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Enhancing Crop Production through Digital Agriculture: A Review of Emerging Trends and Technologies

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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Review Article

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ABSTRACT

Digital agriculture means using various technologies and their various processes, which leads to a significant moral development in improving agricultural production and addressing the challenges of feeding the world's growing population, and striving to achieve sustainable global food security. One of the most practical tools for this type of advanced agriculture is the rapid collection of data and the ability to analyze it. Through various tools such as drones, satellite imagery, and sensors, farmers can collect real-time information about their agricultural holdings, including soil moisture levels, nutrient content, and real-time resource monitoring. This data-driven forecasting enables farmers to make informed choices regarding irrigation, fertilization, and damage management, leading to more efficient use of resources and crop productivity. Digital agriculture facilitates the implementation of precision agriculture techniques. Through GPS technology and advanced machinery, it enables precise planting of seedlings, application of inputs, and witnessed creeping on the racer. This level of precision not only reduces the waste of cherry resources, but also increases each plant, which will ultimately lead to increased vegetables and profitability. In addition

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to improving necessity, digital agriculture plays an important role in the sustainable production of vegetable crops. By relying on precision irrigation, for example, farmers can reduce water use and mitigate the environmental impact of irrigation use. To achieve this goal, targeting of drugs and pesticides relies on specific chemical runoff parameters, which leads to harmful effects on multiple ecosystems and biodiversity. Therefore, the task of this assignment is to explore the diverse applications of digital agriculture, considering their impact on the need, sustainability and overall agricultural productivity. This review provides an overview of the importance of digital agriculture applications in improving field crop productivity and it provides farmers with an idea on how to invest digital agriculture in their field work.

Keywords: Digital technology; sustainability; process; smart transformation.

1. INTRODUCTION

Innovations in science and technology, especially in areas such as information and communication technology and biotechnology, are causing a major transformation in the global economy, and this has been greatly facilitated by the digital revolution and developments such as the Internet, the web, mobile communications, satellite communications, cloud computing, geospatial technologies, computers, genetic engineering, wireless sensor networks, plant tissue culture, and others [1]. Ubiquitous computing and analytics tools are enabling the development of many new farming and agriculture concepts, and this trend has led to the emergence of a new discipline called precision agriculture or digital agriculture. In the context of agriculture, “precision agriculture” usually refers to the way satellite, computer, and soil monitoring technologies are used in crop management [2]. Digital agriculture technology has gradually been accepted as a technical service that serves various elements of crop production to improve their efficiency and sustainability, especially for large farms. Precision agriculture uses cutting-edge technology to increase agricultural productivity while minimizing environmental impacts. Smart digital agriculture is an advanced approach that harnesses advanced technology and data analytics and processing tools to improve plant growth and productivity, and is a critically important solution to many of the major problems facing current agriculture, such as ensuring adequate food supply amidst a rapidly growing population [3].

There is an urgent need to improve traditional breeding design methods to develop different crop genotypes that are able to withstand the current negative impacts of ongoing climate change. Modern and multiple digital methods such as the Internet of Things, artificial intelligence, big data analysis and remote information transfer are important in improving and developing crop production methods. In crop breeding, digital agriculture suffers from a clear shortcoming in this area in terms of the genetic gains it can provide to improve crop production. However, crop production will improve significantly with the development and improvement of smart digital technologies, which in turn will lead to increased agricultural production and productivity [4].

The importance of the research lies in the potential importance of digital agriculture applications in improving agricultural production methods in general and crop production methods in particular, and achieving agricultural sustainability by highlighting the most important digital agriculture applications, and the impact that these applications can have on sustainable agricultural production processes.

2. METHODOLOGY

The information used in the study was used through studies and research conducted by many researchers, which included different types of secondary data, and focused on the most important applications of digital agriculture and its role in sustainable agricultural development. The data was collected from published scientific papers that addressed the concept of digital agriculture and the importance of investing in it to achieve sustainable agricultural growth.

3. RESULTS AND DISCUSSION

3.1 The Most Important Applications of Digital Agriculture

3.1.1 Artificial intelligence (AI)

Studies are now moving towards agricultural modernization using modern smart technologies

to find solutions for the efficient use of scarce resources there by meeting the ever-increasing consumption needs of the world's population. With the emergence of the Internet of Things and digital transformation in rural areas, these technologies can be used to monitor soil moisture and crop growth remotely and take preventive measures to detect crop damage and threats. The use of AI-based analytics to quickly analyze operational data such as weather services, expert advice, etc., to provide new insights and improve decision-making by enabling farmers to implement "smart agriculture". Remote management and automation of agricultural activities using new technologies is the focus of this research activity [5]. Several studies have pointed to the harnessing of artificial intelligence and the Internet of Things for crop management, the transformative impact of digital technologies in agriculture, and the need to integrate the Internet of Things (IoT), cloud computing, and artificial intelligence (AI) in promoting sustainable agricultural practices. IoT technologies enable real-time monitoring of agricultural conditions using sensors and drones, while cloud computing provides powerful data processing capabilities. AI leverages this data to conduct predictive analyses of crop yields, detect diseases, automate agricultural operations, improve resource use, and adapt to climate change [6].

