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Integration of Remote Sensing and IoT for Real-Time Monitoring of Irrigation in Smart Farming

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Abstract— **Smart farming, enabled by the integration of Remote Sensing (RS) and Internet of Things (IoT) technologies, represents a revolutionary approach to modern agriculture. This paper explores the synergistic application of RS and IoT for real-time monitoring of irrigation practices in smart farming systems. Remote sensing provides a bird's-eye view of agricultural landscapes, capturing crucial data on crop health, soil moisture, and environmental conditions. Concurrently, IoT devices deployed in the field offer ground-level data, including real-time sensor readings and feedback from automated irrigation systems. The integration of these two technologies facilitates a comprehensive and dynamic understanding of the agricultural environment. This paper discusses the challenges, methodologies, and benefits of integrating RS and IoT in the context of irrigation management. The proposed framework enhances precision agriculture by enabling timely decision-making, optimizing water usage, and improving overall farm productivity.**

Keywords: Smart farming, Internet of Things, Irrigation, Precision agriculture, Real-time monitoring, Agricultural technology, Sensor networks, Crop health, Water management.

I. INTRODUCTION

One important industry and the backbone of the economy is agriculture. Agriculture automation is starting to pose serious issues for many nations. There is an increasing need for food as a result of the expanding global population [1]. The growing need of food and changing consumer tastes make the agricultural sector finds it very challenging to create policies and strategies that would enable them to completely meet the rising needs. [2]. Since agriculture fosters innovations, it is one of among the most significant sectors of society. To increase overall results and performance, it is crucial to ensure that reforms are done in this area. The technology used in food

production should encourage significant advancements and innovation to meet the evolving requirements of consumers [3]. Since most nations depend on the agricultural sector, it is essential to utilize the agricultural resources.

Agriculture is defined under the Act of 1947 as the raising of cattle, dairy farming, horticulture, fruit, and seed. The goal of agriculture is to maximize land use and boost revenue. The farming industry must embrace more intelligent farming practices [12]. Precision farming methods and other innovative agricultural approaches assist address these issues. Using information technology, precision agriculture is a farm management technique that makes sure crops and soil get exactly what they need at the right time for increased production and health. [4]. Utilizing cloud computing with the Web of Things as well (IoT) technologies, in recent years, researchers have been focusing on developing controlled irrigation systems for managing irrigation IoT is defined as a network of independent objects that communicate and share information remotely over the Internet [5].

DOI: 10.1002/9781394213948.ch13 for title An Internet of Things-Integrated Home Automation with Smart Security System similar concept used with IoT. The agricultural supply chain is being further taxed by the widening imbalance between supply and demand. Among the irrigation techniques that have traditionally been accessible are terraced systems, sprinkler systems, drip irrigation, and ditch irrigation. Doi: 10.3233/ATDE221224 with title Automated Solar Tracking System to Run Utility Systems at Minimal Loads During Load-Shedding by Charging Solar Batteries also uses automation related to proposed system. The drive for increased output, water scarcity, and subpar agricultural practices are the three categories used to categorize typical irrigation techniques. Automated irrigation systems are used to overcome these issues [6].

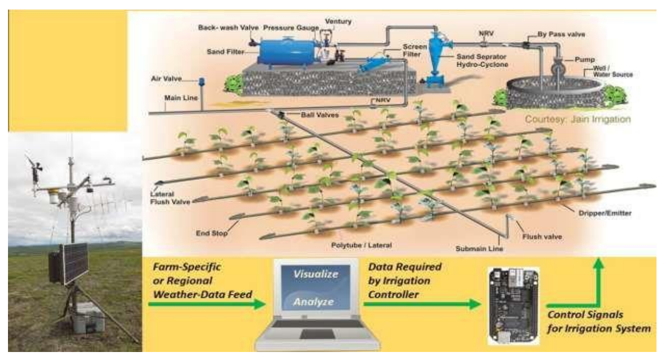

Figure 1 Automated irrigation systems [7]

