REVIEWING THE SMART IRRIGATION SYSTEM BASED ON IOT

Abstract

Agriculture plays a vital role in food production within any country, and the economic development of a nation heavily relies on the production of high-quality crops in substantial quantities. In India, agriculture contributes approximately 18% to the total GDP (Gross Domestic Product) and provides employment to a significant number of people. Additionally, water is a fundamental resource for survival on Earth, and it is crucial to maintain adequate freshwater levels. However, freshwater resources are limited, and two primary challenges currently affecting agriculture are the ever-changing environment and the continuous decline in water levels due to various factors. Without water, irrigating agricultural fields becomes impossible.

To conserve water and ensure its optimal usage, it is essential to develop an automated irrigation system that can effectively manage irrigation and enhance crop efficiency. Such a system could serve as a solution for optimizing water usage in irrigation processes. Traditional irrigation methods demand substantial effort and time from farmers. By implementing a sensor-based irrigation system, we can significantly reduce irrigation time and alleviate the financial burden and labor-intensive nature of farming. This paper aims to provide an overview of sensor-based irrigation systems, incorporating IoT (Internet of Things) technology, and explore their applications through the examination of various research and review papers.

Keywords: Agriculture, Automatic, IoT (Internet of Things), Irrigation, Sensor, Water Saving.

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I. INTRODUCTION

Irrigation is an essential requirement for agriculture, which serves as a primary source of income for many Indians. Approximately 70% of Indian farmers and the general population depend on agriculture for their livelihood. Over the years, researchers have undertaken numerous studies and introduced innovations aimed at improving agricultural yields in the face of labor shortages and limited resources. However, the demand and supply ratio in agriculture does not align with the rapid population growth experienced in recent times.

Traditionally, farmers in India relied on manually operated irrigation systems. However, in present times, these outdated irrigation methods have largely been replaced by semi-automatic or fully automatic systems. Nevertheless, in certain underdeveloped rural areas, manual irrigation systems are still in use [1], [2].

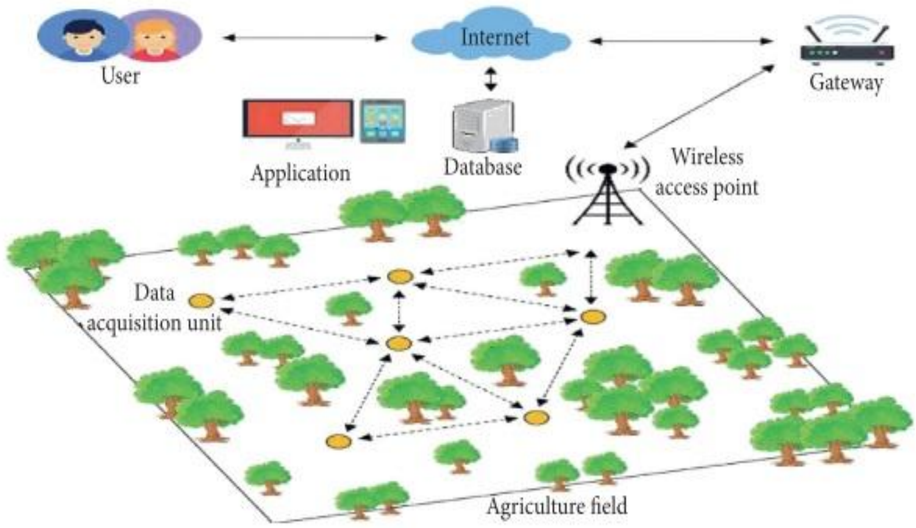

Figure 1: Layout of IoT based Automatic Irrigation System in Agriculture[4]

Recent advancements in science and technology have revolutionized the field of smart farming, offering farmers the ability to remotely monitor their agricultural fields and crops using sensors and automatic irrigation systems via the internet. The implementation of sensor-based smart agriculture systems enables farmers to gather extensive information concerning climate change, soil moisture levels, crop conditions, and more. Consequently, these systems contribute to improved productivity and yield outcomes. An integral component of smart agriculture systems is IoT-based smart irrigation, which surpasses the efficiency of traditional irrigation methods [3]. Figure 1 illustrates the layout of an IoT-based automatic irrigation system in agriculture.