Artificial intelligence is a very important tool in improving agricultural production methods, and it enters into many agricultural stages from selecting suitable varieties according to soil type and climate to suggesting the best types of fertilizers and pesticides according to the condition of the cultivated crop, thus increasing the quality of production and enhancing sustainability. Moreover, the article discusses the importance of space technologies in smart agriculture, and presents developments such as drones and big data analytics. These innovations are crucial in developing economies, addressing global challenges such as food security and contributing to economic growth [6].

3.1.2 Precision agriculture (PA)

Precision agriculture includes a set of technologies that combine sensors, information systems, optimized machinery, and informed management to optimize production by considering variability and uncertainty within agricultural systems. Specifically allocating production inputs to each plant or animal species on the farm allows for the best service and the best quality and quantity of products. Precision agriculture is an important method for evaluating and monitoring the stages of plant and food production, and assessing the quality of agricultural products and their derivatives [7]. Precision agriculture involves the use of advanced technologies such as GPS, soil moisture sensors, and drones to monitor and manage field variability. This approach allows farmers to use inputs—such as water, fertilizers, and pesticides more efficiently, resulting in optimal plant growth and reduced costs. For example, precision irrigation systems can significantly reduce water waste by delivering the exact amount of water needed directly to the root zones of crops [8]. Precision agriculture relies on the interconnection of advanced sensors and modern digital tools to achieve a qualitative shift in the concept of modern agriculture. This agriculture relies on the use of various sensors and multiple digital technologies such as big data processing, the Internet of Things (IoT), and artificial intelligence (AI), and their use in the field of developing crop production and improving production processes, and working to achieve comprehensive agricultural sustainability based on digital scientific foundations. This comprehensive integration process helps to achieve the maximum possible benefit from digital development and to achieve the greatest possible level of digital awareness and education for agricultural producers [9]. Precision agriculture is the ideal integration of digital technologies into crop and animal management and other agricultural operations. For farmers, precision agriculture offers the opportunity to increase production, save costs in the long run and eliminate risks, and agricultural researchers see it as a data collection tool that has the potential to simplify data collection and analysis, and improve predictive skills when it comes to crop management, animal behavior and production. Digital agriculture relies on a database that includes many types of large agricultural data, from soil analysis to studying agricultural product markets, weather conditions and plant conditions, which facilitates the process of making the right decision that suits each stage of agricultural production [10]. The introduction of precision agriculture allows for market study and determination of supply and demand through modern digital tools, simulation models and real-time market monitoring, quality maintenance throughout the life cycle of agricultural products, and increased daily productivity [11].

3.1.3 Remote sensing (RS)

Modern sensors are used in many services and processes related to agricultural production such as robotics, digitization, and underwater photography. Sensors supported by artificial intelligence play an important functional role in the field of smart agriculture. Artificial intelligence adds a special quality to the results of remote sensing, and the emergence of Internet of Things (IoT) tools and the development of their use and widespread spread have led to the development and increase in the effectiveness and efficiency of tools that rely on sensing and sensors [12]. Several extensive studies have been conducted on the advancements in smart sensors and IoT, used in remote sensing and agriculture applications such as assessment of weather conditions and soil quality, crop monitoring, use of robots in harvesting and weeding, and deployment of drones [12].

Remote sensing technologies have enhanced the ability of farmers to monitor crop health and field conditions from a distance. Satellite images and drones equipped with multispectral cameras provide insightful information about plant health that cannot be seen with the naked eye. These tools can detect stress in crops, such as nutrient deficiencies or disease outbreaks, allowing for timely interventions that can save crops and resources. Furthermore, remote sensing aids in soil management by providing information on soil composition and moisture levels, which are essential for efficient crop production [13]. Multispectral technology plays a very vital role in digital agricultural operations. It provides important digital data during the different stages of crop production, and provides researchers and producers with very important information such as growth analysis, pest control, pesticide application, fertilizer application dates and rates, plant variety identification, plant morphological characteristics, and their prevalence and distribution [14]. The sensors in the fields allow access to clear and distinct digital data and digital maps of the field location and the resources that can be obtained and entered into production processes. They also provide researchers with accurate information about the soil properties and climatic data for the area under study [11].

