Digital Innovation and Automation as Sustainable Development Strategies for Enhanced Agricultural Sector

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Abstract

In many developing countries, such as Nigeria, dwindling resources and growing populations are aggravated by rising food demand and insufficient skilled manpower. The excessive usage of water resources from irrigation is reducing the amount of water available for future crops, and some of these concerns are affecting food security. In the end, an effective development strategy for efficient agricultural output will be required. This paper, titled "Digital innovation and Automation as sustainable development strategies for enhanced agricultural sector," focuses on advancements in agricultural technology and innovation, such as automation, artificial intelligence (AI), and wireless communication to achieve system optimization. Cross-cutting technology like the cloud, sensors, robotics, and digital communication tools are among the instruments that enable digital agriculture for improved efficiencies, healthy crop production and less waste in the field.

To improve storage and processing capability, digital agriculture needs the collecting of digital data at a rate of several zettabytes (ZB—the equivalent of several trillion gigabytes, or GB) per year. Artificial intelligence-powered software and remote sensors increase the value of agricultural machines all around the world. The findings reveal that autonomous robots increased output yields by lowering farmers' dependency on pesticides and herbicides. In the near future, it is recommended that the farming process be modernized to include automation and digital innovation for enhanced agricultural practices.

1.0 Introduction

Farming systems in emerging countries such as Nigeria require modern technology and creativity. This becomes important in order to avoid the disadvantages of traditional farming approaches. According to research, agriculture and the global food system would struggle in the near future to feed the world's population due to limited land and water availability (Charis & Galankis, 2020). The global population is quickly increasing, resulting in greater demand for food and labour (Yantai et al, 2013). Agricultural land areas cannot be expanded because the bulk of the world's arable land has already been developed. Urbanization is eroding the remaining areas, which must be maintained for habitat conservation, biodiversity, and climate buffers (Mattia & Silvia, 2016).

In the future, increased global production levels, as well as agricultural digital innovation, will be necessary for the principal source of protein, carbs, and nutrients: crops. like as rising African countries (Yansi et al, 2021). Agriculture and food systems have unprecedented data-driven innovation prospects (Saritha et al, 2020). These technology advancements can help with a variety of agricultural advances (Pradeep et al, 2021). Agriculture has been transformed by artificial intelligence (AI). Climate change, population increase, job uncertainty, and food security concerns are all things to think about (Christopher et al, 2020).

Artificial intelligence is used in agriculture (Tanha et al, 2020). AI in agriculture not only helps farmers automate their farming, but it also helps them in transitioning to precision cultivation for higher crop yield and quality while using fewer resources. Agricultural businesses have benefited from artificial intelligence. AI uses applications like automatic machine adjustments for weather forecasting and illness or pest identification. The goal of digital agriculture is to create more productive, profitable, and long-lasting systems (Mario et al, 2020). To overcome the drawbacks of traditional agricultural practices and complement the efforts of automation and digital innovation currently underway in developed nations, it is necessary to identify some of the challenges that have resulted in food shortages, water scarcity, disease outbreaks, and land scarcity, to name a few.

Challenges in Agriculture

Some of the most significant problems affecting Africa's expanding economy are trypanosomiasis, foot and mouth disease, and liver fluke. Institutional instability, a water shortage, and productivity-boosting initiatives are important problems.

Changes in climatic conditions are a perennial issue for most developing countries because they rely on rain-fed agriculture. Unpredictably severe weather causes crop loss, soil damage, extreme poverty, a lack of infrastructure, and a range of other problems.

As a result, the focus of this study is on teaching farmers how to embrace digital innovation and use existing agricultural technology to boost agricultural productivity and economics, ensuring the agricultural sector's long-term survival.

Technological advancement in Agriculture

Any country's development currently depends on technological advancement. To solve various obstacles, agriculture in most countries has been digitized using information and communication technology (ICT), and it now has a crucial role in the world economy. The demand for agricultural expansion grows in tandem with the human population. Automation, artificial intelligence, cloud computing, and other advancements are among them.

Automation in Agriculture

In industrialized countries like China, an increasing number of companies, including the agriculture industry, are focusing on automation such as robotic innovation to produce drones,

autonomous tractors, and robotic harvesters (Edward et al, 2021) as shown in figure 2. Even though these technologies are still very new, more traditional agriculture businesses are integrating farm automation into their operations. (Astill et al, 2020).