The term "IoT" was first coined by the Massachusetts Institute of Technology (MIT) in 1999. In a smart irrigation system, various sensors are utilized, including temperature/humidity sensors, soil moisture sensors, pH sensors, electrical conductivity (EC) sensors, and photo cell sensors. Among these, the soil moisture sensor holds significant importance. It measures the water content, or moisture, in the soil. This measured value is then compared with a preset threshold value to determine the difference between the two levels, indicating high or low moisture levels. Temperature/humidity sensors are responsible for measuring the surrounding air temperature and relative humidity, which defines the ratio of actual moisture present in the air to the maximum moisture capacity at a specific temperature.

Table-1: Comparison between Conventional and Automatic Smart Irrigation System[6]

Comparison Factors	Conventional Irrigation System	Automatic irrigation System
Quantity and time of irrigation control	Manual and estimated	Automatically and according to the plant's needs.
Soil test time for irrigation	Manual and take about 20-30 days	Automatically and take about 2 minutes
Quantity of added irrigation	Approximately	When needed
Farmer health	More dangerous	More safety, less dangerous
The effect of the water level to the plants and productivity	Sometimes more water level is affects the plants	Maintain water level automatically and increase productivity
Costs	The cost of conventional irrigation is high	Reduce the use of the water and labor, so the cost is low
Energy Consumption	High	Low

There are three primary types of irrigation systems employed in smart agriculture, depending on the crop's requirements: channel irrigation with automatic on/off control of motor pumps, drip irrigation, and sprinkler irrigation. Various studies have demonstrated that smart irrigation systems, particularly those incorporating soil moisture sensors, enable water conservation for farmers. Table-1 illustrates the comparison between conventional and automatic smart irrigation systems. In modern times, the adoption of IoT-based smart irrigation systems in agriculture is driven by several advantages over traditional irrigation methods, as supported by research [5].

- Easy on/off control of motor pump sets through automated irrigation systems.
- Minimization of water consumption by efficiently managing irrigation.
- Effective cost savings, time efficiency, and elimination of human errors.
- Efficient utilization of water resources.
- Protection from damage caused by birds and adverse weather conditions.
- Reduction in manpower requirements and conservation of energy and resources.
- Minimization of soil erosion and leaching of nutrients.
- Increased productivity of crops in terms of both quality and quantity.
- These advantages contribute to more sustainable and productive agricultural practices.

II. LITERATURE REVIEW

1. Authors Karan Kansara, V. Zaveri, S. Shah, S. Delwadkar and K. Jani researched on the topic, **"Sensor based Automated Irrigation System with IOT: A Technical Review"**. The authors of this work primarily focused on the objective of implementing an automatic irrigation system. In their review paper, they highlighted the benefits of this system,

including cost savings, time efficiency, and reduced reliance on manual labor for farmers. The authors also discussed the significance of utilizing various sensors in the automatic irrigation system to enhance the overall efficiency of agricultural practices [1].

2. Authors M. Ayaz, M. Ammad-Uddin, Z. Sharif, A. Mansour and El-Hadi M. Aggoune researched on the topic, **"Internet-of-Things (IoT)-Based Smart Agriculture: Toward Making the Fields Talk"**. In their study, the authors explored the potential of Wi-Fi sensors and IoT in the context of smart agriculture. They investigated how this technology can be applied in various stages of agriculture, ranging from crop cultivation to packaging, transportation, and beyond. Additionally, the authors emphasized the use of unmanned aerial vehicles (UAVs) for crop monitoring and other supportive tasks. They provided an overview of the current state of IoT-based agricultural systems and identified both the existing and future demands for IoT in this field [2].

3. Authors Raquel G. Chabla, Karina R. Aviles, C. Moran, P. Grijalva and T. Recalde researched on the topic, **"IoT Applications in Agriculture: A Systematic Literature Review"**. The authors conducted a literature review focusing on IoT-based applications and tools for smart agriculture in their work. They explored various tools and software applications currently available in the market that are relevant to IoT systems in agriculture. Additionally, they highlighted the benefits associated with this emerging technology, providing valuable insights into its potential applications in the agricultural domain [3].

