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Review Article

A Review on Analysing the Impact of IoT on Smart Agriculture

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Abstract: Nowadays technology has made significant strides, with countless of devices and techniques available in the agricultural sector. The Internet of Things (IoT) plays a vital role in increasing production, efficiency, and worldwide market reach, as well as lowering human involvement, expenditure, and time, all of which are crucial in the sector of agriculture. The Internet of Things (IoT) is a system that connects computing devices, objects, mechanical and digital devices, and living beings. These IoT components are given unique identifiers and can send data across a network without requiring human-to-human or human-to-computer interaction. To increase productivity, IoT partners with agriculture to enable smart farming. In this paper, we study the role of IoT in the sector of agriculture to make it smart farming.

Keywords: Smart Farming, IoT, sensors, productivity, Interfacing Sensors, water management, WPAN.

1. Introduction

India's economy is mostly supported by its agricultural sector. The biggest obstacle that traditional farming faces is climate change. The various effects include lower rainfall, intense hurricanes and heated winds, massive flooding, and other climatic changes. The result of these factors is a significant decline in performance. Natural consequences of climate change frequently include periodic changes in plant lifecycles.

In the farming industry, innovative thinking and Internet of Things techniques were required to boost output and lower barriers. Now, the Internet of Things (IoT) is turning its attention to the agriculture industry, helping farmers overcome the many challenges they encounter. Farmer access to a plethora of information about emerging trends and innovations could be facilitated by IoT.

The Internet of Things' impact on smart agriculture is revolutionary, altering traditional farming practices. Thanks to the Internet of Things, farmers may now more effectively monitor and manage crops, livestock, and resources. Real-time data gathering and analysis have become critical tools for agricultural process optimization because of the Internet of Things. Farmers can use IoT sensors and devices to remotely monitor soil moisture, temperature, and nutrient levels, which increases crop yield and quality. Smart irrigation systems powered by IoT change watering schedules based on real-time weather forecasts and soil conditions, saving water. Livestock monitoring with IoT devices guarantees animal health and well-being by tracking health over time and detecting diseases early. IoT applications in agriculture have resulted in more exact and targeted use of fertilizers and pesticides, lowering environmental impact. The incorporation of IoT in agriculture has revolutionized supply chain management, ensuring that produce is delivered on time to the market. IoT-driven predictive analytics assist farmers in making educated decisions, reducing risks, and increasing revenues. Overall, the Internet of Things' impact on smart agriculture has ushered in a new era of sustainable and efficient farming operations.

"In India, where farming supports 80% of the population, Smart Agriculture appears to be a realistic answer. This program focuses on critical elements such as water management, weather forecasting, and canal control in both automatic and manual modes, which are all operated via a mobile application. Users receive alerts and notifications depending on predefined parameters. The system, which is controlled by an internet-connected mobile device, increases performance by integrating sensors and providing wireless communication."

2. Background details

A. Internet of Things (IoT)

The term IoT or Internet of Things, refers to the interconnected web of gadgets and the technology that allows them to communicate with one another, with the cloud, and among themselves.

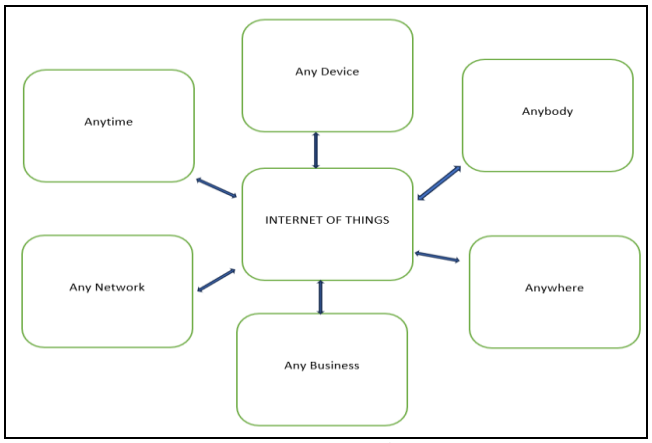

Figure 1. Internet of Things (IoT)

B. Sensors

Sensors are critical for designing IoT solutions. They are instruments that detect and convert external data into a signal that humans and machines can understand.