3.1.4 Internet of things

The Internet of Things is an important and reliable advanced means that provides the most appropriate solutions to many current agricultural problems, and facilitates the smart digital management of agricultural production processes, thus reducing and avoiding human errors, and thus increasing the accuracy and efficiency of the production process. It is a technology that can be continuously developed. The reliance on network technologies used in IoT-based agriculture has increased, including network architecture and layers, network topology and protocols. It is important to note the relationship of IoT-based agricultural systems with related technologies such as cloud computing, big data storage and analytics. There are many applications based on smartphones and sensors designed for various aspects of farm management [11]. The emergence of the Internet of Things (IoT) and sensor technology has played a pivotal role in smart agriculture. Sensors deployed in agricultural environments collect real-time data on parameters such as temperature, humidity, and soil moisture. This data is transmitted via IoT networks, enabling remote monitoring and management of agricultural operations, leading to improved decision-making and resource optimization. Precision agriculture is an innovative and futuristic solution, using technologies such as GPS, drones, and remote sensing. These tools help farmers analyze field reality and accurately evaluate production processes, leading to increased efficiency, reduced resource waste, and improved crop productivity [15].

3.2 Smart Crop Management through Networking of Digital Agriculture Tools

The interconnection of various digital agriculture applications supported by artificial intelligence and other modern digital tools has led to the creation of new methods for managing fields and farms in a modern, more qualitative and sustainable way. For some crops such as sugarcane, this integration has reduced production costs, enhanced input applications, allowed communication between devices and different data sets, and improved the sustainability of agricultural systems. Digital mechanization means applying digital methods in operating and controlling machines. Digital transformation has performed many functions such as monitoring the operation of mechanical machines in real time, controlling and evaluating automatic

processes, and their efficiency in management [16].

Emerging technologies, including precision agriculture, the Internet of Things (IoT), artificial intelligence (AI), blockchain technology, and many more, have emerged as powerful tools to address these challenges in the agricultural sector. These technologies have revolutionized agricultural practices, resource management, market access, and rural livelihoods, and the role of precision agriculture in improving resource use, the Internet of Things and remote sensing in data-driven decision-making, artificial intelligence in crop management, and blockchain in supply chains is deepening. The importance of digital financial services to improve financial transactions in remote areas far from city centers, and the importance of responsible adoption, regulatory frameworks, and equitable access to ensure that emerging technologies benefit everyone, especially smallholder farmers and marginalized communities [17] is also highlighted. The benefits of digital agriculture applications extend beyond individual farms; they contribute to global food security by enabling higher levels of production on existing farmland. With the increasing population growth, the challenge of feeding this population requires innovative solutions. Digital agriculture not only enhances productivity, but also supports sustainable practices that protect the environment. By reducing input waste and improving resource use, these digital solutions help mitigate the role of agriculture on climate change [18]. In a study to identify smart management methods for crop production operations that rely on coordination between various digital tools, In a recent study on current digital methods introduced into agricultural operations, such as the Internet of Things, artificial intelligence, and smart sensing, to increase the efficiency of agricultural operations and the quality of agricultural products in a sustainable manner, the results indicated that coordination between various digital agriculture tools, artificial intelligence, and other modern digital capabilities can provide researchers and producers with real-time data about their crops, identify and evaluate soil properties, irrigation water, pest density and prevalence, and other environmental factors, and reach sound planning and make accurate decisions based on the digital data provided as a result of linking various digital tools. This can also be enhanced by the integration of tools such as drones, which can increase monitoring capabilities through comprehensive field surveys and track crop growth with high accuracy. On the other hand, big data analytics and artificial intelligence are crucial in analyzing comprehensive datasets to uncover patterns and trends and provide valuable insights to improve agricultural practices [19].

To interpret the large amounts of data provided by modern digital agriculture technologies, this data must be analyzed using the most advanced digital tools and programs, and here the importance of digital agriculture in agricultural data analysis emerges. By processing, analyzing, understanding, and linking historical data with current data in real time, farmers can make informed decisions about planting dates, sustainable crop rotations, and pest management. Continuously evolving smart agriculture programs can predict potential yields based on various factors such as weather and soil [20]. The advent of mobile applications has also made digital agriculture accessible to farmers of all levels. These applications provide users with weather forecasts, market prices, and agricultural advice tailored to local conditions. By using mobile technology, even small-scale farmers can incorporate modern practices into their operations, promoting more sustainable agriculture. For example, farmers in developing regions can use applications to access expert advice and market opportunities, which enhances their productivity and income [21].

