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Developing a Smart Agricultural and Sustainable Farming Model by Amalgamating AI Algorithms and IOT Tools and Techniques

Suchit Lamba

NIIT University, Neemrana, Rajasthan, India

ABSTRACT

In recent years, there has been a growing emphasis on leveraging technologies such as AI and IoT in farming, alongside advancements in computer science. This shift reflects recognition of the potential of these technologies in agriculture, which has long been pivotal for human sustenance. Notably, effective agricultural practices have been instrumental in supporting various crop types over millennia. The emergence of sophisticated IoT capabilities holds promise for monitoring agricultural ecosystems and ensuring high-quality production. However, Smart Sustainable Agriculture (SSA) encounters significant challenges, including the widespread dispersion of agricultural procedures, issues related to IoT and AI device deployment and management, data sharing and governance, interoperability, and the handling of vast quantities of data. This study explores existing IoT technologies utilized in SSA to identify architectural components that could facilitate SSA platform development. Additionally, it evaluates the current landscape of research and development in SSA, underscores existing information gaps, and proposes an IoT and AI framework as a foundational approach for SSA.

INTRODUCTION

Sustainable agriculture is defined by its ability to maintain long-term viability and ecological harmony in grain production practices. It encompasses techniques and methodologies that support the enduring well-being of both humans and natural resources. Financially feasible, sustainable agriculture safeguards soil quality, mitigates soil degradation, conserves water resources, fosters land biodiversity, and ensures a healthy, natural environment. This approach is pivotal in preserving natural resources, curbing biodiversity loss, and reducing greenhouse gas emissions. Ultimately, sustainable agriculture aims to uphold the integrity of nature while safeguarding the ability of future generations to meet their essential needs.

Furthermore, sustainable agriculture serves as a method to enhance farming efficiency. Its effectiveness largely stems from the core achievements of precision farming, such as crop rotation, nutrient management, pest and disease control, recycling, and water conservation. These advancements contribute to creating a safer world overall.

Nevertheless, the impact of sustainable agriculture is increasingly overshadowed by challenges such as a growing global population, escalating hunger, rapidly changing climate conditions, resource overuse, and food and water wastage. Addressing these challenges requires the development of technologies and infrastructure capable of meeting both present and future demands. Throughout history, technological innovations have been crucial for agricultural development, from ancient times to the present day, as depicted in Figure 1. Milestones such as the invention of basic tools, utilization of animals, introduction of fertilizers and pesticides, adoption of small machinery, and deployment of robots have driven the evolution of agriculture to its current state.

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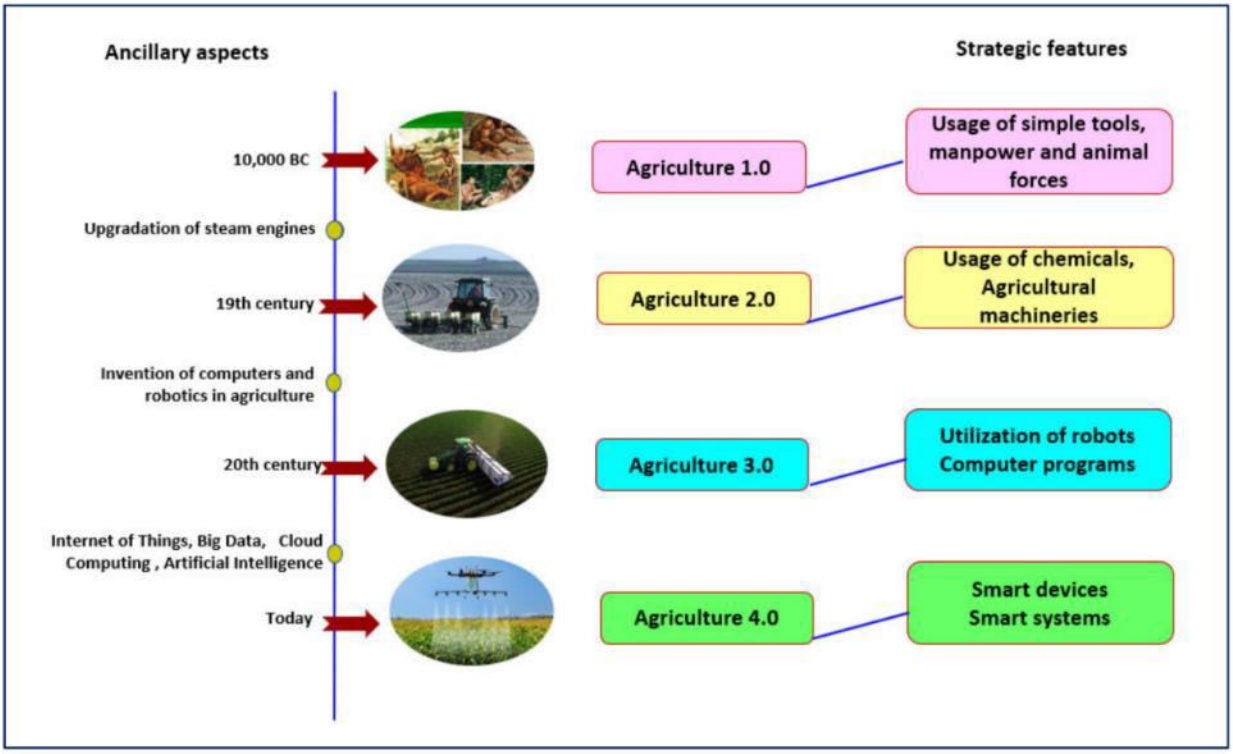