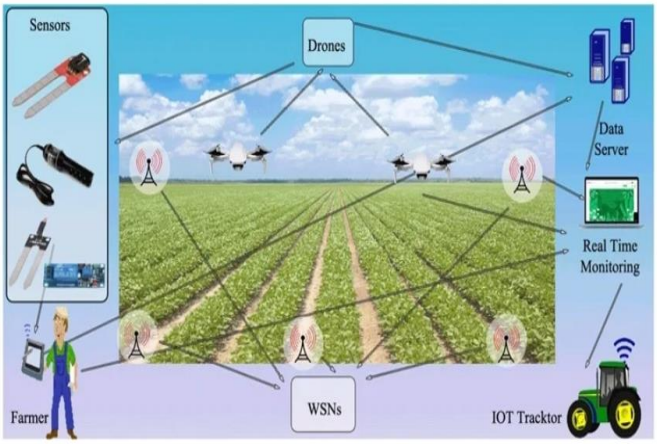

Figure 2. IoT Sensors Using in Smart Farming

C. Productivity

IoT improves efficiency by saving time and resources, two critical components of production. Ultimately, IoT allows employees to focus on key company operations rather than operational responsibilities. Companies that leverage the Internet of Things (IoT) enjoy a competitive advantage.

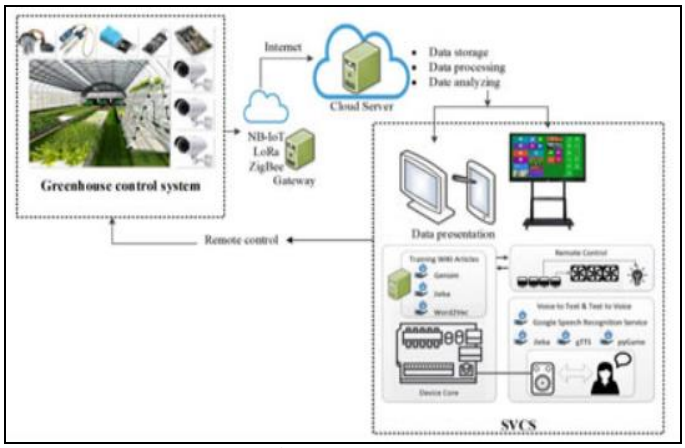

Figure 3. Enhancement of agriculture productivity using the intelligent IoT

D. Smart Farming/ Agriculture

Smart farming is a concept that seeks to provide the agricultural industry with the infrastructure necessary to measure, monitor, automate, and analyze processes using cutting-edge technologies such as big data, cloud computing, and the Internet of Things (IoT).

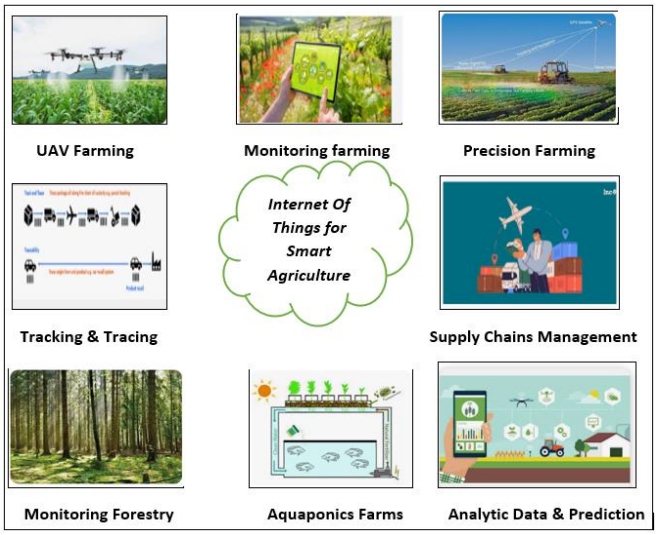

Figure 4. Role of IoT in Smart Farming

E. Interfacing Sensors

Interfacing sensors is the process of connecting and permitting communication between sensors and other devices, such as microcontrollers or computers, to gather and process data.

