent climate change and waste management (Food and Agriculture Organization (FAO), 2023). In addition, farmers need to increase and maximize productivity to meet the demands of a growing population by tackling current challenges like labour, food scarcity, waste management, climate change, energy water quality, biodiversity, soil management, among others. This has led to introduction of farm machineries, notably advanced agricultural technologies will greatly reduce the need for physical manual work in farming and apparently improve crop and livestock yields (Tolga and Basar, 2020). Agriculture shift from human labour to technology driven will continue over the decades to lead to new farming opportunities, models, developments and services (Digital Economy, 2024). However, application of these technologies to agricultural production can be a life-changer for humanity globally as currently there are massive extreme weather change, flood, drought, collapsing ecosystems, massive erosion, poor attitudinal knowledge, rise in population, poor food entitlement etc. which make food production more and more complicated, scare and expensive (Fawole et al., 2021).

Additionally, agriculture industry has been valued worldwide and accounts for a large share of GDP and employment in developing nations (FAO, 2023). For example in US, agriculture contributes 1.4% of the GDP and 1.62% of the work force, in South Asian regions 18.6% of the GDP and 50% of the workforce and in Nigeria 3.25% of GDP and 2.1% of workforce. However, despite the fact that agriculture is employing nearly one in five people worldwide (19% of the world's population) the agricultural sector projected to decline due to population growth, pest resistance, burden on natural resources, among others (FAO, 2020). Therefore, current agricultural practice alone cannot sustain the projected global population growth which is approximately estimated at 9.7 billion by 2050 (Taylor and Francis Group, 2017).

Smart agriculture is an emerging concept which is able to provide information about agriculture based on user input practices to increase the sustainability in farming systems. Its practices are noted as the most appropriate adaptation strategies that will aid to achieve food security, mitigating climate challenges, preservation of natural endowment as well as preservation of important ecosystem (FAO, 2023). Smart agriculture can be referred to as digital agriculture which comprises a number of tools that help the management of agricultural resources and crop production. Smart agriculture referred to as smart farming is the acceptance and use of advanced technologies and data-driven farm tools and operations to optimize, maximize and improve sustainability in agricultural production (United Nations (UN), 2021). It can be referred to as smart farming which is a practice in agricultural production with high manpowered technologies like data analytics, internet of things (IOT), sensors, location systems, robots, artificial intelligence and machine learning (AI), automation, robotic, drones, cloud soft wares, information and communication technologies (ICTs), supply chain intelligence suites, environmental intelligence suite, intelligence asset management and integrated workplace management systems (IWMS), among others into

machinery to increase productivity and supplies in agricultural production systems (Raharno and Yosephine, 2024).

Smart agriculture is also a process of handling, managing and monitoring agriculture activities using wireless technologies and sensors. Smart agriculture involves climate-smart agriculture (CSA) which is a set of farming methods with three main objectives to tackle climate change so as to avert risks and food scarcity. The methods deal with building resilience to climate change adaptation, natural resources management and policy to correctly address society preferences (Chandrachud et al., 2024). More so, focuses on increasing agricultural productivity and sustainability, minimizing gas emissions from agriculture as well as environmental impacts (land issues). In addition, Vendouw et al. (2021) noted that smart agriculture is currently showcasing the benefits of digitalization through big data, artificial intelligence, among others and linked data into agricultural system. It aids farmers to have tools and strategies to improve yields and sustainability of agricultural production. Smart farming is the pathway and heart of innovation, a transformational approach leverages cutting-edge innovations to revolutionize traditional agriculture.

2. Types of Smart Agriculture Technologies

2.1 Farm management software

Smart farming software is designed to help with various aspects of farm management. This is the hub that farmers use to plan, monitor and analyze activities. The software contains weather records, animal monitoring data, farming equipment conditions status, ideal and historical planting schedule, real-time environmental conditions for field monitoring and record management (Macfadden et al., 2023).

2.2 Grain elevator management software

This software include accounting and other financial data, operational data facility maintenance and monitoring in real-time, fleet management and other moving equipment for monitoring and safety control (Tolga and Basar, 2020).

2.3 Agricultural robotics

These are devices designed to improve agricultural processes by performing time-consuming or labour-intensive tasks typically done by farmers such as crop monitoring, irrigation and data analyzing. They include drones used for general monitoring of fields, crop spraying and data collecting; automated tractors designed for planting, harvesting and cultivation; mixing and feeding robots made to compile food rations and deliver them to designated places; robotic harvesters special for picking fruits and vegetables using robotic arms without damaging the plants (Vendouw et al., 2021).

