

A review of IoT in Agriculture: Opportunities, Challenges, and Benefits for Farmers

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Abstract: A crucial occupation vital to human survival, modern agriculture can benefit significantly from the implementation of the Internet of Things (IoT) for sustainable water management. This technology offers the potential to monitor and regulate water resources effectively across various industries. By integrating IoT in agriculture, it becomes feasible to boost agricultural yield and streamline water usage. This study investigates the application of IoT for water management in agriculture, a critical issue for farmers worldwide. The research underscores current IoT-based strategies for water management in agriculture, including the deployment of sensors and monitoring technologies such as automation systems, remote sensing, and in-field sensing. The study elaborates on how IoT facilitates real-time monitoring of water consumption for farmers, optimizing water conservation through the implementation of irrigation schedules and providing recommendations regarding the timing and volume of water required for crop irrigation.

Keywords: Internet of Things (IoT), Sustainable agriculture, water management

1. Introduction

The world's expanding population has an increasing need for food, and agriculture is a key sector of the economy in many areas across numerous continents. An essential part of economic development is agriculture. Agricultural activities must consider ecological and environmental limits in order to meet these objectives. While ensuring ideal and pure water conservation, it is very important to prevent rapid land deterioration. Even the Food and Agriculture Organization of the United Nations (FAO) stresses the importance of developing a modern agriculture policy that preserves, protects, and promotes natural resources while also guaranteeing the protection of human health. In general, significant efforts are needed to enhance agricultural areas like forestry, animal husbandry, and crop production in order to meet the world's food need. However, water is a natural resource that is essential for supplying the aforementioned nutritional requirements. It has a crucial role in the growth of plants and is particularly significant in the sector of agriculture.

The goal is to intelligently classify, locate, track, supervise, and control agricultural activities and objects. The "Human-Machine" connectivity of agricultural IoT enables more sophisticated and dynamic discovery, management, and control of many agricultural aspects, processes, and systems. Additionally, it substantially increases our ability to manage complex agricultural systems and helps us deal with agricultural emergencies.

It also greatly advances our understanding of the fundamental components of agricultural plant and animal life. Although agricultural IoT technology is currently the subject of extensive and expanding global research, most applications are still in the demonstration stage. This is an article that systematically summarizes the state of IoT research in agriculture. Building dams to hold rainwater, desalinating seawater, treating wastewater, and keeping an eye on water pipelines for control are a few ways to assist conserve and safeguard water resources. For any damage or leaks, look around. Agriculture is one of several industries that has been altered by the Internet of Things (IoT), and it will substantially benefit from new technologies. The Internet of Things (IoT) for agriculture has emerged as a game-changer, presenting a variety of options, resolving substantial problems, and providing farmers and society at large with enormous advantages.

The current agricultural sector can become sustainable agriculture with the help of the IoT solution. IoT solutions can boost agricultural output and economic growth, especially in a nation that is heavily dependent on this sector. The Internet of Things (IoT) may completely transform Indian agriculture. People rarely associate the internet with agriculture in general. Once more, IoT enables farmers to link their equipment to the web. This enables devices to connect via Wi-Fi, enabling communication between them and data transmission to the internet. Additionally, it simplifies effective livestock management, enhances pest control, leverages agricultural inputs, and improves operations and management to reduce waste and improve output. In order to analyze advancement and contemporary problems associated to the use of water in agriculture in particular, it is necessary to construct a state of the art due to the growing importance of the literature on this subject.

Water resources are undoubtedly essential to the agricultural sector. Farmers may encounter difficulties as a result of the pressures of industrialization, urbanization, and climate change, particularly with regard to the provision of water and the effective management of their farms. Therefore, the proposed system that can manage water resources intelligently for farmers in the agricultural industry was discussed in this study. The agriculture of the future will be networked farms. Farmers have a lot of new prospects because to IoT in agriculture. The capability to remotely monitor and manage systems is one of the main advantages. IoT has a lot of potential for agriculture, but it also has several issues that need to be resolved. Privacy and data security are the two key concerns. There is a chance of unauthorized access, data breaches, or the misuse of sensitive information given the volume of data being produced and shared. To secure data integrity and preserve trust between farmers and stakeholders, robust encryption and cybersecurity techniques are required. The integration and compatibility of various IoT solutions is another problem. It is crucial to offer seamless interoperability and data interchange as the market gets more saturated with devices and platforms. The development of open protocols and standardization initiatives can speed up communication and make it easier to use IoT solutions in a variety of agricultural contexts.