Figure 5. Interfacing Sensor in IoT

F. Water management

Water management is carefully controlling and distributing water supplies to ensure their efficient use for a variety of objectives, including agriculture, industry, and domestic requirements, while also considering conservation and environmental sustainability.

Figure 6. Farm Water-level Monitoring and Control

G. WPAN

WPAN stands for Wireless Personal Area Network. It is a form of wireless network that operates over a limited area, usually within a person's workstation or personal surroundings, such as a room or building. WPANs employ short-range wireless technologies like Bluetooth or Zigbee to communicate with personal devices such as smartphones, tablets, and wearables.

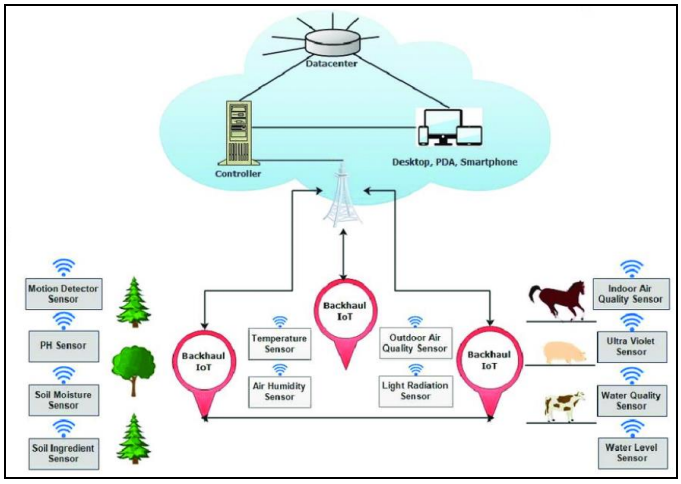

Figure 7. IoT-based Smart Farming Topology

3. Literature Survey

Smart agriculture, enabled by the Internet of Things (IoT), has revolutionized the way farming is done by integrating technology into traditional agricultural practices. This review focuses on analyzing the impact of IoT on smart agriculture, highlighting the various benefits, challenges, and future implications of this innovative approach.

One of the key impacts of IoT in smart agriculture is the enhancement of farming efficiency. IoT devices such as sensors, drones, and automated machinery collect real-time data on factors like soil moisture, temperature, and crop health, allowing farmers to make timely and informed decisions. By providing valuable insights into crop conditions, IoT technology optimizes resource utilization, increases crop yields, and reduces operational costs. Some prior works in this field are summarized in Table 1.

Table 1. Related work

S.No	Paper Title	Description	Limitation
1	Smart Water Management Using IOT [1][2]	This project employs sensors to monitor water levels in tanks, with data stored in the cloud and accessible via a mobile app. It allows for automatic or manual control of water motors depending on the water level shown on mobile phones, providing remote monitoring and control for a variety of applications, including industrial use and flood prevention.	High Installation Costs, Limited, Network Reach, Problems with Interoperability, and Lack of Standardization.
2	Internet of Things in Agriculture [3][4]	Agriculture uses a wide range of instruments and methods, and technology is always evolving. Knowledge processing is the preferred IoT use case in the agriculture division. Information can be gathered with the use of added sensors. Technology based on the Internet of Things (IoT) has changed every aspect of smart agriculture. The industry has shifted from factual to quantitative methodologies as a result. The outcome of innovations in smart agriculture strongly influences this work.	Risk minimization needs to be done
3	Internet of Things-based architecture for effective transmission [5][6]	An Internet of Things-based WSN architecture with several design layers was presented in this paper as a smart agriculture application. Initially, pertinent data is collected by agricultural sensors, which then use a multi-criteria decision function to identify a collection of cluster heads. To produce reliable and effective data transmissions, signal-to-noise ratio (SNR) is also used to measure the strength of the signals on the transmission connections. Second, by employing the linear congruential generator's recurrence, data transfer from	limited resource constraints and computational capabilities.