India's economy is strongest when it comes to agriculture. However, the amount of water used in agriculture each year exceeds the amount of rainfall Increased agricultural output is required to meet the growing global food demand brought on by population growth. Predicting and considering ecological circumstances can increase farm productivity. Collecting data from the farm, such as the temperature outside, humidity, and soil moisture content, is how crop quality is assessed. Innovative machinery and technology can increase farm output. The large volumes of ecological and agricultural data that may be collected might be made easier by the advent of IoT technology. "Smart homes, smart cities, smart transportation, and smart farming are just a few of the many innovative intelligent concepts that the Internet of Things will soon be implementing" [8] [28]. This method may improve quality and production by applying the proper quantity of pesticide, fertilizer, water, etc. for example, the outside humidity, temperature, and soil's moisture content, by putting up a sensor network, it is feasible to monitor water management in an agricultural area effectively.

The smart farming system

According to Shaji, 2018 [9] The ecological footprint of agriculture is reduced via wise farming. Reduced or site-specific input consumption, such as fertilizer and pesticide use, will lower greenhouse gas emissions and ease worries about leaching in precision agricultural systems. With clever farming, farmers can discover that agriculture is more lucrative. Less labor and money will be spent by farmers on resources, and more reliable spatially explicit data will lower hazards. Optimal, site-specific weather predictions, yield estimates, and likelihood maps for illnesses and catastrophes derived from copious amounts of meteorology and climatic data would optimize crop productivity [28]. Site-specific information also opens up new insurance and financial options for the whole value chain, from technology and input providers to farmers, processors, and the retail sector in developed and developing nations. Moreover, smart farming may make products more palatable to consumers.

Figure 2 Technologies for Smart Forming Applications

By providing farmers with relevant environmental information from their farmed regions, smart farming technologies can assist them become more profitable and competitive. [7] [10]. However, the adoption of smart farming is hampered by the dearth of models that provide practitioners with advice on the fundamental components of IoT-based monitoring systems. Interoperability among the planned components faces considerable challenges due to the extensive varied nature of IoT setups. However, the adoption and widespread deployment of smart devices in our everyday lives may be facilitated by a well-designed architecture built on modern, improved IoT technology [8]. Numerous articles have attempted to address the optimal network architecture and technology for intelligent agricultural applications in recent years. [11].

According to Bacco et al., 2019 [12], Smart farming is a technique that relies on cyber-physical agricultural management using AI and IoT. Since smart agriculture makes it possible to monitor changes in soil properties, moisture content, and other climate-related elements, it tackles several challenges connected to agricultural output. Due to its ability to connect devices together over the internet so they may be controlled automatically, the Internet of Things (IoT) Numerous distant sensors, including those on robots, drones, and the ground, may be connected via technology [13].

It's challenging for tiny farmers to use this kind of equipment on their farms since commercial sensors for irrigation and agricultural systems are unreasonably expensive. Manufacturers, nevertheless, are already offering inexpensive sensors that can be connected to nodes to create inexpensive agricultural monitoring and irrigation control systems. [14]. More low-cost sensors have been suggested in studies due to the need for low-cost sensors to monitor agricultural and water. Examples are a water saltiness looking at sensor made of steel coils, a leaf pressure water quality sensor, a multiple the amount moisture in the soil detector made of rings of copper placed together a PVC pipe, and a turbidity of water sensor made of cultured and infrared led producers and receptors. [15].

II. IOT BASED SMART FARMING

According to Mageshkumar & Sugunamuki, 2020 [16] IOT The online programmed known as "based smart farming" gives farm owners a simple method to water their crops whenever and wherever they are—without having to physically be in the field. The manual technique of assessing parameters and irrigation of the area is still in use today and is among the oldest methods in agriculture [11]. Both the quantity of workers required and the cost of paying them are substantial. Using this approach, the farmers independently confirm all of the variables and measurements. Additionally, the watering process is only monitored manually. I.T. For efficient operation, based smart farming essentially requires two primary parts. Farm owners may inspect and track their fields with the aid of user login, requiring the username and password. The application module will show the field's moisture content, temperature, and humidity level [28]. If the field's parameters change, those values will be updated automatically. This will assist farm owners in staying current with their industry. For the proprietors, maintaining the large field takes a lot of work, particularly when they are not present. In addition, the procedure is expensive since it takes a lot of manpower to irrigate the land. Therefore, keeping an eye on and watering the field is simple for large-scale field owners.