Farm automation technology's main purpose is to cover simple and routine chores (Rebecca & Diana, 2015). Modern agriculture has been drastically revolutionized by new breakthroughs in routine technology such as robotics and drones (see Figure 3), as well as computer vision software (Achilles et al, 2022). Harvest automation, precision agriculture, artificial intelligence, autonomous tractors, seeding and weeding, and drones are some of the most prevalent technologies used by farmers in developed countries (Matthew et al, 2020).

Artificial intelligent Positive impact in Agriculture

i. Reduce pesticide usage:

AI manages weeds by combining computer vision, robotics, and machine learning to collect data on weeds. This allows farmers to spray pesticides only where weeds are present, rather than spraying an entire field with chemicals.

ii. Data from weather forecasts:

AI Data to estimate and predict crop yields and revenues without putting the crop at risk. By comprehending and learning with Artificial Intelligence, the farmer can take precautions by analyzing the data generated. Implementing such a process aid in making timely decisions.

iii. Crop and Soil Health Monitoring:

AI conducts or monitors the soil for probable flaws and nutrient deficits as shown in figure 1. Artificial Intelligence recognizes potential faults in images acquired by the camera and assists in the understanding of soil defects, plant pests, and diseases.

Precision agriculture in automated farming.

Precision agriculture in automated farming is one of the current technologies being used in industrialized countries to increase sustainable agriculture and resource conservation farming. Sensors, drones, GIS technology, autonomous steering, GPS, and wireless connectivity are also used today. As illustrated in Figure 5, several real-time apps and monitoring software are utilized as precise instruments in sustainable agriculture. Figure 4 depicts how market news and social media can aid in forecasting and anticipating market movement, resulting in financial gains. (Goirgia et al, 2018).

Figure 1: Crop monitoring Using AI (Abdullahi et al, 2016)

Figure 2: Robot harvesting tomatoes (Arreola et al, 2019)

Figure 3: Data Assistance Drone (Abdullahi et al, 2016)

Figure 4: Precision Agriculture via Satellite Monitoring (Arreola et al, 2019)

1.5 Agriculture's digital innovation via Cloud Computing.

According to Juan Guillermon, 2021, in the newest agricultural trends, digital innovation for agriculture is expected to result in a significant increase in the knowledge base. They also require a structured agricultural knowledge-based system that allows users to search and get information from an existing database. The database must include standard vocabularies as well as significant variables related to crop statistics. (Juan et al, 2021). The goal of recommending cloud services is to reduce communication delays while also increasing scalability. Because cloud computing consists of a network of interconnected servers, virtual machines, and storage devices, performance will be a big concern. In terms of application and software, cloud virtualization offers for greater flexibility and customization. As a result, of an IOT smart irrigation controlling and monitoring system would make a better model selection.

2.0 Agriculture Artificial Intelligence (AI) Proposed with Digital Innovations

A mobile software application with weather channel features can provide growers with soil moisture conditions, precipitation data, forecasts, wind speed and direction, and water functionality. Users can use the precise feature app to figure out how much product or water they'll need to treat a specific field area, as well as how much product they'll need to achieve the volume-to-volume ratio. The pesticide mixing sequence, as well as the growth degree

functioning adjuvants and foliar products, are all determined by this program. To determine crop maturity, look at current and historical growing degree days data for a certain farm site.

The proposed automated irrigation model employs an LGT8F328P microprocessor programmed with the Arduino interface, which works with ATMEGA328. In addition, it included big data, Artificial intelligence, Machine learning with an Arduino mini board. C was used to program this CPU as shown in figure 5, 6a and 6b.

A text editor, a message field, a text area, a toolbar with buttons for a common technique, and a series of menus are all included in the Arduino Integrated Development Environment (IDE) or Arduino software. It establishes a connection with the LGT8F328P hardware in order to load the software and communicate with it. Following that, the soil moisture sensor monitors the soil moisture content to control irrigation by measuring the soil moisture content over time due to evaporation and plant absorption. The water pump works by sucking water through its intake and releasing it via its output. When the water supply is turned on, water will flow into the pump's intake and out the outlet. All farming communities' benefit from AI feasible solution ideas and technology innovation. Because AI cognitive solutions are open source, they are more economical, which will lead to faster adoption and higher insight among farmers. Crop metrics must be built over thousands of acres of cultivable land using techniques such as hyper spectral imaging and 3D laser scanning. It has the ability to bring about a fundamental shift in how farmers monitor fields in terms of both time and effort. AI is suited and effective in the agriculture sector since it maximizes resource utilization and efficiency. It alleviates resource and labor scarcity to a significant extent. AI is gaining popularity. As illustrated in Figure 8, farming has a bright future. Every year, new precision agriculture technology become available.