2. Literature Review

In this paper, we present a survey of the opportunities, difficulties, and advantages for farmers. We examine the need to conserve water resources, save the environment, and advance agriculture by utilizing innovative technologies. We focus on four agricultural application areas that actually stand in the way of this objective. To enhance smart farming systems with IoT, these application areas are carefully investigated. We focus on a few particular concepts and tactics that make use of contemporary technology to build a smart farming system. This survey aims to investigate IoT applications and energy-efficient software for sustainability. From a "IoT and sustainability" standpoint, the report that follows offers pertinent information. Kassahun et al. did research on the application of IoT in precision agriculture. The usage of IoT sensors to collect real-time data on soil moisture, temperature, and nutrient levels has been highlighted. The study highlights how IoT-based precision agriculture can boost agricultural production, minimize environmental impact, and optimize resource consumption. The authors of a study report examined the application of IoT in the production of livestock. They describe how IoT sensors can track animal health, behaviour, and eating patterns to improve livestock management practises. Research has emphasised the potential of IoT for early disease diagnosis and prevention in livestock in order to improve overall animal welfare. He also spoke about the difficulties and possibilities presented by IoT in agriculture.

This has highlighted how crucial data analytics are to maximizing the potential of IoT devices. Informed decisions on irrigation, fertilization, and pest management can be made by farmers with the aid of efficient data analysis, the study claims, which can boost output and cut expenses. They talked about how to perform precise and effective irrigation methods by employing IoT sensors to monitor weather conditions and soil moisture. IoT-enabled smart irrigation can maximize agricultural growth while preserving water resources, according to research. The author has researched the security and privacy concerns with IoT in agriculture. This clarifies how susceptible Internet of Things (IoT) devices are to hacker attacks and data breaches. The report emphasizes the necessity for robust security measures, encryption methods, and data privacy legislation to secure sensitive data in IoT-based agricultural systems. Tripathy et al. conducted research to examine the financial effects of IoT adoption in agriculture.

Input optimization and better resource management are two strategies he discusses that can help farmers cut costs. According to research, IoT-based agriculture can increase the farming sector's sustainability and profitability. Studies show how gathering, analyzing, and monitoring real-time data remotely can maximize resource use, boost output, and reduce environmental impacts. However, concerns like data security, privacy, and interoperability must be resolved in order for IoT in agriculture to be widely adopted and implemented. The authors understood the value of doing a methodological evaluation of the literature after studying current works utilising IoT principles in agriculture. An overview of the IoT concept will be used to identify the existing positions, obstacles, and issues affecting the subjective sector as well as the suggested quick corrective remedies over time. Using a database that already exists, briefly describe the most significant research that has been done in the field of agriculture.

3. Internet of Things (IoT): an overview

Letters and phone conversations were the main forms of communication in the mid-1980s. The introduction of the term "Internet" denoted a significant shift in communication methods. VoIP, or voice throughout internet protocol, also started to show signs of promise over time. Traditional ideas about the Internet have been replaced in the modern day by the idea of the Web of Thing (IoT). This is way to use the power of the Internet to connect and control items. Early in the 1990s, A to-ID Labs at the Massachusetts College of Technology (MIT) was presented with the idea of introducing the Internet of Things (IoT). The Internet of Things (IoT) seeks to establish a networked ecosystem in which commonplace items are outfitted with sensors and connected to the internet so they may gather data, carry out operations, and even come to their own conclusions. These gadgets could be able to link thanks to the IoT, which makes large dataset exchange and analysis easier.

This increases convenience and efficiency and opens up new business prospects across several industries. These physical items range widely, from basic sensors that measure moisture and temperature to more sophisticated gadgets like wearables, automobiles, smart household appliances, and industrial machinery. A variety of transmission protocols, including as satellites that are Bluetooth, Wi-Fi, and other mobile phone networks (2G, 3G, 4G, to 5G), and low-powered Wide Area Networks (LPWAN), are used by this devices to connect to the internet and transfer data.