The Internet of Things (IoT) is a key component in automating traditional operations in the contemporary world. It has been used as a productive solution to several typical engineering issues [17]. IoT concepts must be combined with different kinds of sensor data to produce automated systems that will process data in accordance with user requirements.

III. REMOTE SENSING TECHNOLOGIES FOR IRRIGATION MONITORING

According to Bwambale et al., 2022 [18] The science, technology, and art of using satellites or planes to acquire data about objects is known as remote sensing. Through the sense of ground-based energy, remote sensors acquired data. The energy might be sound, force fields, light, or any other type of electromagnetic radiation. A regular camera might be a remote sensor. When light from an object is reflected through the lens and captured by the light-sensitive film, it creates a latent picture. After that, a photo studio creates and processes an image for interpretation. RS, as described above, is used in various domains, including architecture, archaeology, medicine, industrial quality control [19] , robotics, extraterrestrial mapping [20], and so on.

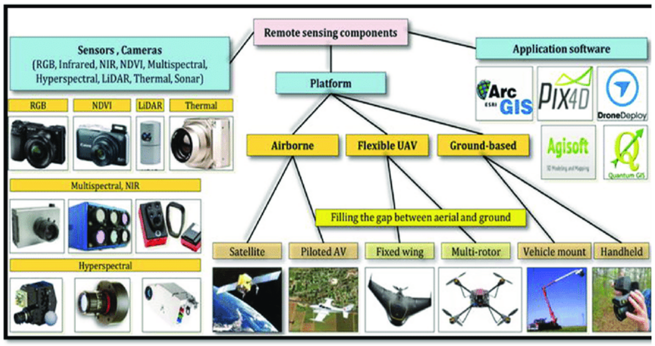

Figure 3 Remote Sensing Technologies for Irrigation Monitoring

According to Omia et al., 2023 [21] By tracking crop growth in a potentially effective way, information regarding the "state of the field crop" can now be gathered thanks to the use sensor technology in agriculture. Combining spectroscopy with imaging, hyperspectral imaging (HSI) is one of the most promising recent developments in the area. In contrast to imaging, Spectroscopy produces a single spectrum, which indicates the intensity of each pixel in the image. This indicates that a three-dimensional (3D) dataset—also referred to as a data cube—is generated from a spectral picture.

IV. Smart Irrigation Systems

According to [22] Numerous studies on the use of clever technologies in agriculture have been carried out, such as IoT, Wireless Sensor Networks (WSNs), and smart sensors [23]. More survey information on increasing agriculture's water productivity [24]. For the state of the art by combining sophisticated irrigation management techniques with agricultural water monitoring technologies to increase water production. Figure 4 depicts the many construction stages of smart irrigation systems.

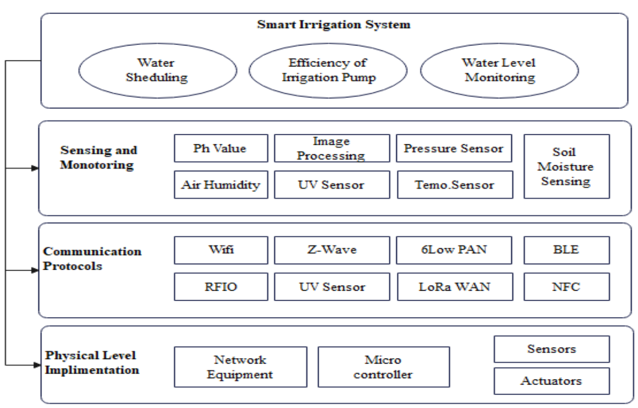

Figure 4 Smart Irrigation Systems Building Layers

A. Development of Irrigation System

This section presents four distinct time periods from 1970 to 2022 that illustrate the evolution of irrigation. Fig. 5 illustrates this development.

