Krishi Netra

Revolutionizing Agriculture: Innovations and Hurdles in Smart Farming Technologies

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Manuscript No: KN-V2-03/002

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Abstract

The agricultural sector is undergoing a profound transformation driven by advancements in smart farming technologies. The paper explores innovations and difficulties associated with this revolution in agriculture. It delves into the transformative potential of smart farming technologies, like Internet of Things (IoT) applications, robotics and data analytics in optimizing agricultural practices. This paper also highlights the hurdles that hinder the widespread adoption of these technologies, including issues related to cost, accessibility and data privacy concerns. Additionally, it discusses the imperative of addressing these challenges to fully harness the advantages of smart farming technologies in improving crop yield, resource efficiency and sustainability. By examining both the opportunities and obstacles in revolutionizing agriculture through smart farming technologies, this study offers insightful information for policymakers, researchers and stakeholders aiming to shape the future of farming.

Key words: Internet-of-things,Problems, Smart farming, Technologies,

Introduction

The traditional agricultural era 1.0 was defined historically as the production of food on farmed lands for human survival and animal breeding. This mostly involved employing humans as well as animals.Simple farming implements like shovels and sickles were utilized.New types of machinery emerged in the 19th century, such as steam engines, arrived in the agricultural industries, but work was still mostly done by hand and productivity remained low.The agricultural era 2.0 began with the widespread utilization of agricultural equipment and an abundance of chemicals by farmers, which also led to an external improvement in farm productivity and farmer effectiveness. But concurrently, extremely detrimental effects including environmental destruction, chemical pollution, resource waste, and overuse of energy emerged.The twentieth century saw the emergence of the agricultural era 3.0 as a result of the quick development of electronics and computation. Agricultural machinery with programming, robotics and other technologies improved agricultural processes effectively.Agricultural era 2.0 problems were resolved, and policies were updated for agricultural era 3.0 with the help of effective pest control methods, site-specific nutrient application, precise irrigation, decreased chemical use and labour distribution.The agricultural era 4.0, which involves the use of modern technologies like big data analysis, Internet of Things,cloud computing,remote sensing and artificial intelligence, is the nextagricultural iteration and the current one.The adoption of new technologies has significantly enhanced agricultural activities through the development of low-cost sensor and network platforms. These platforms aim to improve production efficiency while reducing the negative effects on the environment and reducing the utilization of energy and water resources.

Smart farming

Also known as Farming 4.0 or digital farming, smart farming is the application of information and data technologies to optimise complex farming systems. It involves individual machines and all farm operations. Introducing innovative technologies into agricultural activities is the essence of smart farming.Big data, the Internet of Things, drones, satellites, artificial intelligence and other technologies have made agriculture and farming "smart" enabling producers to maximize productivity and achieve superior outcomes.As a result, agribusiness becomes more cost-effective by decreasing the manual labour percentage, lowering financial expenses and increasing production volumes.