FIGURE 1. Upgradation of agriculture.

Currently, with the integration of smart technology, agriculture is on the brink of transitioning into a smarter domain.

Smart farming has emerged as a critical aspect of sustainable agriculture. Traditionally, significant investments of time, money, and effort are required in various stages of crop cultivation, processing, transportation, and marketing. Smart farming technologies offer solutions to these challenges, presenting more efficient methods for agricultural operations.

Moreover, agriculture faces threats from pesticides, adverse environmental conditions, and declining soil, air, and water quality due to pollution. Biodiversity, crucial for the survival of species, is particularly vulnerable to contamination from waste emissions, pesticide use, decomposed plant matter, and other factors. Given the impact of greenhouse gas emissions on living organisms and the environment, creating a conducive atmosphere for life becomes imperative.

In India, agriculture significantly contributes to the GDP, employing a large portion of the rural population. However, despite overall agronomic growth, there has been a decline in the number of farmers over the years. Economic factors, inadequate soil maintenance, and migrations to non-farming occupations contribute to this decline. To address these challenges, integrating wireless technology into the agricultural landscape can facilitate digital interaction among farmers, crucial in the current technological era.

However, agricultural land is limited and faces various constraints such as soil quality, terrain, temperature, and climate. Additionally, political, budgetary, and urbanization factors contribute to land fragmentation, putting pressure on arable land availability. In recent years, there has been a decrease in the percentage of agricultural land used for

food production. Furthermore, optimizing crop production requires monitoring soil quality, irrigation flow, nutrient presence, and pest resistance, necessitating different approaches in space and time.

The integration of IoT and AI holds promise for enhancing productivity, reducing waste, and meeting consumer food demands. Various studies highlight the extensive potential applications of AI and IoT in agriculture, as depicted in Figure 2.

