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ijirset@gmail.com

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Study of Smart Agriculture in India using Internet of Things

Deepmala Sharma¹, Apoorva Patil²

Assistant Professor, Department of Electronics & Communication Engineering, UIT, Barkatullah University,
Bhopal, India^{1,2}

ABSTRACT: Smart agriculture, powered by the Internet of Things (IoT), has emerged as a transformative approach to address critical challenges in Indian agriculture, such as inefficient resource management, unpredictable weather patterns, and low productivity. This study explores the application of IoT in Indian agriculture, emphasizing its potential to enhance precision farming, optimize irrigation, monitor crop health, and streamline supply chain management. By leveraging IoT-enabled sensors, devices, and cloud platforms, farmers can access real-time data for informed decision-making and efficient farming practices. However, widespread adoption faces challenges, including connectivity issues, high implementation costs, and limited digital literacy among farmers. The study also highlights government initiatives, such as Digital India and agritech startup contributions, which aim to promote IoT integration in agriculture. Addressing these barriers through targeted policies and stakeholder collaboration can unlock IoT's full potential, paving the way for a sustainable and resilient agricultural future in India.

KEYWORDS: Internet of Things, Smart Farming, Efficiency, Productivity

I. INTRODUCTION

Agriculture is the backbone of India's economy, contributing approximately 18% to the nation's GDP and employing over half of its workforce. Despite its critical role, Indian agriculture faces several challenges, including resource inefficiency, unpredictable weather, declining soil health, and post-harvest losses. These issues have hindered productivity and placed immense pressure on farmers, who often rely on traditional farming methods.

The advent of emerging technologies, particularly the Internet of Things (IoT), offers an innovative solution to modernize agriculture. IoT refers to a network of interconnected devices that communicate and share data in real time, enabling automation and improved decision-making. When applied to agriculture, IoT empowers farmers to adopt precision farming practices, where resources like water, fertilizers, and pesticides are used more efficiently based on real-time data [1].

In India, IoT-driven agriculture has the potential to transform the sector by addressing critical challenges. Smart devices, including soil sensors, weather monitoring systems, and automated irrigation systems, can optimize input usage and reduce wastage. Moreover, IoT applications enable farmers to monitor crop health, predict pest infestations, and access market insights, fostering sustainable agricultural practices [2, 3].

However, the integration of IoT in Indian agriculture faces several barriers, such as poor rural connectivity, high costs of IoT devices, and limited digital literacy among farmers. Despite these challenges, initiatives by the Indian government, agritech startups, and private enterprises have accelerated the adoption of IoT technologies in agriculture. The Internet of things (IoT) is the most proficient and critical strategies for advancement of answers for the issues. IoT develop from various building a square which incorporates bunches of sensors, software's; organize parts and other electronic gadgets. Additionally it makes information more powerful. IoT permits to trade the information over the system without human contribution [4].

In Internet of things, we can speak to things with characteristic way simply like ordinary individual, similar to sensor, similar to auto driver and so forth. This thing is doled out an ip address with the goal that it can exchange information over a system. According to the report created by Garner, toward the finish of 2016 there will be 30% ascent in consider of associated gadgets contrasted with 2015. He additionally says that, this tally will increment to 26 billion by

2020 [1]. The IoT innovation is more productive because of following reasons:

1. Global Connectivity through any devices.
2. Minimum human efforts
3. Faster Access
4. Time Efficiency
5. Efficient Communication

II. SMART AGRICULTURE

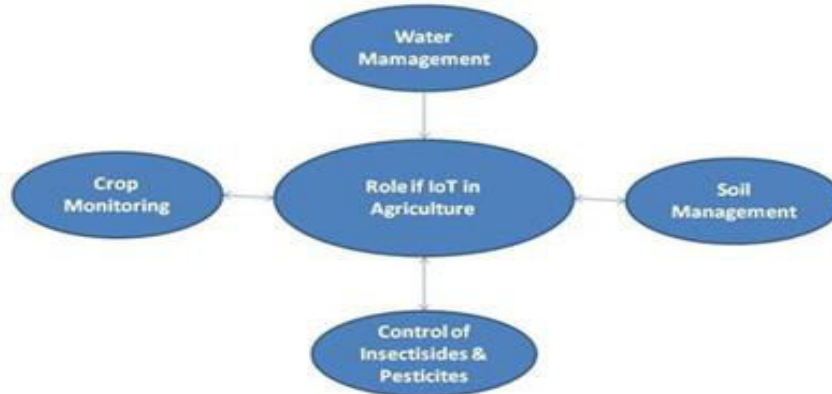
Smart agriculture refers to the application of advanced technologies, including the Internet of Things (IoT), Artificial Intelligence (AI), Big Data, and Machine Learning (ML), to improve farming practices and achieve greater efficiency, sustainability, and productivity. Unlike traditional farming, which relies heavily on manual labor and generalized practices, smart agriculture leverages data-driven decision-making and automation to optimize resource usage, monitor crop health, and boost yields [5, 6].