4. Authors Wei Li , M. Awais, Weimin Ru, W. Shi, M. Ajmal, S. Uddin and C. Liu researched on the topic, **"Review of Sensor Network-Based Irrigation Systems Using IoT and Remote Sensing"**. In their research, the authors highlighted a decision support method utilizing Wi-Fi sensors for remote measurement of various parameters in an agricultural field, as well as for irrigation purposes. The data recorded by these sensors can be directly transmitted to a cloud server through IoT technology. Users can access the captured parameters through internet-enabled devices from any location worldwide. This technological advancement transforms traditional agriculture into a modern and cost-effective practice, increasing overall efficiency.

   The authors also addressed a problem identified in previous review papers: the irregular power supply for operating automatic irrigation systems. To tackle this issue, they proposed the use of solar panels to store energy in batteries, ensuring a continuous power supply even in the absence of electricity from the grid. Additionally, they suggested the utilization of power-class antennas to resolve problems associated with radio-range frequency and transmission. Power-class antennas are upgraded technologies employed in radio-frequency transmission [4].

5. Authors J. Jegathesh Amalraj, S. Banumathi and J. Jereena John researched on the topic, **"A Study on Smart Irrigation Systems For Agriculture Using IoT"**. In their research, the authors dedicated their focus to identifying and addressing the problems, issues, and challenges encountered by farmers in agriculture. They proposed solutions to these challenges by leveraging smart technologies and transforming traditional agriculture into a modernized approach. Among these technologies, the authors highlighted the significance of IoT-based irrigation systems in enhancing agricultural efficiency. IoT has

emerged as one of the most successful and effective techniques in the agricultural field. The implementation of smart irrigation systems plays a crucial role in supporting crop production by providing the necessary water to the soil or land [5].

6. Authors D. Rani, N. Kumar and B. Bhushan researched on the topic, **"Implementation of an Automated Irrigation System for Agriculture Monitoring using IoT Communication".** The authors of this study targeted the practical applications of IoT in agriculture and provided a modern solution for farmers to monitor and maintain crop health through an automated irrigation system. Their research specifically focused on the development of rice crops and employed IoT technology to monitor the agricultural field. Various sensors were utilized for different tasks, such as a pH sensor to measure soil acidity, moisture sensor to measure soil moisture levels, and temperature sensor for soil temperature monitoring.

   The authors concluded that the implementation of a smart irrigation system is a current farming approach. They also introduced a dashboard concept, enabling users to control the water pump and irrigate agricultural land by turning it on or off. This dashboard serves as a user interface for managing the irrigation process [6].

7. Authors A. J. Rau, J. Sankar, A. R. Mohan, D. D. Krishna and J. Mathew researched on the topic, **"IoT Based Smart Irrigation System and Nutrient Detection with Disease Analysis"**. The adoption of modern technologies in Indian agriculture is steadily on the rise. According to data from the World Bank, approximately 60 percent of the land in India is dedicated to cultivation. However, there is a significant gap between the demand and production of food in the country. The output of agricultural land is influenced by various factors such as water availability, temperature, soil moisture, and soil pH levels.

   In this research, the authors visited the Kerala Rice Station and engaged in discussions with farmers to gain insights into the challenges related to crop production [7].

8. Author Zhang Feng researched on the topic, **"Research on water-saving irrigation automatic control system based on Internet of things"**. In this research, the author delved into the control method and design of an automatic irrigation system that relies on IoT and wireless sensor networks. This system aims to enhance the efficiency of farmland while reducing irrigation water costs. Farmers are empowered to monitor their agricultural fields remotely through mobile phones or Wi-Fi systems. They can control the irrigation water based on the specific requirements of their fields, leading to more precise and optimized irrigation practices [8].

9. Authors S. N. Durga and M. Ramakrishna researched on the topic, **"Smart Irrigation System Based on Soil Moisture Using IoT"**. The authors of this research emphasized the significant contribution of agriculture to the Indian GDP and highlighted its status as a primary occupation for the Indian population. The focus of their study was on various traditional irrigation techniques such as sprinkler irrigation and drip irrigation. These techniques now require integration with the internet to enable automation and smart functionality, thereby enhancing water efficiency.