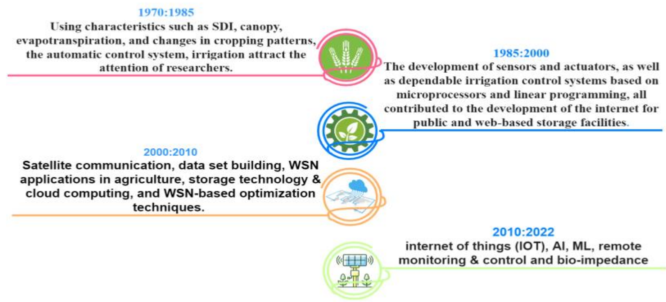

Figure 5 Development of Irrigation System

B. Techniques of Irrigation System

There are several sources of water that may be utilized for different types of irrigation techniques. The ultimate objective is to apply water to a field in an equal manner so that every plant gets the right quantity of moisture. [25]. Water is directly supplied to the root zone of crops via sophisticated irrigation systems. Water wastage is effectively reduced by modern systems, which also evenly distribute the water and energy saved and effectively manage the irrigation phase. Both conventional and modern irrigation methods are shown in the figure in Figure 6.

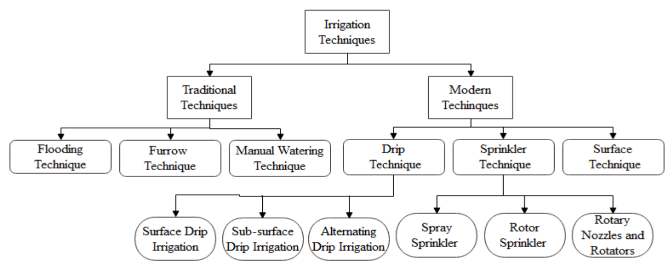

Figure 6 Techniques of Irrigation System

C. ***Monitoring of Smart Irrigation Systems***

To maximise water consumption, it's essential to monitor a few variables that affect plant growth and development. Using state-of-the-art communication technology, real-time data collection on cropped area the environment, health of plants, and soil health is necessary for context management of smart irrigation. *[26]*. A list of potential monitoring options for intelligent irrigation systems is shown in Figure 7.

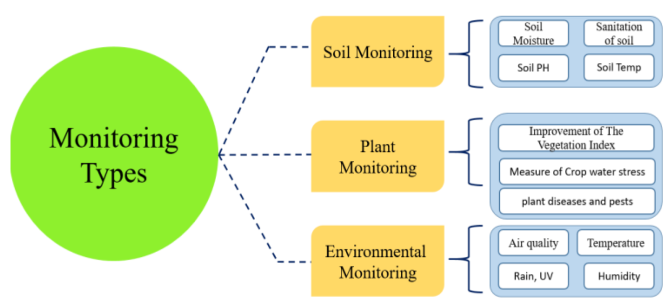

Figure 7 Monitoring of Smart Irrigation Systems

IoT based Smart Irrigation

A new scientific discipline called "smart irrigation" is emerging. It lessens environmental effect while raising agricultural yield using data-intensive strategies. A variety of sensors are used in modern agricultural operations to gather data, This enhances comprehension of the operational environment and actions.[27]. Making decisions becomes easier and more accurate as a result. Additionally, this makes it possible to optimize resources and accomplish the sector's declared objectives. [28]. Utilizing these technologies in irrigation systems saves water, making them a major contributor to the United Nations' Sustainable Development Goals (SDGs), notably Goal 6 and Target 6.4 [29]. The SDGs for Smart irrigation systems might be used to meet the needs for both the environment and water in order to improve everyone's quality of life over the long run. [30].