Key Features of Smart Agriculture

1. **Precision Farming:**
 - a. Use of IoT sensors for real-time data on soil moisture, temperature, and nutrient levels.
 - b. Site-specific management to minimize input wastage and maximize output.
2. **Smart Irrigation Systems:**
 - a. Automated irrigation using soil moisture data and weather predictions to reduce water consumption.
 - b. Techniques such as drip and sprinkler irrigation integrated with IoT systems.
3. **Crop Health Monitoring:**
 - a. Drones and satellite imagery for detecting crop diseases, pest infestations, and nutrient deficiencies.
 - b. AI-powered image recognition for early disease diagnosis.
4. **Livestock Management:**
 - a. IoT-enabled wearables for livestock health monitoring, tracking activity levels, and detecting illnesses.
 - b. Automated feeding systems based on animal health data.
5. **Supply Chain Management:**
 - a. Real-time tracking of harvested crops for better storage and transportation.
 - b. Blockchain for improving transparency and traceability in the food supply chain.
6. **Weather Prediction and Risk Management:**
 - a. IoT-enabled weather stations providing hyper-localized forecasts.
 - b. Data analytics for disaster prediction and early warning systems.

III. SCOPE OF IOT IN AGRICULTURE

Agriculture is the principle spine of India's Economic development. The most critical hindrance that emerges in customary cultivating is climatic change. The quantity of impacts of climatic change incorporates overwhelming precipitation, most extraordinary tempest and warmth waves, less precipitation and so forth. Because of these the efficiency reductions to real degree. Climatic change additionally raises the ecological results, for example, regular changes in life cycle of plants. To help the profitability and limit the boundaries in horticulture field, there is have to utilize inventive innovation and procedures called Internet of Things. Today, the Internet of Things (IoT) is changing towards agribusiness industry and empowering ranchers to rival the gigantic difficulties they confront. Ranchers can get immense data and information about ongoing patterns and innovation utilizing IoT.

**Figure 1: Role of IoT in Agriculture**

The smart farming business sector is relied upon to reach \$18.45 Billion of every 2022, at a CAGR of 13.8%. BI gauges that 75 million IoT gadgets will be delivered for horticultural uses in 2020, at a CAGR of 20%. IoT gadgets can be of incredible help in improving the generation and yield in the agribusiness part since these gadgets can be utilized to screen soil corrosiveness level, temperature, and different factors. In addition, savvy agribusiness will help in observing domesticated animals efficiency and wellbeing also. IoT sensors are fit for furnishing ranchers with data about harvest yields; precipitation, both pervasion, and soil nourishment are important to generation and offer exact information which can be utilized to enhance cultivating methods after some time. Web of things, with its continuous, precise and shared qualities, will convey extraordinary changes to the farming inventory network and give a basic innovation to building up a smooth stream of horticultural coordination's [7].

The key advantages of using IoT in enhancing farming are as follows:

1. Water administration can be effectively done utilizing IoT with no wastage of water utilizing sensors.
2. IoT serves to consistent screen the land with the goal that safety measures can be taken at beginning time.
3. It expands profitability, diminish manual work, lessen time and makes cultivating more productive.
4. Crop checking can be effectively done to watch the development of product.
5. Soil administration, for example, PH level, Moisture content and so forth can be distinguished effectively with the goal that agriculturist can sow seeds as indicated by soil level.
6. Sensors and RFID chips helps to perceive the maladies happened in plants and products. RFID labels send the EPC (data) to the peruser and are shared over the web. The agriculturist or researcher can get to this data from a remote place and take vital activities; automatically products can be shielded from coming infections [2].
7. Crop deals will be expanded in worldwide market. Rancher can undoubtedly associate with the worldwide market without limitation of any land territory.

IV. LITERATURE REVIEW OF IOT IN AGRICULTURE

The idea of the Internet of Things initially wound up well known in 1999, through the Auto-ID Center at MIT and related market-examination distributions. Scientists have proposed diverse models for horticulture segment with one or various advances said above e.g. water system framework in light of soil water estimation to choose water system measure of the water is depicted in [1]. Which utilizes the Bluetooth show for the correspondence which has its own confinements like restricted range and gadget settlement? In the time of 2009, a creator recommended planning for the power supplies to the sensors which will help in enhance vitality proficiency [2]. Utilization of IoT in agribusiness is said by a creator in paper [3]. Anyway it demonstrates absence of interoperability which is fundamental when we discuss expansive horticultural fields. For correlation of vitality utilization between two apparatuses, Jinsoo han has given an approach in paper [4] distributed in 2011. N.K. Suryadevara, S.C. Mukhopadhyay has utilized ideas of inescapable processing, information accumulation and so on to screen the ecological components utilizing Zigbee [5] in their paper. Increment in number of sensors is proposed by the creator to enhance the exactness of the information gathered. Anyway it may raise the issue of more power utilization as more hubs has been conveyed. Way to deal with

