A review on Internet of Things (IOT) based Smart Irrigation System

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Abstract—
Water is one of the most basic and necessary resources for human survival. Water depletion has been growing in recent years as the population has increased. As a consequence, this has turned into a global crisis. Since the old irrigation scheme uses a lot of water, smart strategies for reducing the amount of water wasted for irrigation are needed. In any domain, from tiny and basic applications to massive and complicated applications, we've seen a significant increase in demand for Internet of Things. In practise, implementing a Smart Irrigation system is a difficult task, but when combined with IoT and the use of smart wireless sensors, it creates an excellent control system. The Humidity and Temperature Sensor detects the amount of water vapour present in the air as well as the temperature around the crop. The Soil Moisture Sensor senses the moisture content of a plant's soil; if the content is below the minimum requirement, water is supplied from a reservoir through a relay, and an ultrasonic sensor tests the reservoir's water level before transmitting the data to the ESP8266 NodeMCU. The ESP8266 NodeMCU is a microcontroller that receives data from smart wireless sensors, processes it, and sends it to its intended destination.

Keywords— Smart Irrigation System, Internet of Things, Water, Soil Moisture Sensor, Humidity and Temperature Sensor

1. INTRODUCTION

Agriculture plays a vital role in India's development, because agriculture is the back of the country because major source of income is from agriculture sector, 70% of the farmer and people is depend upon agriculture. Agriculture issues have always impacted the development of the country. Smart agriculture is the only solution to this issue by modernizing the new conventional methods of agriculture. The proposed approach is therefore aimed at making agriculture smart using automation and IoT technologies. The Internet of Things (IoT) facilitates multiple applications for crop growth tracking and selection, irrigation decision support, etc. The IOT automated irrigation system based on Raspberry Pi is proposed to modernize and increase crop productivity. The main objective of this project is on crop production at low water usage, in order to concentrate on the water available to plants at the appropriate time, farmers have to spend time in the field to check appropriate time for irrigation. Effective water control should be established and the size of the device circuits minimized. The proposed device was built on the basis of the information sent from the sensors and the estimation of the quantity of water required. Two sensors are used to collect data from the base station on the humidity and temperature of the atmosphere, the humidity, the temperature and the length of the sunshine each day. The suggested schemes are based on these values and are needed to measure the volume of water for irrigation. The key benefit of the device is the introduction of Precision Agriculture (PA) with cloud storage, which can maximize the use of water fertilizers while optimizing crop yields and will also assist in the study of field weather conditions. Due to data store in cloud, we can do predictions in future for better timing of irrigation based on change in season and temperature.

2. LITERATURE REVIEW

The Internet of Things (IoT) is developing, growing, and getting more common by the day; in today's world, nearly 5 billion items are linked to the internet. It is projected that about 50 billion items will be wired to the internet by 2021. IoT is opening up a lot of doors for new uses, and it's also being used in a lot of areas, including intelligent home control systems, food supply chain management, precision agriculture, and so on.

The below are some of the benefits of using an automatic irrigation control system:

A. Would maximize the role of current water-saving equipment, ensuring optimum performance and quality.

B. More water and energy efficiency, lowered irrigation costs, and increased irrigation productivity through the use of automated control technology.

C. It would irrigate in a more scientific manner in order to promote and enhance maintenance. Agricultural modernization necessitates the control and encouragement of water-saving irrigation technologies.

D. Crops can be constantly tracked and prompt decisions can be made as a result.

E. By prompt preventive and control measures, it can help to reduce casualties due to unexpected disease and insect attacks.

F. Earlier environmental alerts and warnings.

3. METHODS OF IRRIGATION

Irrigation is the artificial application of water to crops to meet their water needs. Irrigation is another means to supply nutrients to crops. Irrigation management needs to be systematic in order to boost crop efficiency, save water, and act as a source of energy. Some of the most popular irrigation methods are described in the subsections below.