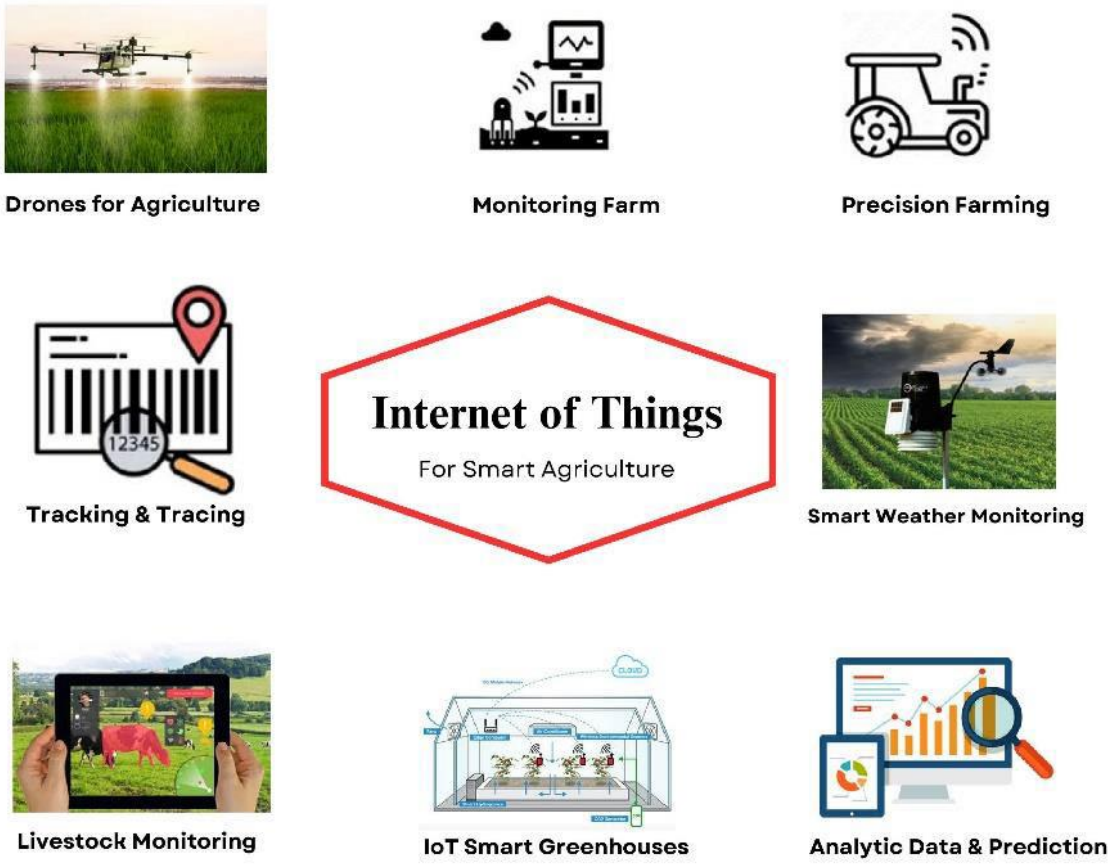

FIGURE 2. IoT for Smart agriculture.

A. SMART GREENHOUSES IN AGRICULTURE

Smart greenhouses utilize the Internet of Things (IoT) to optimize crop yield through proportional control systems. Equipped with sensors, these greenhouses create a regulated environment for crops, remotely monitored and data processed via cloud servers [4]. By tracking temperature, light, and humidity levels, smart greenhouses reduce the need for human intervention while ensuring optimal growing conditions.

B. DRONES FOR AGRICULTURE

Versatile drones, capable of ground and aerial operations, play a crucial role in agriculture. They assess crop health, monitor infestations, and examine soil efficiently. Additionally, drones collect real-time field data, sow seeds, manage irrigation systems, and spray crops [5]. The acquired information enables production forecasts, nutrient level evaluation, and external impact mapping.

C. SYSTEMS FOR PRECISION FARMING

Precision farming stands out as a common application of agricultural technology, offering services such as variable rate irrigation (VRI) optimization and soil moisture testing. Leveraging sensors, autonomous equipment, and internet connectivity, precision farming optimizes water resource utilization efficiently.

D. SOLUTIONS FOR TRACKING AND MONITORING LIVESTOCK

Wireless Internet of Things (IoT) networks and linked devices streamline livestock monitoring, reducing labor requirements. IoT devices accurately determine animal location and monitor health status, facilitating swift illness detection and isolation within herds. This proactive approach safeguards livestock health and minimizes costs.

E. SENSORS FOR CROP AND SOIL MONITORING

Robots and unmanned aerial vehicles armed with thermal or multispectral sensors continuously assess crop and soil conditions. This facilitates precise application of fertilizer and controlled watering, ensuring optimal crop nutrition. Additionally, AI analyzes soil features to select the most profitable crops for cultivation.

