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Smart Agriculture Using Internet Of Things: A Survey

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Abstract: Agriculture serves as the primary and most essential source of food products worldwide, while also being the backbone of a country's economic system. It not only provides food but also furnishes raw materials for various industries such as Textiles, Jute, Oil, Tobacco, etc. However, as the world population continues to grow, ensuring food security by supplying diverse varieties of food products has become increasingly crucial. In this regard, Smart Farming emerges as a promising concept that employs modern information and communication technologies to enhance the quantity and quality of agricultural products. Smart Agriculture incorporates the application of Internet of Things (IoT) technology, such as sensors, autonomous vehicles, hardware, and control systems like robots, to enhance livestock and farm monitoring. In this paper, we review various approaches to IoT-based Smart Farming to identify new opportunities for future research.

Index Terms **- Agriculture, Food Security, IoT, Smart Farming.**

I. INTRODUCTION

Based on a survey report [1], the global population is presently (in 2020) increasing at a rate of approximately 1.05% per year, resulting in an average population increase of around 81 million people annually. As the population continues to expand, it is essential to consider the number of individuals who are facing hunger and malnutrition. In many places, we require sufficient knowledge to collect reliable and timely data to estimate the severity of food crisis. Now, the disruption caused by COVID-19 pandemic may cause even more distress in the living community [2]. At this time of global challenges, it is crucial to redouble our efforts to defeat hunger and malnutrition by applying of emerging technologies. IoT based Smart Farming is an emerging technology in which a system with sensors for capturing light rays, measuring humidity, temperature, soil moisture, etc. and automating the irrigation with hardware components is built.

II. RELATED WORKS

Amine Faid et al. [3] presented a cost-effective architecture for Smart Farming that utilizes wireless sensor networks and supports plug-and-play nodes. They utilized a change point detection algorithm and leach protocol for network clustering, and the wireless sensor nodes of different types are responsible for transmitting data on soil moisture, ambient temperature, air quality, etc. to the corresponding cluster heads periodically. The Base Station collects, processes, and stores the collected data. However, the scalability and performance of the network depend on its size, and therefore, the algorithms need to be improved for network clustering and life expansion.

Anusha Vangala [4] presented a security architecture for Smart Farming based on blockchain technology. The proposal was developed after an extensive analysis of security aspects, application areas, benefits, limitations, and computational and communication costs involved. This work can be used as a guide for future research in the field. Kausik Sekaran [5] proposed a framework that integrates cloud computing with the

Internet of Things (IoT) to monitor crops, which can reduce farmers' time and energy while increasing crop productivity by reducing the wastage of resources in agriculture fields.

Muhammad Ayaz [6] emphasized the potential of wireless sensors and IoT in agriculture, identifying current and future trends along with potential research challenges. The use of IoT-based sensors and communication technologies is essential for precise monitoring of farmland. Muthunoori Naresh et al. [7] presented a concept in which various sensors empower agriculture to increase crop productivity. The authors also proposed future enhancements such as using particular hardware devices for spraying fungicides and pesticides. G. Vennila et al. [8] suggested that IoT devices could help collect information on climate, humidity, temperature, soil profitability, water level, bug territory, creature break into the field, and crop improvement.

Agrawal and Kamboj [9] discussed the role of IoT-based automated technologies in assisting infrequent farmers with soil fertility, weather conditions, crop growth, temperature, rainfall, and information about seed planting. This is achieved through the use of sensors, smart cameras, mobile applications, and devices such as mini chips. However, challenges such as extreme climate, increasing temperature changes, and the environmental impact of intensive farming practices need to be considered in future improvements. Abhiram MSD et al. [10] proposed an advanced IoT-based solution for monitoring soil conditions and the atmosphere to promote efficient crop growth. The system sends an SMS notification about environmental conditions to the farmer's phone using Wi-Fi. Vippon Preet Kour [11] explored recent IoT technologies in the agriculture sector and proposed a precision farming framework based on IoT, along with discussing current scenarios, applications, research potential, limitations, and future aspects of IoT in agriculture.