The authors also discussed the role of IoT in saving water by preventing wastage and reducing the time and labor involved in irrigation activities. By leveraging IoT technology, agricultural practices can be optimized for more efficient water usage [9].

10. Authors S. J. Muneeswari, Merlin Janet E, Rajeshwari and G.Selvarani researched on the topic, **"Smart Irrigation System using Iot Approach"**. In this research, the authors employed the Arduino microcontroller and a soil moisture sensor to develop an IoT-based smart automatic irrigation system for agriculture. The system focused on controlling the water flow mechanism using Wi-Fi connectivity over the internet. This setup allowed for remote monitoring and control of irrigation activities, enhancing the efficiency and effectiveness of water management in agriculture [10].

11. Author Srishti Rawal researched on the topic, **"IOT based Smart Irrigation System"**. The author presented a proposed irrigation system that utilizes an ATMEGA328P microcontroller on an Arduino board for system control. The system gathers information from various sensors, which is then continuously updated on a webpage via a GSM/GPRS SIM 900A modem. Through the implementation of IoT, farmers can conveniently check the on-off status of sprinklers whenever necessary, empowering them with remote control capabilities provided by the automated irrigation system [11].

12. Authors R. Sable, S. Kolekar, A. Gawde, S. Takle and A. Pednekar researched on the topic, **"A Review on Different Irrigation Methods"**. In this paper, the authors provided a comprehensive review of various irrigation systems commonly used in agriculture, including both traditional and automated methods such as surface irrigation, subsurface irrigation, drip irrigation, sprinkler irrigation, and smart irrigation, among others. The authors examined and highlighted the differences between manual irrigation systems and automated irrigation systems. After discussing 16 different irrigation systems, the authors concluded that automated irrigation systems offer advantages such as higher crop production, savings in manpower, time, and water compared to manual irrigation systems [12].

III. REQUIRED COMPONENTS

The various components used in the project's model, based on previous work, may include:

1. Sensors

- **Temperature & Humidity sensor:** The DHT11 sensor is commonly used to measure temperature and humidity in the atmosphere. It is a digital sensor that provides digital data for temperature and humidity readings. In a system setup, the DHT11 sensor can be connected to a microcomputer processor system such as Raspberry Pi. The temperature and humidity data captured by the sensor are then sent to a cloud server for storage and further analysis [7].

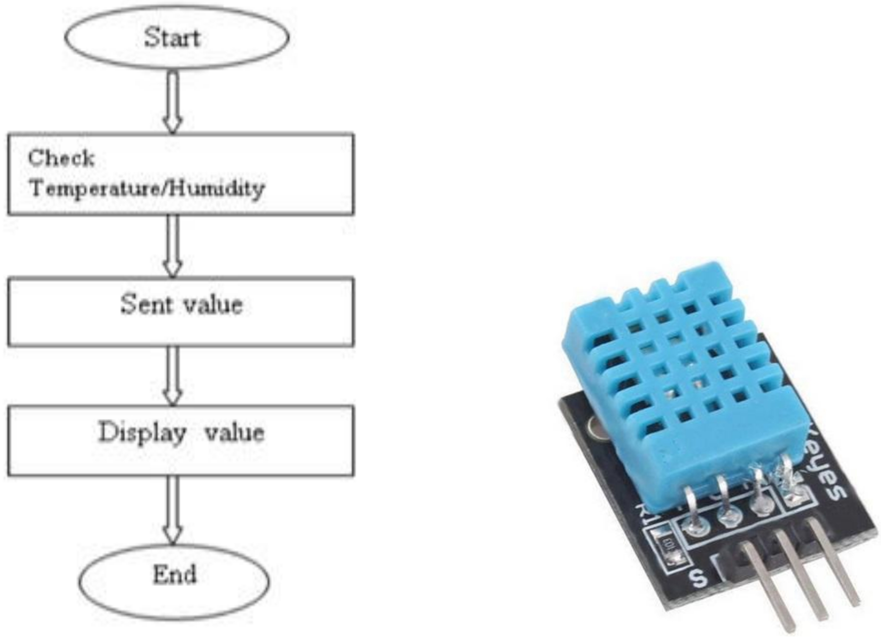

Figure 2: Working flow chart[13] & DHT11 Sensor

LM35 is another temperature sensor commonly used in various applications, including temperature sensing in agriculture. Unlike the digital DHT11 sensor, the LM35 sensor is an analog sensor, meaning its output is an analog signal that is directly proportional to the instant temperature value. The LM35 sensor's output voltage can be easily converted to temperature readings in Celsius. One of the main advantages of the LM35 sensor is that it does not require external calibration, simplifying its implementation and providing accurate temperature measurements [11].