		agricultural sensors to base stations (BS) is secured.	
4	Survey data on the cost and benefits of climate-smart agricultural technologies in western Kenya [7][8]	Data was collected from houses picked at random to assess climate smartness, profitability, and soil conservation measures. The data, collected via a standardized questionnaire administered by trained assistants and analyzed in STATA, is stored in an open-source data repository for future research and analysis.	Limited knowledge and awareness. Many farmers may need to be aware of climate-smart agriculture practices and learn how to implement them on their farms, High upfront costs, Market challenges, Policy and regulatory barriers, Social and cultural barriers.
5	A Model for Smart Agriculture Using IoT [9][10]	Indian farmers are rapidly adopting smart agriculture, which uses IoT for automated and guided information technologies. This strategy combines sensor technologies and wireless networks to provide a Remote Monitoring System (RMS) for real-time data collection and access. This technology sends out alerts and information about weather patterns and crop conditions, allowing farmers to react to changing agricultural conditions and manage resources more efficiently.	high implementation cost, data security, and lack of sufficient digital knowledge in farmers.
6	Combined Radar–Radiometer Surface Soil Moisture and Roughness Estimation [11][12]	A robust methodology for assessing surface soil moisture and roughness, termed as active-passive (C-AP) estimate, is described. This approach optimizes radar and radiometer observations to obtain ideal soil moisture retrievals, as proved by simulations and field data analysis, with unbiased root mean squared errors ranging from 0.18 to 0.03 cm. The method also employs numerous observations of distinct polarizations to recover more than one unknown parameter, resulting in a completely adaptive scheme for soil moisture retrieval.	requirement for high-quality, real-time data transmission
7	Architectural Framework of Smart Water Meter Reading System In IoT Environment [13][14]	The Internet of Things (IoT) provides a variety of residential applications, including smart metering to improve water management. Water flow and heat measurements can be monitored and managed using IoT-based smart meters, resulting in reduced water waste. This architecture framework incorporates MediaTek's cloud sandbox as a platform for cost-effective data storage and remote user access, with an emphasis on environmental sustainability via Restful-based web services.	data privacy and security concerns
8	An Internet of Things (IoT) based Sustainable Water Management [15][16]	Rural regions increasingly rely on groundwater, resulting in unsustainable extraction. Groundwater management is crucial in India due to its uneven supply. This study proposes a sustainable IoT-based water management system that automates water distribution, storage, and regulation to overcome water scarcity in rural areas such as Gudipadu Cheruvu in Andhra Pradesh. The system intends to eliminate human intervention, improve sustainability, and address issues like illiteracy and the digital divide in rural areas.	inaccurate data collection and management.
9	Internet of Things (IoT) Enabled Water Monitoring System [17][18]	Water management and conservation are critical to human survival, especially in light of environmental challenges. This study presents an IoT-based water monitoring system that measures water levels in real-time, with an emphasis on consumer-based humanitarian projects and disaster-prone areas. The system detects levels using a water level sensor and sends alerts via social networks such as Twitter. It can be expanded with more	Continual assessments of the water's quality will be difficult and time-consuming.