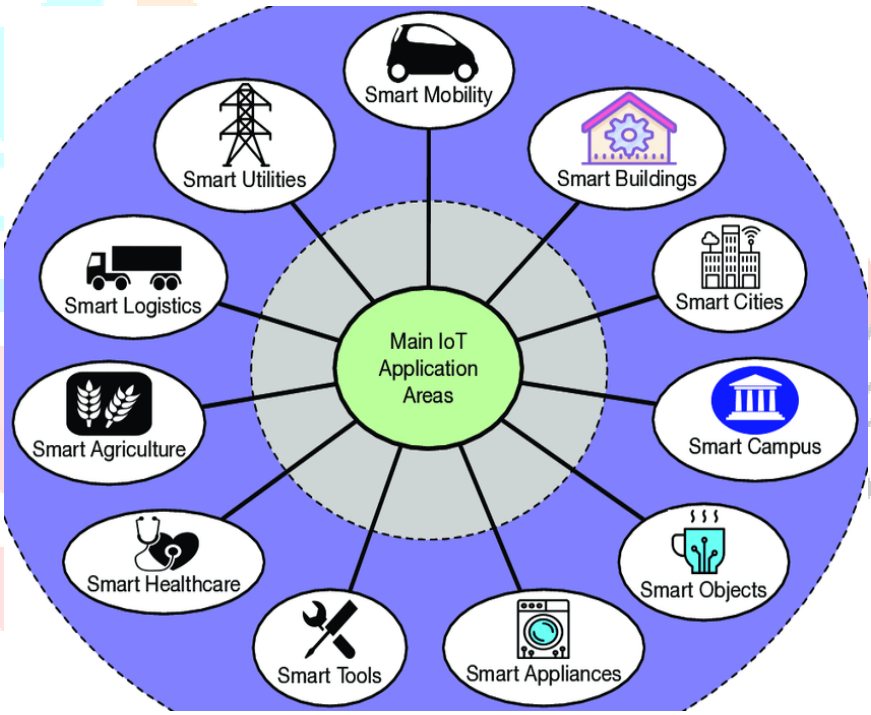

Figure 1. Applications of IoT

III. APPLICATIONS OF IOT

IoT refers to a network of connected computing devices, digital machines, and mechanical hardware that have unique identifiers (UIDs) and can transmit data across a network without the need for human-to-human or human-to-computer interaction [12]. Here are some of the applications of IoT:

- Smart Home Applications: These applications provide the security, comfort, convenience for the home owners. They can independently and remotely control their houses by installing apps into their smart phone or other networked device. Some of the controlling activities are managing lighting, climate, entertainment systems and appliances.

- Wearables: These are electronic gadgets that can be worn as accessories, integrated into clothing, implanted in the user's body, or even inked on the skin. They rely on Bluetooth, Wi-Fi, or cellular

technology to track real-time information. These hands-free gadgets are powered by microprocessors and have practical uses.

- Healthcare: IoT can be used in healthcare for tasks such as remote patient monitoring, observation of treatment progress, and storage of vaccines. Devices such as fitness bands, blood pressure/heart rate monitoring cuffs, and glucometers can provide personalized attention to patients by reminding them to keep track of their calorie intake, exercise routine, upcoming appointments, and changes in blood pressure levels, among other health-related aspects, to promote a healthier lifestyle.

- Smart Cities: The IoT based smart cities provides efficient and higher quality lifestyle for the residents of and optimizes the infrastructure, mobility, public services, traffic management, parking, waste management and utilities of a city.

Smart Agriculture: By automating the traditional manual processes of farming through the use of robots, drones, sensors, and cameras, IoT-based agriculture can improve the quantity and quality of crops. Benefits of smart agriculture include increased production, efficient water management, real-time climate forecasting, reduced operational costs, accurate farm and field evaluation, improved livestock farming, reduced environmental impact, remote and equipment monitoring.

Industrial Automation: Using control devices such as computers, robots, and information technologies to handle different processes and machinery, industrial automation aims to replace human activities, leading to higher productivity, lower operating costs, improved quality, flexibility, information accuracy, and safety.