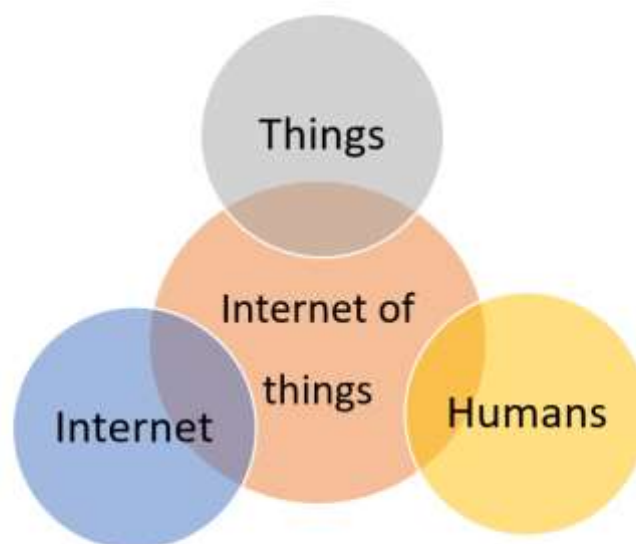


Fig.1. Tri-Sectional of Internet of Things

Agriculture has improved significantly as a result of the IoT, which has changed conventional agricultural methods and made it possible to create more sophisticated and effective farming systems. Agriculture has undergone a transformation because to IoT technology, which has updated traditional agricultural methods and made farming operations smarter and more effective. IoT devices are essential for keeping an eye on the health and well-being of animals. Sensors that continually monitor an animal's location, activity, and vital signs can be used to identify health problems and possible threats in advance.

This enhances animal wellbeing and makes prompt intervention possible. Drones used for agricultural surveillance, autonomous machinery, robotic milking, and automated feeding systems are examples of IoT technology in action. Automation lowers labor costs, improves operational effectiveness, and boosts output all around. IoT sensors may also be used to detect leaks and other issues in irrigation lines. By gathering IoT data with sophisticated analytics, trends in water use, irrigation efficiency, and agricultural water demands may be revealed. Farmers may use this data to pinpoint regions that need improvement, modify their irrigation techniques, and decide how best to distribute water. Farmers may be able to increase revenue, cut down on resource waste, implement more accurate and sustainable farming methods, and maximize output by analysing such data. Those in the agricultural industry may integrate and manage their farms with ease by using smart farming practices and utilizing cutting-edge technology like sensors, big data analysis, cloud computing, and the Internet of Things.

A small number of sensors are used in the AGRI2L system to enable real-time water level and leak monitoring. The internet has solved many issues and greatly improved communication. With the addition of sensors that correspond with their individual functions, this idea has spread its effect to billions of gadgets in the present period. Large amounts of data are produced by these devices when they are connected to the internet through sensors, and this data is then evaluated to help make wise decisions. With around 5 billion smart devices in use worldwide, the use of innovative communication technologies has grown significantly in recent years.

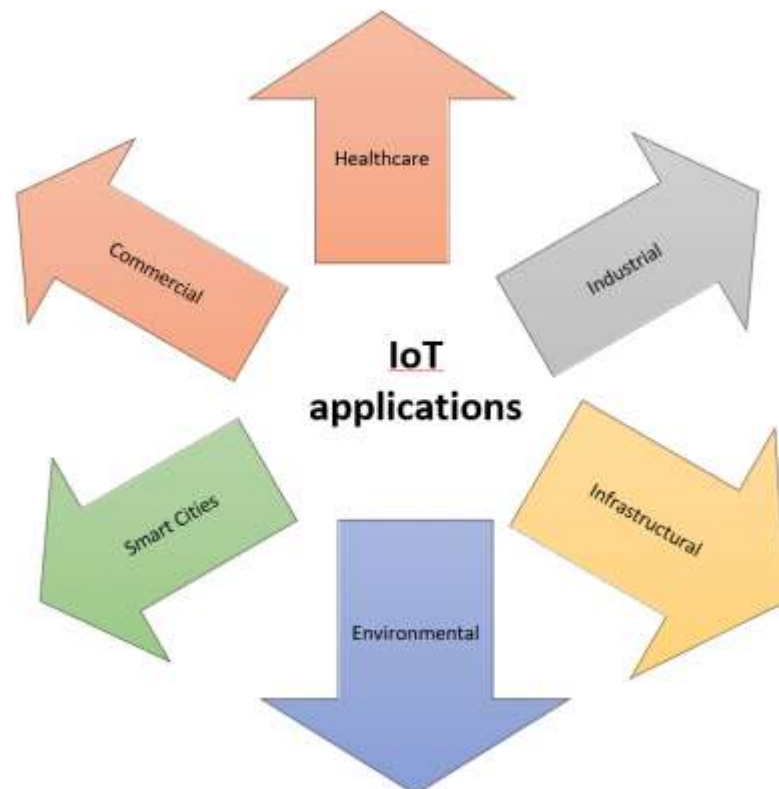


Fig. 1. IoT Application

According to projections, there will be over 50 billion internet-connected gadgets by 2020. By the conclusion of this ten years, the value added of IoT will reach more than three hundred billion dollars, opening doors for the creation of technological advances in communication and the

exploration of inventive methods for coordinating existing devices with internet-connected sensors. It is important to recognize that evaluating the practical capabilities of this technology requires a thorough comprehension of the ongoing breakthroughs in this domain. The importance of IoT research is evident in both the academic and industrial spheres, highlighting the continuous requirement to create novel approaches for integrating various devices over the internet with the assistance of additional sensors. These days, a number of societal domains—including Smart Transport, Smart Grids, Smart Residences and Buildings, Security and Environmental Tracking, Medical and Healthcare, Manufacturing Processes, Agriculture and Livestock Management, and Autonomous Living—consider this concept to be a guiding framework for advancement.