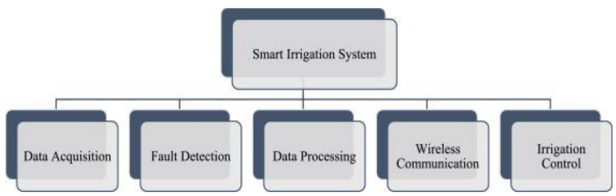

Figure 8 Smart Irrigation System

According to Abedin et al., 2017 [31] The most recent innovation for controlling irrigation systems and reducing water use is called the SMART irrigation system, which also enhances performance. With the help of this technology, farmers can meet demand by using a novel, well recognized method that controls irrigation according to soil and climatic circumstances, saving water throughout the process. Figure 4 depicts the SMART irrigation system, which incorporates data collecting (sensor), irrigation control, wireless connection, data processing, and problem detection. Each of these components may be utilized in IoT devices.

The Internet of Things (IoT), Farmers can now monitor the exact health of their field using smartphone applications and sensors. These technologies provide information on soil temperature, water requirements, weather, and much more. [32]. The Internet of Things (IoT) may be seen as a growth of the existing internet to include all internet-connected devices having electrical equipment communication capabilities, hence improving usability and user experience. In a similar vein, IoT is associated with automation of all farming and agricultural activity sectors to raise overall production and efficiency. [33].

According to Rodrigo Togneri, 2021 [34] In agriculture, irrigation is essential for ensuring proper crop yield since it keeps crops from becoming over- or under watered. Furthermore, it is a major economic factor since it takes a lot of energy to move water and operate irrigation equipment; in certain areas, the cost of the water itself is high [10]. Delivering the appropriate volume of water at the appropriate time to the appropriate location, smart irrigation seeks to maximize savings for the farmer by using precision irrigation and the Internet of Things [28].

According to [34] Water shortage is also a concern for the irrigation system. As a result, a smart irrigation system that uses water precisely is required. Because water is so important in irrigation systems, new irrigation techniques should be implemented in a way that demands less water use than existing technologies. Smart irrigation implies not only utilizing less water, but also supplying water when needed. This boosts agricultural efficiency and the potential of risk reduction. Using wireless sensors, this system remotely monitors weather conditions, plant soil conditions, and reservoir water levels. Smart irrigation systems may reduce water waste by up to 95%, while conventional approaches result in 20% to 70%.

Novelty:

This paper delves into the fusion of remote sensing and IoT technologies tailored specifically for real-time irrigation monitoring in smart farming, a pivotal facet of contemporary agriculture. It introduces a pioneering method to harmonize remote sensing data with IoT devices, furnishing farmers with actionable insights to refine irrigation techniques and bolster resource stewardship. Through the presentation of a case study and deliberation on challenges and remedies, this study enriches the practical application of integrated systems within authentic farming settings, thereby narrowing the chasm between theoretical frameworks and real-world precision agriculture.

Objectives:

Develop an integrated system merging remote sensing and IoT technologies for the instantaneous monitoring of irrigation in smart farming.

Demonstrate the efficacy of the integrated system in enhancing irrigation practices, fostering water conservation, and amplifying crop yield.

Illuminate the obstacles encountered during the integration phase and propose solutions for seamless deployment across diverse agricultural landscapes.

Contribute to the progression of precision agriculture by exemplifying the pragmatic implementation and advantages of integrating remote sensing and IoT for irrigation management.

V. Conclusion

In conclusion, a major development in contemporary agriculture is the integration of IoT and remote sensing technologies for real-time irrigation monitoring in smart farming. This study has shown that integrating these technologies to optimize irrigation techniques, save water, and increase agricultural yield is both feasible and practical.
Farmers may now obtain actionable insights and make well-informed decisions regarding irrigation management. Farmers may modify irrigation schedules and amounts based on real-time information on crop health, weather, and soil moisture levels provided by the system, which seamlessly integrates remote sensing data with Internet of Things devices.

In addition, the case study included in this paper illustrates how the integrated system is actually put to use in actual farming situations.

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