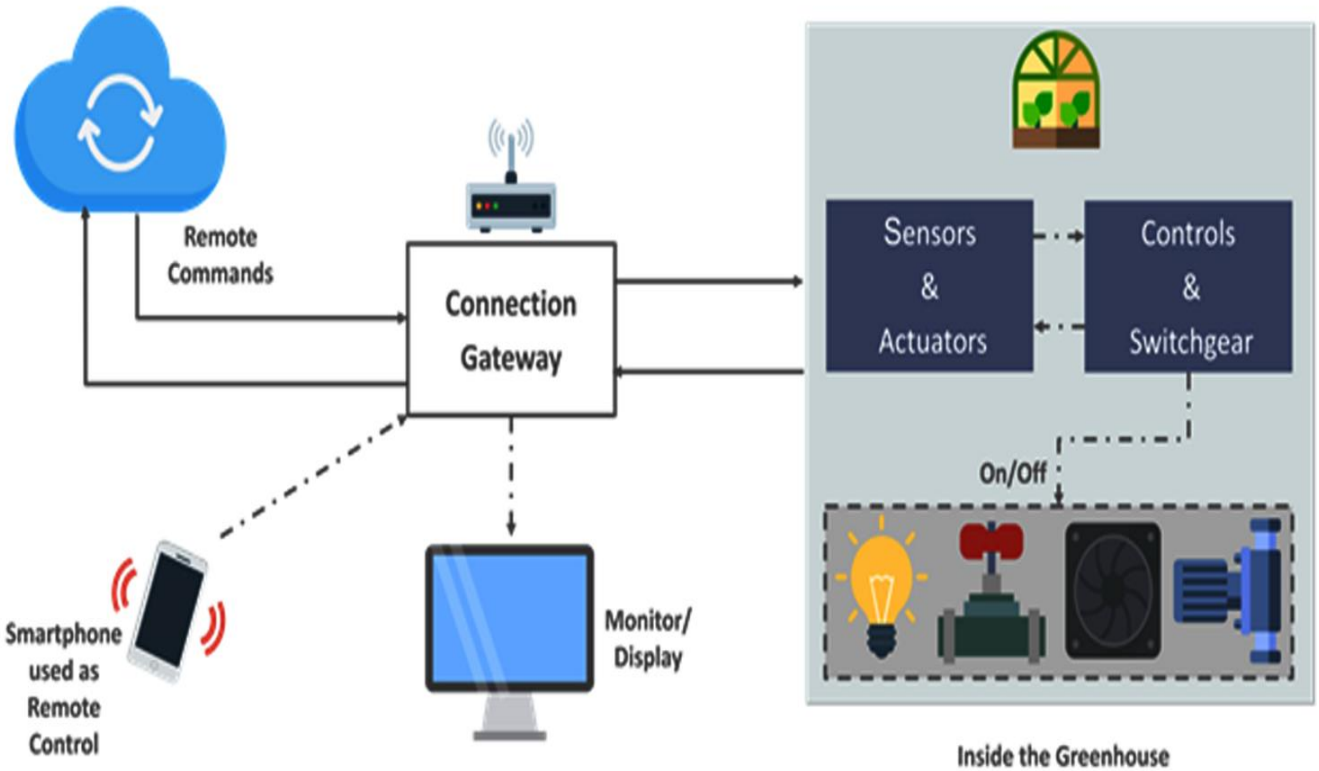

Figure 2. Smart Greenhouse Farming

Figure 2 shows how to do smart greenhouse farming using IoT. Agriculture can benefit greatly from IoT-based solutions, as manual handling can result in production loss, energy loss, and labor costs. Greenhouse farming, for example, can enhance crop yields by controlling environmental parameters. However, embedded devices can make monitoring and controlling the climate inside the greenhouse easier, more effective, and

more efficient. Sensors can measure different parameters according to plant requirements and send data to the cloud, where it is processed and control actions are applied.

According to a survey report, IoT technology and automation are efficient due to various reasons. For instance, different hardware devices can be connected and interfaced via the internet, and automating the farming process leads to a reduction of human resources and error. Additionally, farmers can monitor the work process instantly, and stakeholders can communicate with each other efficiently. A wide range of analyses can also be done, including predicting necessary actions to be taken for further processes.

In terms of applications, IoT plays a vital role in smart agriculture or smart farming, including agriculture monitoring, controlled agriculture/smart greenhouses, and precision farming/smart farming. IoT monitoring systems can help maximize productivity, improve crop quality, reduce the need for pesticides, and ensure predictability and control of optimal harvest dates [13]-[15]. Moreover, farmers can use smart agriculture monitoring systems to collect and process data, predict future soil health, and plan for the next year's crops.

Table 1 presents the detailed comparative study of different research papers on IoT based Agriculture. A detailed comparison of the recent works in regard to Smart Agriculture and IoT are enlisted. It is evident that several sensor-based approaches in order to improve the efficacy of conducting the entire process of agriculture right from seeding, to soil analysis, and the right time to sow, plant, and harvest has been integrated with several techniques for crop production is surplus. Also, smart farming based on a sensor-based technology and other innovative methods have been described. Apart from the IoT Technologies but even several image processing schemes with deep learning algorithms have facilitated in smart farming, and crop surplus production. Most of the techniques enumerated in smart farming and precision agriculture focus on live agriculture and farm datasets which has ensured a proper in-time harvest, and seeding for achieving the best production of crops. Apart from harvesting in surplus but also these IoT based farming help in preventing cattle, elephants, and other wild life in entering the farms with minimal risk to the life of the intruder.