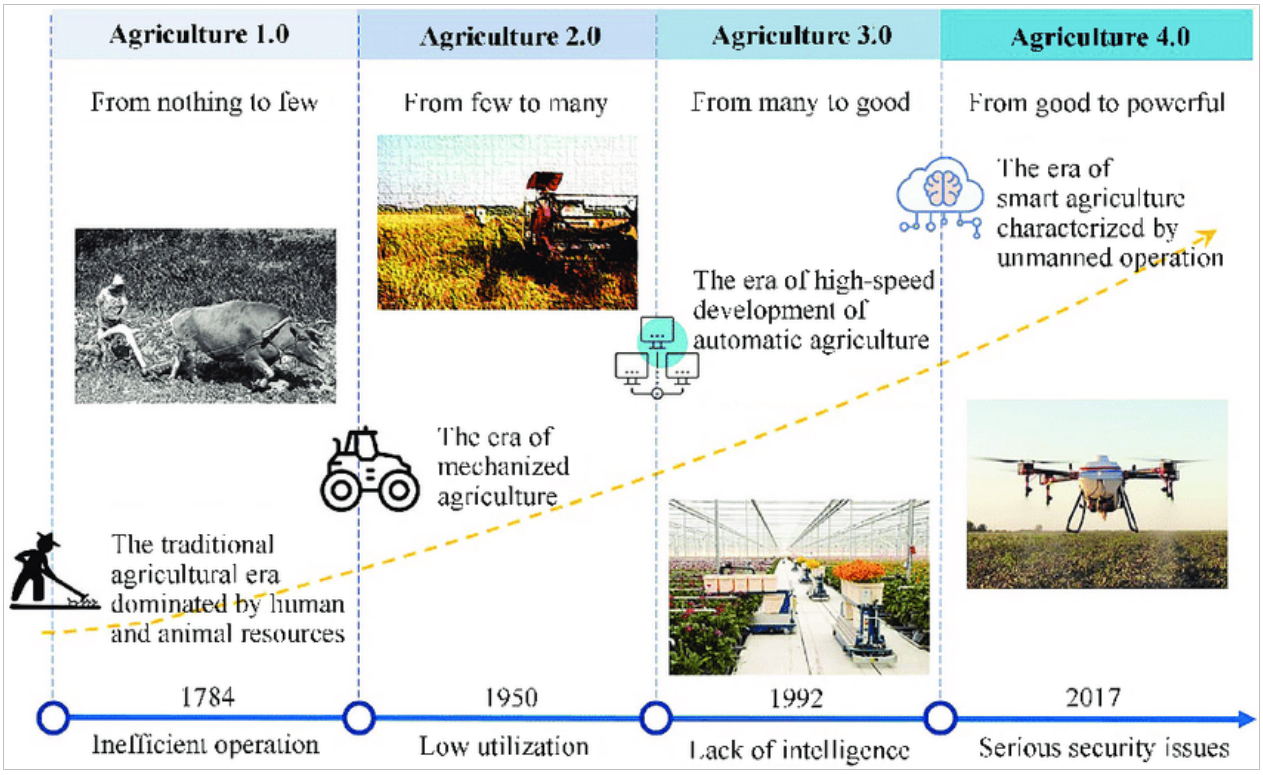

Figure 1. Characteristics and confronted issues of agriculture development (from Agriculture 1.0 to Agriculture 4.0).

Advantages of Smart Farming

Smart farming generally offers growers the following benefits:

- Accelerating data collection and processing
- Elevating the level of precision and accuracy
- Improving the efficiency of production
- Lowering the production expense
- Reducing the requirement for manual labour
- A rise in crop productivity
- Streamlining the forecasting of risks
- Simplifying the process of recording and reporting tasks
- Increasing sustainability

In addition to farmers, other users can benefit from smart farming techniques such as satellite image analysis, mobile apps, drones and robotic systems. Financial institutions, cooperatives in agriculture, input suppliers, insurance agents and so forth can use them.

Technologies of Smart Farming

The word "smart farming" refers to a broad range of instruments and technological advancements for improving agricultural operations. The following are some of the most useful and practical smart farming tools:

1. **Machine learning:** With self-learning technologies,you can forecast changes in content of carbon, pestand disease spread, soil, climate and water parameters and more.

2. **Smart farming sensors:** Farmers can track even the smallest alterations in the situation of their fields and surroundings in real time with the aid of sensitive sensors.

3. **Satellites and drones with cameras:** Growers can remotely monitor the territory and make updated

maps without having to visit the field with their assistance.

4. **Big data:** It is inconceivable to think of activity scheduling, accurate forecasting, or creating more effective business models without them. Smart farming and big data give you the ability to take immediate action and make long-term decisions.

5. **Internet of Things (IoT):** Provides you with the chance to integrate all of theinstruments and fixes into a unified system. Every software and device have the ability to share data and carry out particular tasks according to patterns.

IoT Smart Farming Solutions

Managing a vast network of drones, sensors, apps and other agricultural equipmentand software is difficult. Using wireless connections and the internet, smart farming (IoT) in agriculture resolves this issue by merging all available data sources into a single working system.