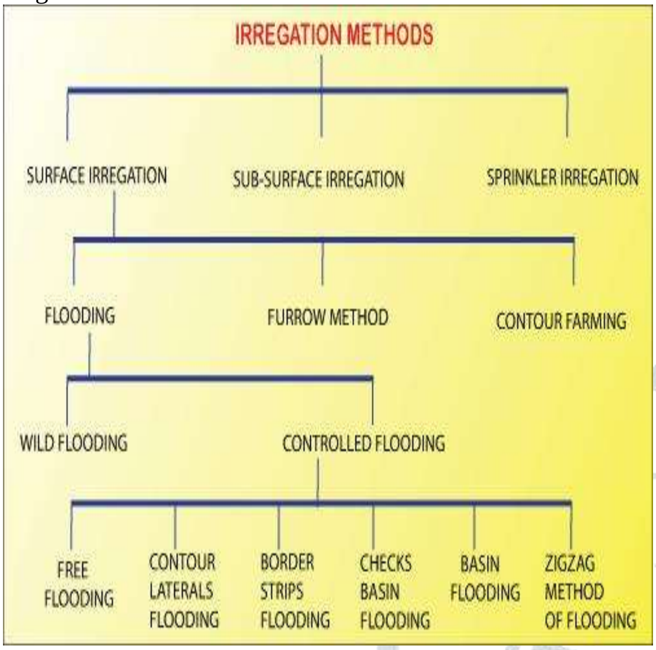

Fig. 1 Type of Irrigation

a. Sprinkler Irrigation

Sprinkler irrigation is a water application method that mimics natural rainfall. Pumping is commonly used to convey water across a network of pipes. It's then sprinkled into the air, breaking up into tiny water droplets that fall to the ground. When the amount of water available is small, this approach comes in handy. It also needs less manual labor and uses less water.

b. Surface Irrigation

It is the most common form of irrigation, in which water is spread and spread by gravity over the soil surface. It is a widely used irrigation system in many parts of the world. However, this approach is inefficient since it may induce water logging, which slows plant development.

c. Drip Irrigation

Based on the amount of water available in the region, drip irrigation is the most effective form of irrigation. The main purpose of a drip system is to reduce water use and avoid water shortages. Drip irrigation's main advantages are that the water soaks into the soil before evaporating and that it is only applied to the field when it is required. This method may be used to develop systematic irrigation management. Drip irrigation can be used on any kind of soil and on a wide range of plant species. The proposed work employs the drip irrigation method, which is thought to be more beneficial and is more often used for plant cultivation. Of all irrigation systems, drip irrigation uses the least volume of water. It is the most common form of irrigation in arid regions of the world.

d. Center Pivot Irrigation

A centre pivot irrigation method irrigates crops in a circular pattern around a central pivot using a mechanised irrigation system. It is made up of a radial pipe and towers that pivot around a central point. Nozzles are evenly distributed around the radial tubing. Water is sprayed from the nozzles as it rotates, irrigating the fields.

4. MONITORING IN SMART IRRIGATION

A reliable monitoring system for various parameters that influence plant growth and development is critical for developing an effective irrigation control system that increases food production while reducing water loss. Monitoring in the form of precision irrigation often entails using wireless sensor networks (WSN) and Internet of Things (IoT) technologies to gather data that reliably represents the real-time state of soil, plant, and atmosphere in the irrigation areas of the plants. The Internet of Things has paved the way for the use of low-cost hardware (sensors/actuators) and networking systems (Internet) to boost the irrigation process tracking and control system **[1].** Similarly, distributed WSN nodes play an important role in precision farming real-time monitoring. They are a wirelessly linked network of sensor nodes that detect, compute, and relay data on a variety of parameters and are intended for large-scale and long-term implementation **[2].** The use of IoT to track key components in precision irrigation has become a norm, with sensors, cameras, and Unmanned Aerial Vehicles (UAV), drones, and satellites seamlessly linked for data collection and delivery using cloud service platforms **[3]** Data processing of sensor-controlled parameters for decision making, simulation, and behavior are among the resources offered by the cloud platform (Rajeswari et al., 2017). Farmers and researchers will use smartphones or fixed computers to remotely access the IoT cloud server where the control and tracking algorithms are installed to provide deeper feedback and improve the decision-making process in real-time **[6]**. As a result, farmers will be able to track soils, seeds, and weather parameters more effectively and easily, improving the efficacy of precision irrigation control systems and ensuring high-quality food production **[11].** IoT and WSN are important facets of agriculture control, as well as the use of other sensors, where sensed parameters can be transmitted using various wireless networking systems such as Bluetooth, Wi-Fi wireless protocol, and GPRS/3G/4G technology. LTE Cat-NB1 and LTE Cat M1 wireless technologies, as well as Low Power Wide Area (LWPA) wireless technologies, have been used for wide area coverage tracking **[13]**.