Table 1. Comparative Study of IoT-based Agriculture

Author	Concept	Advantage	Disadvantage
Amine Faid et al [3] (2020)	A low-cost architecture for smart farming using wireless sensor networks based on IoT	The efficiency can be increased by automating the processes. Real-time monitoring can be achieved through the implementation of IoT and Artificial Intelligence (AI).	Conducting experiments on the proposed architecture to evaluate and compare its network performance and scalability across networks of varying sizes, including small, medium, and large networks.
Anusha et al.[4] (2020)	This paper offers a comprehensive literature review to examine the latest advancements in the implementation of blockchain technology for ensuring information security.	A generalized security architecture based on blockchain technology has been proposed to meet the core requirements of smart agriculture. It eliminates the need for downloading the entire blockchain.	Not suitable for many IoT communication scenarios. Incurs high communication costs.
Kaushik et al. [5] (2020)	A framework for integrating IoT with crop production has been developed, incorporating various techniques and methods for monitoring crops through cloud computing.	The proposed work has been field-tested on live agriculture fields and achieved an accuracy rate of up to 98% based on the data feed.	consider the potential limitations and challenges associated with implementing such systems.
Muhammad Ayaz et al. [6] (2020)	This study focuses on various topics related to modern agriculture such as food quality and quantity, smart agriculture	It has the potential to decrease total expenses and contribute to the preservation of the environment.	Rural areas in many developing countries lack continuous internet availability, which is

	practices, urban farming, and the use of the Internet of Things (IoT) and automation technologies. It explores the potential benefits of advanced agriculture practices, including the use of agriculture robots, and discusses the future expectations of food production.		necessary for the proper functioning of the system.
Muthunoori et al. [7] (2019)	To enables farmers to stay connected with their residence from anywhere and at any time.	Providing real-time feedback on various crop and site factors. As the name implies, Precision Agriculture is precise in both the extent of the crop area it monitors, as well as in the delivery of inputs such as water, fertilizer, etc	limited in rural areas, making it difficult for farmers to adopt and utilize IoT systems
G. Vennila et al. [8] (2020)	Exploring the Potential of IoT-Enabled Smart Agriculture and Its Applications for Advancement.	Farmers no longer need to worry about factors like soil quality, water levels, and air conditions, which can greatly impact their crops. The Internet of Things (IoT) is revolutionizing the agriculture industry by providing farmers with a wide range of tools and methods to optimize their yields.	The primary challenge is implementing smart agriculture practices on a large scale across multiple countries.
Agrawal et al.[9] (2019)	Addressing their agricultural concerns ranging from determining the optimal seeding time to the harvesting of crops.	With the assistance of IoT, data related to soil fertility, weather patterns, crop growth, temperature, rainfall, and seed planting can be gathered.	Information about soil fertility, weather conditions, crop growth, temperature, rainfall, and seed planting can be gathered through the use of IoT technology.
Abhiram et al. [10] (2020)	A solution utilizing IoT technology to monitor soil conditions and atmosphere for optimal crop growth is presented.	A notification about the environmental conditions of the field will be sent to the farmer's phone via Wi-Fi in the form of an SMS.	Their smartphones should have the Blynk app installed.
Vippon et al.[11] (2020)	Highly detailed images sourced from Google search engine and other Artificial Intelligence (AI) based methods are utilized for this objective.	Automatic mapping of crop yield. Monitoring using drones Monitoring using heavy-duty vehicles.	Deploying devices and technology in agriculture can be challenging for farmers, especially in countries with significant economic differences.
Vaishali Puranik et al. [12] (2020)	The sensor nodes deployed throughout the field collect data which is then transmitted to the cloud for analysis and visualization. The visualized data enables farmers to make precise and effective decisions that impact their crops.	This solution is highly scalable, lightweight, minimizes network bandwidth, and offers robust security.	limited in some rural areas, making it difficult for farmers to adopt and utilize automated systems

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IV. CONCLUSIONS

In this article, a thorough overview of various approaches to implement smart farming using Internet of Things (IoT) technology to improve food crop production and quality is presented. A detailed analysis of the security features, application domains, advantages, limitations, and other aspects of the existing competing methods has been conducted. Additionally, potential research directions to address the current open and challenging issues in this field are also discussed in this study.

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