This smart farming method optimizes the utilization of fuel, electricity, water and fertilizer while lowering waste and increasing overall plant productivity.Additionally, farmers are able to ascertain the optimal tasks automated and which ones should stay in manual mode based on the specifics of their business and sensor data. Leading options that IoT-based smart farming can provide include:

- Unique microclimates insmart greenhouses
- Supervising pastures and livestock from a distance
- Drones are utilized for territory monitoring
- Financial analytics and long-term forecasts
- Accurate irrigation
- Astute control of diseases and pests
- Crop and harvest monitoring
- Monitoring and forecasting weather conditions in farming

Smart farming IoT solutions are intricate projects that can be costly to launch, but over time they prove to be more economical than conventional farming techniques.

Mobile Apps and Smart Farming Software

Smart farming systems integrate software components, such as mobile applications and programs, with hardware components, such as sensors and drones.Farmer access to device data and tools configuration and management are provided by the second section of this complex.A smart farming platform that has been thoroughly chosen enables experts to process data rapidly, decide on the best course of action, and modify their course of action in real time. For instance, mobile applications andprograms that utilize previous information on crop rotation acquired from satellite images and technical guidelines for cultivating particular crop varieties can suggest the most beneficial planting plan.

The utilization of smart farming platforms and apps takes agricultural analytics to an unprecedented level. With their assistance, farmers improve their procedures throughout the growing season, enhancing business profitability, lowering labour expenses, and helping to preserve the environment.

Difficulties and Problems in Smart Farming Implementation

1. Cost of Technology:Current technologies reduce the necessityfor labour and accomplish tasks very quickly and accurately. As a consequence, it is expected that in the immediate future, machines will most likely replace human labour. It is unfeasible, though, as poverty has been experienced in numerous nations where the labour force served as the primary driver for the agricultural sector. The cost of implementingtechnologies and

devicesis very high, so when farmers explore for alternatives to conventional tools, they encounter financial Challenges.

2. Lack of Financial Resources: Financial supporters could offer sufficient loans to agricultural producers if farmers did not receive the expected yield, perhaps as aconsequence of unanticipated disasters like flood,drought, diseases and pests affecting the crops.

3. Farmer Literacy status: One of the biggest obstacles to using technologies in developing nations is the educational attainment of farmers. To operate the tools, one must possess both technical and educational knowledge. The education level helps farmers use computers more easily since it improves their ability to process data and use smart farming techniques to make decisions. The majority of farmers in developing nations lack education and skills due to a lack of interest in learning new things or being aware of new technologies. For this reason, farmers prefer traditional farming than smart farming.

4. Lack of System Integration: Advancement of smart farming technologies requires further integration across systems, encompassing production, property management and decision-making tools. Effective communication among scholars and interdisciplinary teams should address the divide between information science and agriculture.The progress of an information system has prioritized enhancing user effectiveness. Improved decision-making relies on the timely availability of high-quality data; therefore, data integration is essential to generate knowledge and information.

5. Infrastructure for Telecommunications: Agriculture-related activitiesare predominantly concentrated in rural regions, with arable land being more suitable than lands contaminated. However, data transmission is unreliable due to inadequate telecommunications infrastructure, particularly when using tablets and mobile phones. Smart farming needs continuous internet connectivity to utilize information effectively. Furthermore, a strong internet connection is necessary for the operation control systems that regulate seed volume, fertilizer and pesticides to produce output.

6. Data Management:Farmers encounter challenges in arranging and processing data collected by sensors. The weather stations produce data, yet farmers lack the understanding of how to utilize the information and transform the data into a more accessible format. Its intricate systems cause inaccurate calculations besides issues with acceptability and usability.Consultants, farmers and other stakeholders in the production procedures need to enhance accessibility to data and information within productive systems.

Conclusions

In order to meet the demands of an expanding global population for food and the problems of declining arable land, smarter and effective crop production techniques are required. The development of new technologies to boost crop yield and promote farming as a respectable career choice for creative youth. This paper focused on how various farming technologies, especially the Internet of Things, can make agriculture more effective and smarter in order to meet future demands. Thus, it is crucial to manage every square inch of land with sustainable Internet of Things (IoT)-based sensors and communication technologies in order to maximize crop productivity.

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