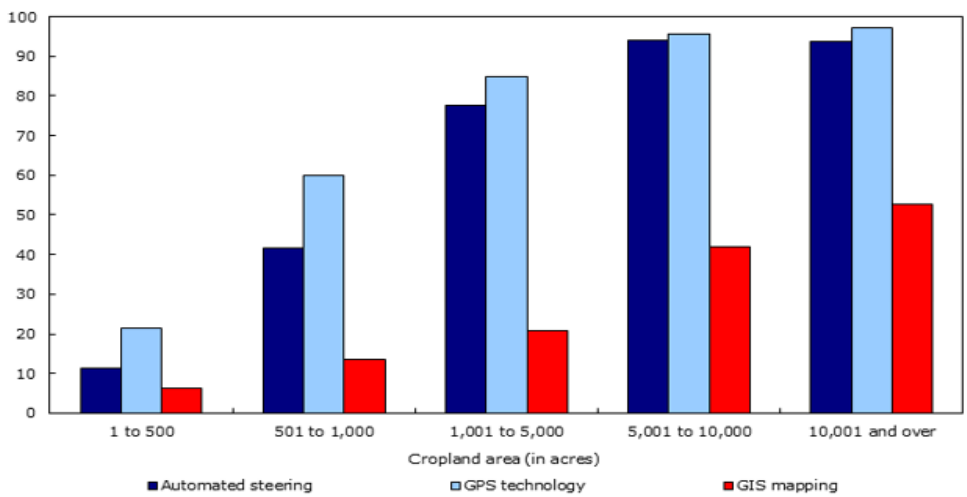

Figure 5: Selected technology in Agriculture (Matthew et al, 2020)

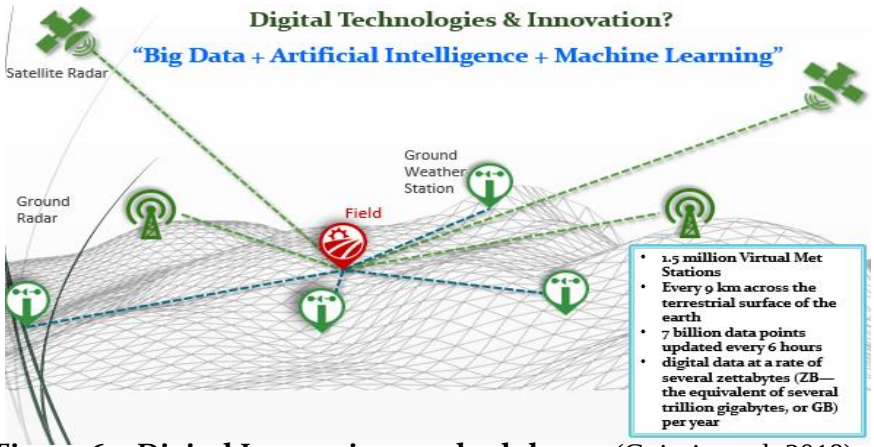

Figure 6a: Digital Innovation methodology (Goirgia et al, 2018).