4. CONCLUSION

Digital agriculture applications in crop production represent a major advance in the way we approach agriculture today. The use of precision agriculture, data analytics, and remote sensing has transformed traditional practices into a modern and efficient system capable of meeting the demands of the world's growing population. As technology continues to evolve, the potential for further innovations in crop production will increase, so embracing this digital transformation is essential to improving agricultural practices in the future and ensuring food security in a sustainable manner. From the above, the study recommends the need to educate farmers about these digital applications as this education will be vital in creating a resilient agricultural sector for future generations. This review recommends that digital production methods should be adopted to improve the

quality and quantity of agricultural crop production.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Clapp J, Ruder SL. Precision technologies for agriculture: Digital farming, gene-edited crops, and the politics of sustainability. Global Environmental Politics. 2020;20(3):49-69.
2. Duncan E, Glaros A, Ross DZ, Nost E. New but for whom? Discourses of innovation in precision agriculture. Agriculture and Human Values. 2021;38: 1181-1199.
3. Karunathilake EMBM, Le AT, Heo S, Chung YS, Mansoo S. The path to smart farming: Innovations and opportunities in precision agriculture. Agriculture. 2023;13(8):1593.
4. Siyunda AC, Chikalipa E, Ramtekey V, Mbuma N, Mwala M, Mwila NM, Nshimbi D. Digital Technologies in Crop Genotype Designing Methods: Scope, Limitations and Future Perspectives. Asian Journal of Research in Crop Science. 2023;8(4):264-272.
5. Navulur S, Prasad MG. Agricultural management through wireless sensors and internet of things. International Journal of Electrical and Computer Engineering. 2017;7(6):3492.
6. Alazzai WK, Obaid MK, Abood BSZ, Jasim L. Smart Agriculture Solutions: Harnessing AI and IoT for Crop Management. In E3S Web of Conferences. EDP Sciences. 2024;477:00057.
7. Gebbers R, Adamchuk VI. Precision agriculture and food security. Science. 2010;327(5969):128-129.
8. Zhang L, Sun R, Wang F. Precision irrigation based on soil moisture sensors. Agricultural Water Management. 2019;216:182-194.
9. Soussi A, Zero E, Sacile R, Trinchero D, Fossa M. Smart sensors and smart data for precision agriculture: A review. Sensors. 2024;24(8):2647.
10. Mihalache DB, Vanghele NA, Petre AA, Cioboata MN. Inteligent systems used in modern agriculture. Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series. 2021;51(2): 367-372.
11. Kumar L, Ahlawat P, Rajput P, Navsare RI, Singh PK. Internet of things (IOT) for smart precision farming and agricultural systems productivity: A review. IJEAST. 2021;5: 141-146.
12. Ullo SL, Sinha GR. Advances in IoT and smart sensors for remote sensing and agriculture applications. Remote Sensing. 2021;13(13):2585.
13. Everett L, Wang H, Johnson C. Remote sensing applications in precision agriculture. Precision Agriculture. 2018; 19(2):123-145.
14. Zhang Y, Zhao D, Liu H, Huang X, Deng J, Jia R, Lan Y. Research hotspots and frontiers in agricultural multispectral technology: Bibliometrics and scientometrics analysis of the Web of Science. Frontiers in Plant Science. 2022; 13:955340.
15. Abd El Kareem Gomaa H. Modern trends in the development of smart agriculture projects. International Journal of Modern Agriculture and Environment. 2022;2(1): 33-44.
16. Molin JP, Wei MCF, da Silva ERO. Challenges of digital solutions in sugarcane crop production: A review. Agri Engineering. 2024;6(2):925-946.
17. Saikanth DRK, Ragini M, Tripathi G, Rajesh K, Giri A. The impact of emerging technologies on sustainable agriculture and rural development. International Journal of Environment and Climate Change. 2024;14(1):253-263.
18. Kumar V, Singh A, Kumar M. Digital agriculture: Strategies for sustainable production. Food Security. 2020;12(5): 1005-1020.
19. Fuentes-Peñailillo F, Gutter K, Vega R, Silva GC. Transformative technologies in digital agriculture: Leveraging internet of things, remote sensing, and artificial intelligence for smart crop management. Journal of Sensor and Actuator Networks. 2024;13(4):39.

20. Wolfert S, Ge L, Verdouw C, Bogaardt MJ. Big data in smart farming – A review. Agricultural Systems. 2017;153:69-80.

21. Jain R, Kumar V, Singh A. Mobile applications in agriculture: A study of features, applications, and adoption. Agricultural Systems. 2020;179:102764.

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