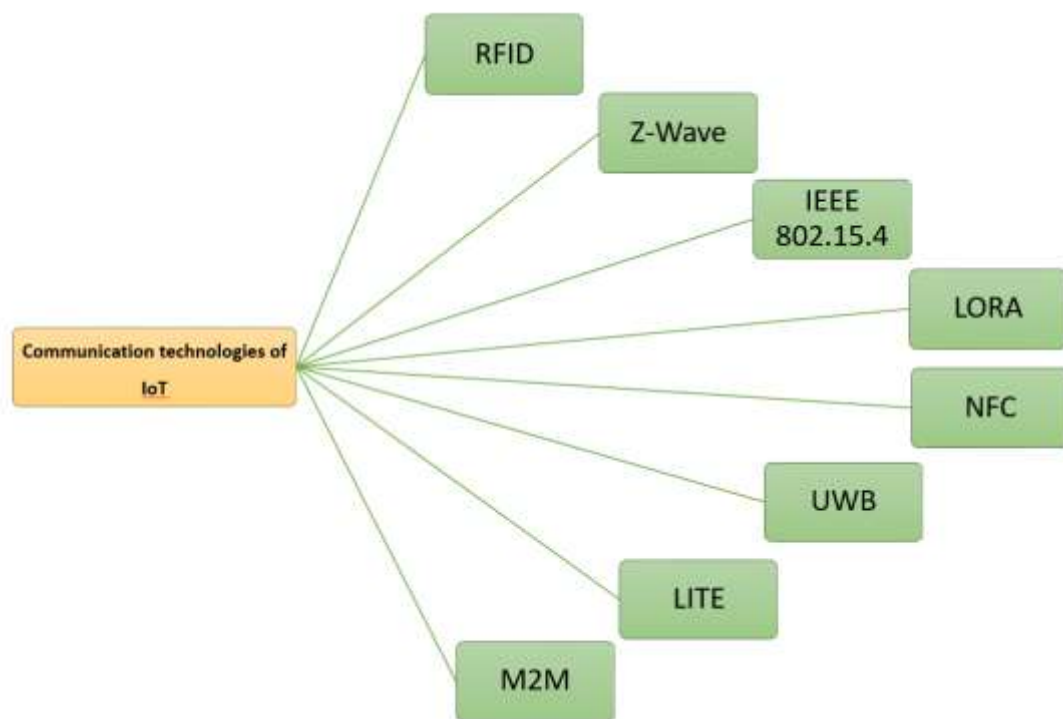


Fig. 2. Communication Technology

In various types of modern applications, connections may be made in a variety of ways, particularly with regard with the Internet of Things. These decisions are unique to IoT-related products and systems. Wi-Fi is one of the widely used technology for wireless communication that facilitates the connection between Internet of Things (IoT) products to LANs and the internet. Due to its quick data transfer rate, it is frequently utilized in settings like smart homes, offices, and public spaces with consistent internet connectivity. On the other hand, NFC provides a form of Bluetooth that enables safe data sharing and communication between devices in close proximity. It is widely utilized for things like quicker IoT device pairing, access control, and contactless

4. Conclusions and Prospects

This study does a thorough literature analysis with an emphasis on the idea of the Internet of Things, specifically as it relates to agriculture. The study also contains numerous other relevant facts from the research papers it evaluates and provides a thorough overview of the suggested IoT

approaches. The Internet of Things is radically changing modern agriculture by enabling farmers to monitor their fields remotely and improve agricultural operations. It is critical to precisely handle and analyze the data gathered from several different sensors. In the future years, a large variety of farming actuators, sensors, and machinery will eventually be connected over the internet, primarily for management, decision-making, and communication. A key factor in determining how agriculture develops in the future is smart farming.

Protecting the environment wisely and increasing yield are made possible by smart farming. IoT has the potential to revolutionize agriculture by changing farming practices. Farmers may increase production, reduce environmental impact, and manage resources more efficiently by leveraging real-time data and technology. However, before it is widely adopted, issues with data security, compatibility, and standards must be resolved. Beyond helping individual farmers, these advantages also improve sustainable agricultural methods and guarantee food security for society at large. To fully realize the promise of IoT in agriculture, ongoing research and technology improvements are essential.

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