F. CURRENT WEATHER MONITORS

Smart sensors integrated with the Internet of Things gather real-time weather and climate data, aiding farmers in crop management decisions. Comprehensive weather projections enable farmers to protect crops against adverse weather conditions, ensuring crop safety and yield stability.

G. ROBOTS FOR AGRICULTURE

Agricultural robots reduce manual labor and save time by performing multiple tasks simultaneously on farms. They assist in agricultural monitoring and harvesting more effectively than humans, maintaining crop quality and preventing weed proliferation. These AI-equipped devices expedite produce sorting and packaging, enhancing output while minimizing negative environmental impacts.

H. DEVICES FOR ESTIMATING FUTURE HARVESTS AND PRICES

Farmers utilize various technologies, including AI, ML, and big data, to estimate crop yields and predict prices based on historical data analysis. Farm mapping enables accurate yield calculations per hectare, considering factors like precipitation, pesticide usage, and temperature [9]. These technologies aid in informed decision-making for optimal agricultural outcomes.

METHODOLOGY

This study conducted an analysis of papers sourced from various periodicals and conference proceedings from reputable scholarly outlets, focusing primarily on predictive analytics in agriculture. The research methodology encompassed a literature review, initiated by searching for information on agriculture and related practices across prominent academic databases such as Scopus, IEEE, and Science Direct. Key search terms included 'smart farming,'

'irrigation facilities,' 'AI and IoT in farming,' 'Implementation of technology in agriculture,' and 'the situation of farming in India.'

The initial filtering process involved assessing the quality of journals and the publication year of articles. Titles and abstracts were then scrutinized, and a minimum of 20 relevant articles were documented to gain perspective. Further refinement involved selecting ten papers based on specific criteria outlined by their titles. Subsequently, a summary of ten distinct research articles was compiled, highlighting recent advancements in technological agricultural operations.

An emphasis was placed on the operational aspect of implementation approaches identified within the selected papers. Through a comprehensive analysis of each paper, proposed strategies were evaluated and integrated into the study's framework.

RESULTS AND DISCUSSION

The agricultural industry has embraced AI with enthusiasm, aiming to revolutionize food production methods and reduce sector emissions by 20%. AI plays a crucial role in managing and regulating unforeseen natural occurrences, enhancing agricultural efficiency, and minimizing undesirable outcomes through data processing.

Recent studies have highlighted various initiatives promoting smart farming practices, including the digitalization of farm cooperatives, the emergence of agricultural start-up ecosystems, and government-led digital farming projects. Efforts also focus on modernizing farmer-producer organizations to improve collective farming practices.

Unmanned aerial vehicles (UAVs) are extensively utilized in agriculture, offering valuable assistance to farmers and creating employment opportunities in rural areas. As the agricultural sector progresses, increased investment in affordable drones is anticipated to further enhance farming practices and information accessibility.

Government support, including funding and incubator operation, fosters an environment conducive to the growth of farm technology businesses. Initiatives like "AI for all" demonstrate a commitment to advancing technological solutions across the agricultural sector.

The Government of India has formulated comprehensive guidelines through NITI Aayog to foster the development of India's AI ecosystem. Encouragingly, projections indicate that agriculture will undergo significant structural improvements in the near future.

CONCLUSION

This study underscores the critical role of contemporary computer technologies, particularly AI and IoT, in the agricultural industry's success. Agriculture, vital for human sustenance, can enhance efficiency, quality, and quantity of produce by integrating modern IoT and AI technologies into existing farming practices.

The analysis of current IoT and AI technologies, based on primary research journals in agriculture, has provided insights into key aspects of intelligent and sustainable agriculture. These aspects encompass crops, human resources, soil, weather, fertilizers, agricultural products, pests, irrigation/water, animals, machinery, and fields.

A significant contribution of this paper is the proposed AI or IoT technology framework for Smart Sustainable Agriculture (SSA). This framework addresses challenges arising from the fragmented nature of farming production, aiming to integrate AI and IoT platforms effectively. This endeavor aims to resolve existing issues and enhance agricultural sustainability and productivity.