2.4 Livestock management and monitoring

It can be referred to as precision livestock farming (PLF). It uses IOT devices and predictive analytics software to track livestock aspects. Examples are behavior, feeding patterns, health and well-being cameras, sensors and apps equipment which are used to identify lameness, aggression, abnormal postures, prolonged inactivity, unusually shorter feeding sessions, shorter step frequency and step length and changes in tail positions (Tripathy and Sharma, 2019).

2.5 Smart crop management

Large farms cannot be inspected easily on a real time, therefore, smart farming devices are installed on fields to provide moisture levels, pesticide levels, ambient temperature levels, soil properties, presence of CO2, O2 and other gases and soil Ph level. Artificial intelligence powered software agricultural application use GPS and various IOT to perform operations. Sensors of different types (weather stations, optical, electro-chemical and camera) can be used for the work (Tripathy and Sharma, 2019).

2.6 Green house monitoring system

This can be termed smart greenhouse equipped with sensors controlling environmental conductors automatically. The components of the system are sensors and wireless connectivity user software. A smart greenhouse maintains an ideal micro climate, temperature, humidity, light and other IOT sensors, control environmental conditions, manages fertilization and irrigation using sensors to collect soil health that provides data based on which farmers can activate sprinkler and irrigation system, provides data or potential plant diseases which help farmers recognize diseases and pests damage and take immediate control (Macfadden et al., 2023).

2.7 Autonomous ground vehicles

Autonomous ground vehicles such as tractors and other agricultural machineries are rising and has made farming easy and reduced the demand for human labour. Artificial intelligence and location tracking software containing map data programs the vehicle's position and controls speed while GPS and controlling equipment count on the machinery. For example, in U.S there are over 10,000 unique and retrofitted units autonomous vehicle. This is advantageous in the sense that, it can eliminate human error, increase fieldwork accuracy, reduce need for human labour and optimize production schedules (Macfadden et al., 2023).

3. Relevance of Smart Agriculture

Smart farming improves crop health. Optional smart farming technologies help farmers to identify crop and livestock diseases and other challenges earlier leading to healthier crops and animals. Smart farming software gives alert about lameness (Bernt, 2023).

Helps feed the increasing global population. The United Nations data (2020) reports that the world's population will grow from 7.7 billion in 2020 to 9.7 billion in 2050. Traditionally, the increase in food production has been linked to agricultural expansion, appropriate use of lands and slopes, cropland, livestock, forests, fisheries and increase in emissions. (UN, 2021; FAO, 2023).

Provides food security in climate scenarios. More efficient smart farming help to adapt to changing climate while maintaining production level. Climate smart agriculture provides a historic change to achieve zero hunger through implementing energy, water, food systems and market access for farmers (Aryal et al., 2020).

It helps to achieve higher yields thereby minimizing operating costs. Smart farms achieve higher yields by 1.75%, lower water use by 8% and lower energy costs. The greater use of various types of smart agriculture is important not only to improve financial performance but also required to meet the needs of the demanding population (Gras and Caceres, 2020).

Smart farming technologies help farmers to control environmental conditions manually because the data received by the software can be easily viewed and analyzed, providing unprecedented insights in the health of the plants (Alfred et al., 2021).

Smart farming software protects grains and seeds, streamline operations, improve safety and make better decision faster and aids machine learning which enhances supply chain (Alfred et al., 2021).

4. Challenges of Smart Agriculture In Developing Countries

Smart agriculture means human beings transitioned to an agrarian lifestyle, shift from a labour intensive to technology driven industry and technological advancements which have led to evolutions in agriculture, resulting in producing greater yields in crop varieties and livestock species (Zulfadi et al., 2024). However, the effects of climate change have massive social economic challenges in a number of key technologies in developing countries which have placed agriculture at the precipice of another evolution that would not only affect the crop variety yields and livestock species but also greater impacts on the food production and food systems of developing countries (Radeny et al., 2022).

The following are the major challenges of smart farming:

Connectivity: The provision of connectivity throughout agricultural environment (field, storehouses, barns, greenhouse), provision of enough space and a reliable uninterrupted connection that would withstand severe weather events. Appropriate ICT utilization for dissemination of current information to the rural farming communities is largely a challenge (Macfadden et al., 2023).

Design and durability: There are a lot of complexity and peculiarity in the design, function and robustness. These technologies should be able to handle the issues of connectivity as well as the conditions of outdoor spaces, weather and monitoring stations to work in smallholder farms.