4.1 Soil based Monitoring: -

One of the most important factors for plant growth is soil moisture. In order to ensure optimum irrigation scheduling, high spatiotemporal monitoring of soil moisture content is needed. Using a Raspberry Pi and an Arduino prototyping board, several IoT-based soil moisture monitoring systems for irrigation management have been created. This is linked to numerous sensors to track real-time soil moisture fluxes for irrigation decision-making and scheduling. **[12]** The type of soil moisture sensing used is a low-cost capacitance-based system that works on the principle of a dielectric device. By correlating the volumetric water content (VWC) of the soil and the capacitance of the sensor probes embedded in the soil with acceptable precision, real-time soil moisture sensing using capacitance-based sensors is applicable for realistic measurements of soil moisture fluxes. A time domain reflectometry (TDR) sensor, which consists of two parallel rods inserted into the soil at the desired depth, will provide a more precise soil moisture sensing solution. The sensor rod emits an electromagnetic pulse, and the rate at which the pulse is conducted into the soil and transmitted back to the soil surface is proportional to the soil moisture content. TDR soil moisture sensors, on the other hand, need a high sampling rate to obtain a good signal reflected from the soil, making this form of sensor prohibitively costly for farmers to instal on a wide scale for soil moisture monitoring. For multisensory calculation of soil water content at various depths, soil, and air temperatures, a low-cost monitoring irrigation system was proposed **[13].** The dielectric probe with an 80 MHz sensing frequency is the soil sensor probe used to track the soil water material. The sensors were connected to an Arduino Uno microcontroller as analogue inputs, with the data being transmitted to the internet via the ESP8266 Wi-Fi module for data logging. Node MCU was used to carry out related analysis **[19]**. Similarly, using Arduino as a controller **[21].,** an IoT-based field management system was deployed with cloud-based monitoring and data processing. Their results revealed that the data obtained was used to make a forecast that was used to minimise water demand and prepare strategies to improve crop yields.

4.2. Weather Based Monitoring

The real-time calculation of the reference evapotranspiration (ETO) using measured weather variables as an indicator of water loss from the plant and the soil atmosphere is one area of increased interest in weather-based monitoring. The rate of water loss is primarily determined by the precision with which solar radiation, air temperature, and wind speed are measured. Weather stations and other devices built on the Internet of Things can be used to collect this data. WSN is one of the most commonly used technical methods for precision tracking of weather and environmental parameters. **[1]** WSN is provided as an alternative and powerful method of interconnecting different sensors to track physical or environmental conditions for a large cropping region in the implementations. According to reports, the system achieves real-time tracking and processing of data from sensors in a feedback loop, which unlocks control devices depending on a pre-calculated threshold value. An IoT-based weather tracking system that uses various weather-based sensors interfaced with wireless connectivity protocols for real-time data transmission and web-based applications to

track and analyse the crop climate such as air temperature, humidity, solar radiation, wind speed, and moisture content in the soil. For precise and effective sensing of moisture content, weather, and leaf wetness of the farm layout, three sensor networks, each with three soil moisture sensors, temperature, and leaf wetness, were used**[18].** Intercommunication between sensor nodes was developed using a ZigBee-802.15.4 wasp-mote board with a transmitting range of 500 m at 38,400 bps via the gateway to the webserver, where an irrigation decision was taken by an expert system.**[17]** used an open-source platform called PANGEA to show a multi-agent-based tracking method for capturing different weather variables using sensors for

temperature, solar radiation, humidity, pH, wind, and soil moisture using an open-source platform called PANGEA. The platform consists of multiple sensors networked Master and Slave nodes that communicate at 433 MHz for sensor data transfer.