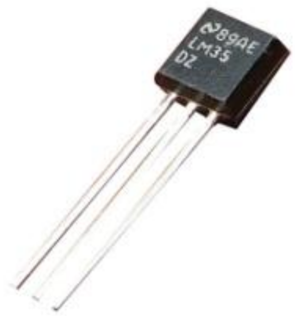

Figure 3: LM35 Sensor

- **pH Sensor:** In smart agriculture systems, pH sensors are utilized to measure the acidity or alkalinity of the soil. It is crucial to monitor and maintain the pH level of the hydroponic nutrient solution for optimal plant growth. The pH scale ranges from 1 to 14 on a logarithmic scale. Values between 1 and 6 are considered acidic, pH 7 is neutral, and values from 8 to 14 are considered basic or alkaline. Most plants thrive within a pH range of 5.5 to 7. Based on this range, the soil nutrient level can be defined. If the solution becomes too alkaline or acidic, it can pose problems that affect plant growth, as the solution is directly absorbed by the plant's roots. Therefore, maintaining the appropriate pH level is essential for ensuring optimal nutrient absorption and promoting healthy plant growth [11], [14].

Figure 4: Analog pH Sensor

- **Soil Moisture Sensor:** The sensor being referred to is the soil moisture sensor, which measures the volumetric water content in the soil and provides information about the soil's moisture level. This sensor can be used in both basic and electronic modes, making it versatile for various applications.

  In smart crop monitoring systems, regular monitoring of soil moisture content is essential. The sensor continuously measures the moisture level and sends this data to users through an Android application. The received data is then compared with pre-set values in the system. If the data falls below or exceeds the pre-set threshold, an automatic message is sent to the user. Based on this message, an irrigation system such as sprinklers or drip irrigation, connected to an Arduino board, can be activated to supply water to the specific area of the agricultural field that requires it [11], [14].

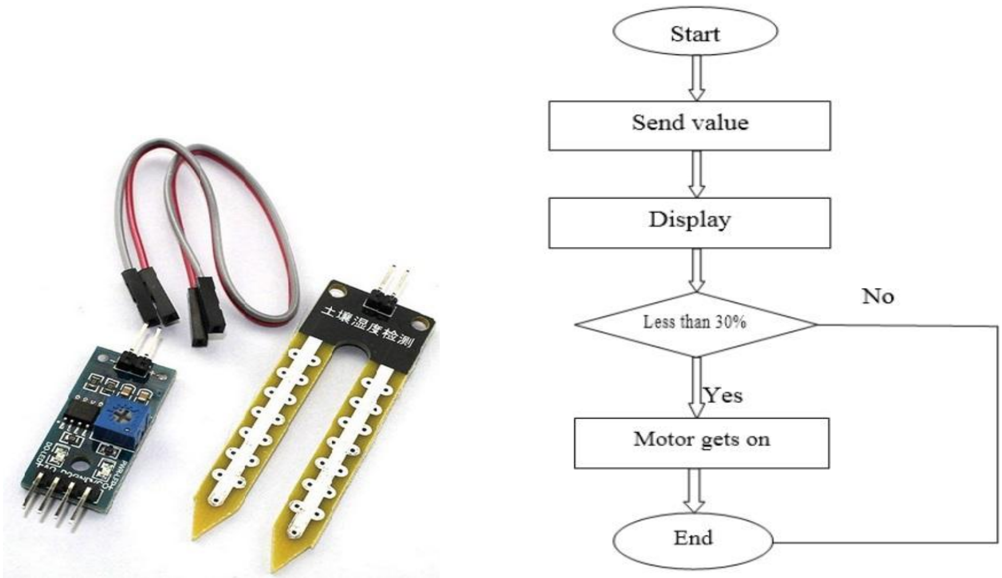

Figure 5: Soil Moisture Sensor and working Flow Chart[13]

- **Photo Cell Sensor:** The photo cell sensor, based on the Light Dependent Resistor (LDR), is employed to detect light levels. The sensor captures the light readings and sends them to an Arduino board for processing. These readings are then compared with pre-set values. If the current light readings deviate from the pre-set threshold, the user can take action to provide additional or artificial light sources for the plants. This enables the user to ensure the plants receive the necessary amount of light for their growth and development.