According to Adebayo and Ojogu (2019), in Nigeria, smart agriculture is faced with many challenges along successful implementation that are institutional and socio-economic which include illiteracy, poverty and inadequate access to technical information. Also, there are still limitations for the adaptation and conversion of smart farms due to high cost of equipment and machineries, non-availability of internet and poor application of knowledge/skill.

High initial investment: Implementing these technologies on farms demands significant high amount due to the complex architecture involving hardware and software equipment and poor policy framework application (Manik, 2019). Also, in Nigeria, it has been reported to be a huge set back and farmers as well as extension agents lack adequate understanding of the process (Adebayo and Ojogu, 2019; Kaptymer, 2019).

Smart farming involves the adoption of advanced technologies and data driven practices to optimize agricultural productivity and improve sustainability, so collecting and managing large amounts of data from sensors and devices can be overwhelming. Therefore, data management, data privacy and security are very important to build trust among farmers and stakeholders/organization (Zakaria et al., 2020).

Challenges such as reduced resources, environmental changes and labour shortages further exacerbate the imbalance, compromising food security and over all lower agricultural productivity in developing countries resulting in a large economic consequence on the overall agricultural sector.

Total negligence of community growing healthy foods. Urban agriculture should be promoted as a way to create more local food growing systems around cities that would benefit and tackle food insecurity, create greener cities, tackle climate change, increase access to consumption of local healthy foods with other related social challenges such as environmental sustainability, community empowerment, social, economic and health implications that extend beyond agricultural policy.

Challenge of genetically modified crops include resource utilization, environment compromises, digitalization disparities and inefficiencies in supply chain. Genetically modified crops (GM Crops) plants used in agriculture which their healthy properties has been modified using genetic engineering methods (FAO, 2017).

Dearth of documentation on the context, poor availability of data, analytical tools and expertise, poor infrastructure, limited access to equipment, input and finance.

5. Strategies For Promoting Smartagriculture In Nigeria

Campaign for adoption of climate-smart agriculture in villages/communities will play a crucial role in promoting climate smart agriculture and adoption of improved agricultural practices among farmers. Farmers' adoption equally shows the power of commentary based financial initiatives (Kaptymer, Ute and Hule, 2019).

In addition, factors that will influence adoption of smart-agriculture should be taken into cognizance and treated properly such factors like labour endowment, land tenure security,

access to extension services, agricultural programmes/trainings, membership of farmers' organization and acquisition of formal education, among others.

Adoption of smart-agriculture should include awareness creation in rural areas of the farm families, gender inequalities in land ownership, encouragement/motivation of rural farmers for healthy crops of their choice for sustainability of food management system through early growing seasons (Ahmed et al., 2022).

Farmers need not be forced to accept innovations but support their willingness to accept innovations, incentives, grow more crops of different varieties which increase resilience and genetic diversity (Omotoso and Omotayo, 2024).

More so, motivation of rural farmers both intrinsic and extrinsic, appropriate support from government and non-government organization and collaborative partnership can equally foster relationships in community level interventions for improving access to fund for smart farming adoption (Vasta et al., 2023).

Consistent practicable government agricultural policies should be put in place. According to Venkatramana et al. (2019) and United Nations Environmental Programmes (UNEP) (2022), designing appropriate achievable policy instruments could help accelerate climate smart agriculture diffusion and transmission.

Noteworthy is the fact that importance of information and communication technologies (ICTs) cannot be left out. This is positively related to adoption because vital information on how a changing climate might affect food security in areas like the food system, agriculture, soil health, food entitlements, food self-providing for the environment are obtained through the use of ICTs (Diro et al., 2020).

6. Conclusion

Sustainable agriculture is crucial to livelihoods of rural farmers and sustainability of food security. Nigerian farmers can adapt to changing climatic conditions and improve their overall productivity using smart agricultural practices. The adoption of smart agriculture is an important adaptation strategies to increase agricultural productivity. It helps to minimize greenhouse gas emissions as well as boosting food security. Smart agriculture technologies adoption by farmers will help to address the anticipated challenges to ensure opportunities for sustained safe production of agricultural products as well as the operational capacity of farmers. It is very important that a good policy framework is established so as to help farmers at the local level and government at all levels to make informed decisions for sustainable agricultural development. The framework among other things should provide solutions to climate change impacts to avoid supply chain disruptions, high food prices and food sustainability of the entire food chain. If smart agriculture is to achieve food security, drive economic growth as well as improve living standard of people, there is urgent demand to build rural farmers capacity, promote adoption of climate smart agriculture, motivate and empower youth development.

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