REFERENCES

1. J.Wu, L. Ping, X. Ge, Y.Wang, and J. Fu, ‘‘Cloud storage as the infrastructure of cloud computing,’’ in Proc. Int. Conf. Intell. Comput. Cogn. Inform. (ICICCI), Kuala Lumpur, Malaysia, Jun. 2010, pp. 380–383.
2. J. Roux, C. Escriba, J. Fourniols, and G. Soto-Romero, ‘‘A new bi-frequency soil smart sensing moisture and salinity for connected sustainable agriculture,’’ J. Sensor Technol., vol. 9, pp. 4–35, Sep. 2019.
3. L. Nóbrega, P. Gonçalves, P. Pedreiras, and J. Pereira, ‘‘An IoT-based solution for intelligent farming,’’ Sensors, vol. 19, no. 3, p. 603, Jan. 2019.
4. K. Gai, M. Qiu, H. Zhao, L. Tao, and Z. Zong, ‘‘Dynamic energy-aware cloudlet-based mobile cloud computing model for green computing,’’ J. Netw. Comput. Appl., vol. 59, pp. 46–54, Jan. 2016.
5. K. Lakhwani, H. Gianey, N. Agarwal, and S. Gupta, ‘‘Development of IoT for smart agriculture a review,’’ in Proc. ICETEAS, Nov. 2018, pp. 425–432.
6. C. V. Raja, K. Chitra, and M. Jonafark, ‘‘A survey on mobile cloud computing,’’ Int. J. Sci. Res. Comput. Sci., Eng. Inf. Technol., vol. 3, no. 3, pp. 2096–2100, Mar./Apr. 2018.
7. S. S. Kale and P. S. Patil, ‘‘Data mining technology with fuzzy logic, neural networks and machine learning for agriculture,’’ in Data Management, Analytics and Innovation (Advances in Intelligent Systems and Computing), vol. 839, V. Balas, N. Sharma, and A. Chakrabarti, Eds. Singapore: Springer, Sep. 2019.
8. S. Rajeswari, K. Suthendran, and K. Rajakumar, ‘‘A smart agricultural model by integrating IoT, mobile and cloud-based big data analytics,’’ in Proc. Int. Conf. Intell. Comput. Control (I2C2), Jun. 2017, pp. 1–5.
9. S. J. Russell and P. Norvig, Artificial Intelligence: A Modern Approach. Malaysia: Pearson, 2016.
10. E. Alreshidi, ‘‘Smart sustainable agriculture (SSA) solution underpinned by Internet of Things (IoT) and artificial intelligence (AI),’’ Int. J. Adv. Comput. Sci. Appl., vol. 10, no. 5, pp. 93–102, 2019.
11. A. A. Jagadale, ‘‘Role of IoT and AI in agriculture technology,’’ Int. J. Adv. Res. Sci. Commun. Technol., vol. 2, no. 2, pp. 257–268, Jun. 2022.
12. H. C. Punjabi, S. Agarwal, V. Khithani, V. Muddaliar, and M. Vasmatkar, ‘‘Smart farming using IoT,’’ Int. J. Electron. Commun. Eng. Technol., vol. 8, no. 1, pp. 58–66, 2017.
13. M. A. Uddin, A. Mansour, D. L. Jeune, M. Ayaz, and E.-H.-M. Aggoune, ‘‘UAV-assisted dynamic clustering of wireless sensor networks for crop health monitoring,’’ Sensors, vol. 18, no. 2, p. 555, Feb. 2018.
14. M. Alam and I. Khan, ‘‘IoT and AI for smart and sustainable agriculture,’’ presented at the Int. Conf. Comput. Techn. Intell. Mach. (ICCTIM), Bathinda, India, Nov. 2020.
15. M. S. Farooq, S. Riaz, A. Abid, K. Abid, and M. A. Naeem, ‘‘A survey on the role of IoT in agriculture for the implementation of smart farming,’’ IEEE Access, vol. 7, pp. 156237–156271, 2019.
16. S. S. L. Chukkapalli, S. Mittal, M. Gupta, M. Abdelsalam, A. Joshi, R. Sandhu, and K. Joshi, ‘‘Ontologies and artificial intelligence systems for the cooperative smart farming ecosystem,’’ IEEE Access, vol. 8, pp. 164045–164064, 2020.