4.3. Plant-Based monitoring

Farm-based monitoring with optical sensors has become a popular method for assessing plant water stress, evaluating crop quality, and identifying possible threats to plant growth and production such as drought, nutrient deficiency, and pest attacks. Some of these optical sensors may be fixed (immovable) near to the farm, whereas others can be placed on moving platforms like helicopters, unmanned aerial vehicles (UAVs), movable sprinkler devices **[15],** and satellites **[16].[20]** used captured photographs of the cultivated plant and soil to establish wireless sensor networks and a gateway node method to gather soil moisture content in the tea plantation. A high definition camera mounted on the UAV was used to take pictures of the tea leaves in order to measure the tea deficit. Since only required fertilisers are injected through the drip method, the proposed system has greatly aided in water conservation and has also reduced soil erosion**.[14]** used in situ monitoring of the Leaf area index (LAI), a critical crop parameter used for optimum irrigation and crop efficiency, to demonstrate the convergence of the Internet of Things with wireless sensor networks. This was accomplished with the help of an optical filter and diffuser for measuring photosynthetically active radiation (PAR), which was needed to calculate an accurate estimate of LAI.

The use of an unmanned aerial vehicle (UAV) fitted with high-resolution cameras for smart aerial surveillance of irrigation area vegetation was demonstrated Precision irrigation is now the subject of increased research in this field. The UAV was programmed to fly over the irrigation field testbed with an onboard camera equipped with a Sony IMX 219 CMOS sensor. The normalized difference vegetation index (NDVI) map was computed using the integration of multispectral images collected by UAV cameras with DSS for precise control of the linear sprinkler machine used for irrigation of the tomato cultivated field layout. The authors claimed that by combining the NDVI technological index with the DSS, they could save more water.

5. Precision Irrigation System for Farmer

Many industries have built a smart watering system that can help achieve high water-saving and precise irrigation, as precision irrigation control is vital for increasing efficiency and maintaining food security. The majority of the items are geared toward achieving precision irrigation while also reducing the burden that comes with manual irrigation.

Farmers and scholars, on the other hand, face a major obstacle in obtaining these cutting-edge instruments due to their high cost. Furthermore, the majority of commercial irrigation systems on the market are custom-built, making it impossible to fine-tune and adaptively manage them.

Furthermore, most commercial irrigation systems do not take into account soil, plant, or environmental conditions when making irrigation decisions for maximum water conservation. Furthermore, most commercial goods are unable to correctly control the effects of disruptions to plants such as evapotranspiration, which represents water leakage from plants and the soil surface, as well as shifting and nonlinear dynamics of plants

6. Future Research Work

The aim of this analysis is to look at the different attempts and improvements made to increase water use quality, water conservation, and, most notably, food protection using IoT-based monitoring and control systems. Researchers and farmers will use the IoT for real-time tracking and data collection for data-driven control, machine learning, and deep learning for intelligent prediction of agricultural processes such as yield, water consumption, and weather, according to the analysis. The use of the normalised dimension vegetation index (NDVI), the lea area index (LEA), and other scientific indexes in determining and preparing irrigation scheduling for vast irrigation field areas needs more research. Furthermore, reliable model-based forecasts may assist farmers in organising operations and preventing unforeseen shifts that can impact agricultural practises.

Furthermore, various control algorithms in the sense of irrigation systems have been discussed; researchers can concentrate on improving any model-based or adaptive controller with real-time monitoring for precision irrigation.

7. Conclusion

The impact of global warming and climate change on water shortages and food security is becoming more widely recognised, prompting researchers to step up their efforts to create cutting-edge real-time tracking and control methods for precision agriculture that can minimise the impact of this unavoidable phenomenon. This study of precision irrigation system monitoring and control techniques is focused on previous and relevant studies to aid in water conservation in agriculture. This review article was able to provide a good understanding of research developments in developing advanced control techniques for precision irrigation, as well as evaluate research opportunities in studies that can ensure water efficiency, maximise crop production, and decrease irrigation energy use. It is intended to spark innovative ideas and inspire readers about how existing surveillance and advance management methods can be strengthened to achieve improved precision irrigation for food protection and aid in water conservation in order to avoid impending water crises.

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