give the constant data to the agriculturists about the land and harvests is characterized in the paper [7], which gives the essential data yet it's an independent framework. In the time of 2015 ideas of IoT, distributed computing, Mobile registering are utilized as a part of keen horticulture in paper [8], where by Prem Prakash Jayaraman, Doug Palmer, Arkady Zaslavsky the idea of phenonet was presented [9], which is system of shrewd remote sensor hubs who imparts the data to each different and in addition focal framework. However both the papers anyway do not give any understanding of the information despite the fact that substantial measure of helpful information is produced. In spite of the fact that analysts have proposed few models in horticulture area utilizing at least one of the innovations said, we mean to build up a coordinated arrangement of various functionalities with information elucidation and more straightforward interface.

Phenonet [5] is a horticultural phenotyping field research center, including an assortment of product considers that are being directed utilizing cutting edge IoT advances [6], including sensor systems, IP cameras, versatile cell phones, and related information examination. These empower close continuous catch of product information for evaluating and anticipating crop execution (both here and now and long haul) for any given natural, soil, preparation, and water system conditions, including climate conditions, plant shade temperature, soil dampness, soil quality and saltiness, compost use, and water system. Phenonet is helping plant researcher and cultivators accomplish the accompanying: (1) distinguish the impact of various conditions on an assortment of harvests in certifiable open air cultivate situations; (2) comprehend water asset utilization keeping in mind the end goal to oversee it successfully; (3) think about the effect of different manures; (4) get ongoing information to figure trim execution; and (5) share information and results. To better clarify Phenonet, we give extra insights about example considers led in Phenonet. One of these examinations plan to assess the impact of sheep touching on trim re-development by taking a gander at root action, water utilize, rate of harvest development, and product yield. In this examination, soil dampness sensors sent at numerous profundities and shade temperature sensors are utilized to track the yield roots' extraction of water from the dirt all through the developing season. This data is then used to gauge and evaluate root action and product development. Figure 1 exhibits an outline of this Phenonet think about that is directed on a square of land that is separated into several plots. A plot is a convergence of a line and a segment in a square of land and has a particular treatment to the product being contemplated. For instance, each plot may have an alternate use of composts or host the utilization of similar manure at various circumstances [10, 11]. This Phenonet consider requires bolster for continuous gathering and conveyance of information to scholars, who at that point share their bits of knowledge with producers and ranchers, and related logical associations. A portion of the fundamental difficulties in supporting such investigations and furthermore typical cultivating exercises incorporate the accompanying:

- Capturing the expansive volume of heterogeneous information delivered by an assortment of IoT sensors (and potentially manual estimations), and doing this for a huge number and assortment of exercises including distinctive investigations and additionally trims.
- Supporting the incorporation and utilization of any IoT gadget, including all economically accessible sensors, camera, climate stations, and so on, as this will accomplish a bring-your-own particular sensor model of activities that will permit agriculturists, producers, and researchers to exploit less expensive/more able IoT sensors, and additionally singular inclinations and spending plans.
- Integrating heterogeneous information from such an awesome assortment of IoT gadgets and furthermore recorded yield execution information delivered by past examinations (such information and results are commonly accessible in CSV documents that make it harder to utilize, investigate, investigate, and share).
- Providing crop execution information investigation programming and related apparatuses for do-it-without anyone else's help inquiry, examination and perception of gathered information over numerous investigations.

V. CONCLUSION

Smart agriculture, powered by technologies like the Internet of Things (IoT), has the potential to revolutionize Indian agriculture by addressing critical challenges such as low productivity, resource inefficiency, and the unpredictability of climate change. Through precision farming, real-time crop monitoring, and smart irrigation systems, IoT enables data-driven decision-making that not only enhances yields but also reduces input wastage and environmental impact.

In the context of India, where a majority of farmers operate on small landholdings, adopting smart agricultural practices can significantly improve livelihoods and ensure food security for a growing population. However, challenges such as

limited rural connectivity, high costs of implementation, and low digital literacy remain significant barriers. Collaborative efforts among the government, private sector, and agritech startups are crucial to overcoming these obstacles and making smart agriculture accessible to all farmers.

With continued advancements in IoT and integration with AI and blockchain technologies, the future of Indian agriculture looks promising. By fostering innovation and scaling adoption, smart agriculture can play a pivotal role in creating a sustainable, resilient, and technology-driven agricultural ecosystem in India.

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