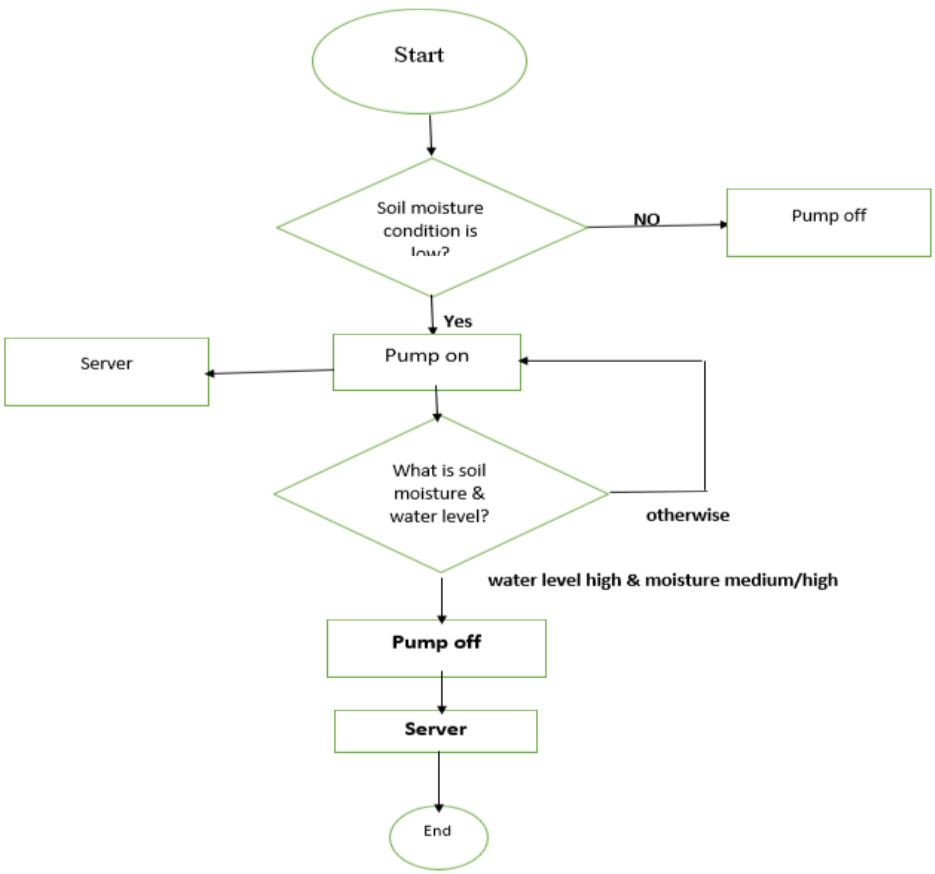

Figure 6b: Principle of Operation of Automated irrigation system (Ramachandran et al, 2018)

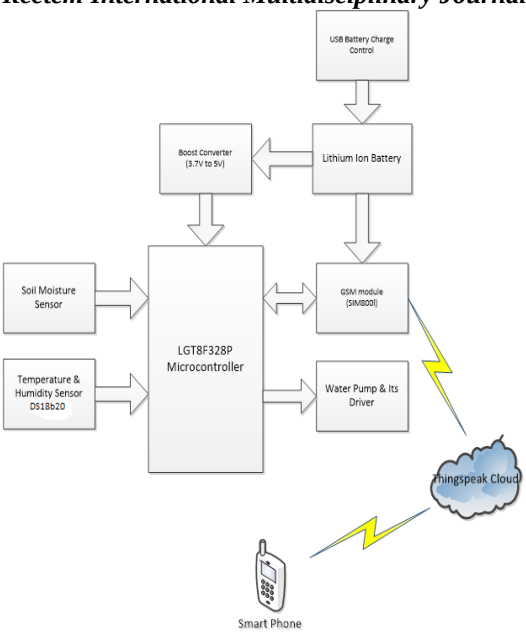

Figure.7: The proposed model's prototype outcome of mobile software application

An Android app provides information on the prototype. This will aid farmers in adopting the most up-to-date digital innovation on agricultural technologies and putting them into practice in real-world situations. Farmers will get access to additional tools such as automatic reminders or alerts, SMS, games, interpreting services, and other offerings.

Figure 8: Digital Innovation for Future agriculture (Alana et al, 2020)

3.0 Conclusion

Farmers in Africa's emerging countries are reaching the early stages of digital agricultural innovation, particularly in farm automation technology, which has the potential to revolutionize agriculture. It provides a road to more sustainable and efficient agriculture through technological developments, production methods, and software. Artificial Intelligence-

driven tools such as remote sensors for detecting soil moisture content and automatic watering using GPS and a mobile application assist farmers solve problems. These autonomous robots boost productivity while reducing the need for pesticides and herbicides that are unneeded. In addition, farmers can effectively spray pesticides and herbicides on their farms using drones, and plant monitoring is no longer a problem. Digital innovation grows every year. What was once considered cutting-edge will soon become commonplace also affordable. Although humans will always play a significant role in agricultural management, fully autonomous vehicles, and more inventions and innovation on the way to change agriculture in the near future.

4.0 Recommendation

1. It is recommended that farm automation techniques can increase agriculture's profitability while simultaneously lessening its ecological impact.

2. That cutting-edge innovations like GPS technology will increase the productivity and profitability of agriculture.

3. Additionally, it is recommended that smart irrigation systems be used to increase production and promote land reform.

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