		accurate sensors for more precision.	
10	Smart Agriculture using IoT and WSN-based modern technologies [19][20]	In India, 70% of the population is dependent on agriculture, which contributes significantly to the national economy. This proposal incorporates a smart GPS-based robot for various farming activities, intelligent warehouse management for temperature and humidity control, and theft detection. The system, which is managed via an internet-connected application, combines sensors and microcontrollers with Raspberry Pi to provide solutions for field activities, irrigation, and storage management.	The cost of labor for managing IoT devices and the cost-of-service registration is included in the system's operational cost
11	Computers And Electronics In Agriculture Field Through Software Computer Science [21]	This study examines the emerging IoT applications in agro-industrial and environmental domains, emphasizing their reliance on various components and wireless sensor networks. References are divided into four domains: monitoring, controlling, logistics, and prediction, with an emphasis on the application of various technologies such as sensors, actuators, and edge computing. According to the proposed IoT architecture, future solutions would necessitate the full integration of cloud services and new connectivity technologies in order to create a truly connected and smart ecosystem.	Maintenance and repair costs
12	IOT based monitoring system in Smart Agriculture [22]	Many developing countries continue to rely on old and outmoded agricultural methods, but technological advances, such as smart farming with IoT, are increasing production efficiency. A revolutionary motor vehicle for cutting, spraying, and weeding is launched, with a controller that monitors environmental conditions such as temperature, humidity, soil fertility, and water management. It can operate both automatically and manually. This technique, which combines green energy and smart technology, is a promising answer for increasing agricultural productivity.	

Research Gap:
Despite the growing interest and investment in IoT applications for smart agriculture, there exists a research gap in the comprehensive analysis of the socio-economic impact of these technologies on the agriculture sector. While existing studies often focus on the technical aspects of IoT implementation and its benefits in terms of enhancing productivity and sustainability, there is a lack of in-depth analysis of how IoT adoption influences the broader socio-economic landscape of agriculture.

Specifically, there is a need for more research that explores the following aspects:

1. Cost-Benefit Analysis: Many studies highlight the potential benefits of IoT in terms of increased yield, resource efficiency, and risk mitigation. However, there is a lack of detailed cost-benefit analyses that consider the financial implications of IoT adoption for different scales of farming operations. Understanding the economic feasibility of implementing IoT technologies in agriculture is crucial for informing policy decisions and investment strategies.

2. Impact on Employment: The introduction of IoT in agriculture has the potential to reshape labor requirements and skill sets needed in the sector. There is a need for research that examines how IoT adoption influences employment patterns in rural areas, including the displacement of traditional agricultural jobs and the emergence of new roles related to technology management and data analytics.

3. Market Structure and Competition: The integration of IoT in agriculture could affect the market structure by enabling data-driven decision-making and fostering new business models. Research is needed to investigate how IoT technologies influence market competition, access to markets for small-scale farmers, and the role of data ownership in shaping value chains in the agricultural sector.

4. Policy and Regulation: With the rapid advancement of IoT technologies in agriculture, there is a lack of clear regulatory frameworks to guide their deployment and ensure data privacy and security. Studying the current policy

landscape and identifying gaps in regulations related to IoT in smart agriculture will be essential for promoting responsible and sustainable adoption of these technologies.
Closing this research gap will contribute to a more holistic understanding of the implications of IoT on smart agriculture and facilitate evidence-based decision-making for stakeholders in the agriculture sector, policymakers, and technology providers.

4. Conclusion and Future Scope

Smart agriculture development would benefit from the Internet of Things. Improved time efficiency, water conservation, crop monitoring, soil management, bug spraying, pesticide safety, and other aspects of agriculture are all made possible by the application of IoT. It also takes out the need for human labor, breaks down agricultural practices, and changes how smart farming is applied. The agricultural industry has always depended on customs and knowledge from the past. But as time has gone on, rural customs have been impacted and have begun to shift with the times. The application of the Internet of Things (IoT) in agriculture would help manage all aspects of production and boost output. Given that a sizable section of the population depends on agriculture for survival, it needs major upgrades.

It is necessary to research the deployment and administration of perception nodes in agricultural IoT systems. Distributed, open, and resource-service sharable design is ideal. This allows for the realization of resource sharing and interconnections between diverse heterogeneous systems, as well as the acquisition of more precise and in-depth agricultural data.

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Competing interests
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Hiresh Singh Sengar has prepared the manuscript under the guidance of Dr. Sakshi Rai. Dr. Sakshi Rai has done Proofreading of the work and reviewed the complete work.

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