Figure 6: Photo Cell Sensor

2. Microcontroller

- **Arduino:** The Arduino microcontroller is a type of circuit board that combines both software and hardware components. It features an integrated development environment (IDE) that provides a user-friendly platform for writing and uploading computer code to the board. Arduino is an open-source platform, which means its software and hardware designs are freely available, allowing users to modify and adapt it for their specific needs. This makes Arduino a popular choice for programming and controlling various projects, including those in the field of electronics and robotics.

Figure 7: Arduino UNO Microcontroller Board

IV. PROGRAMMING PLATFORM

THINGSPEAK is indeed a suitable web server application based on the Internet of Things (IoT) for programming a smart irrigation system. It provides a platform for storing and retrieving data related to IoT applications. THINGSPEAK utilizes a JSON format to convert stored data into a human-readable format. It was initially launched in 2010 by IO bridge as a supporting service for IoT applications.

One of the notable features of THINGSPEAK is its integration with MathWorks, which provides support for numerical computing software such as MATLAB. This integration allows users to analyze and process the data collected from their IoT devices using powerful mathematical and analytical tools.

Users can retrieve and store data from THINGSPEAK over any local area network (LAN) or the internet using the HTTP protocol. Additionally, JSON (JavaScript Object Notation) is used for server/browser communication in an asynchronous manner. JSON is an open standard file format derived from JavaScript and is widely used for exchanging data between server and client applications [13].

V. BLOCK DIAGRAM OF SYSTEM

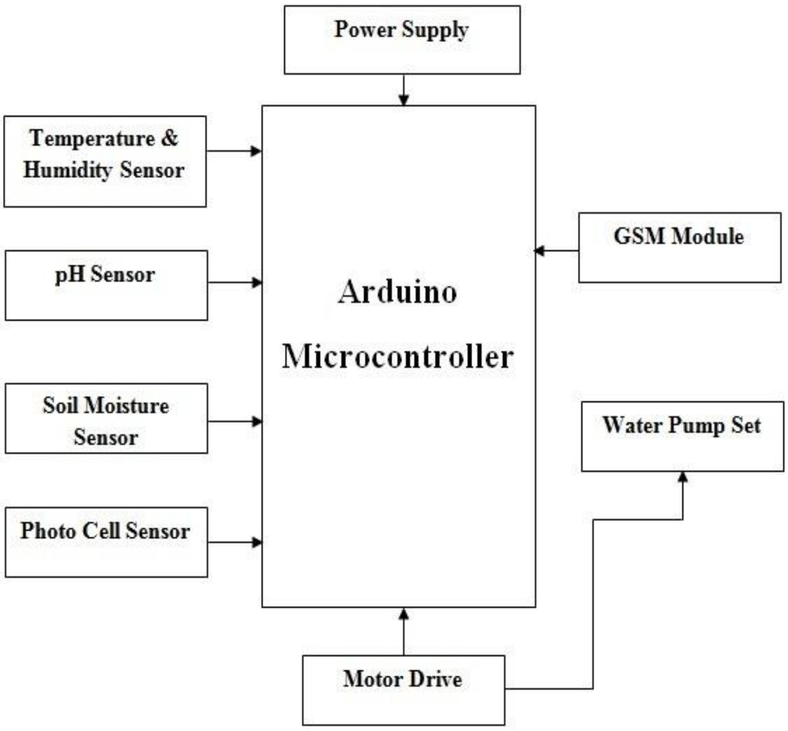

Figure 8: Block diagram of Smart irrigation System

The block diagram for an IoT-based smart irrigation system is shown in Figure 8. The system is designed around an Arduino microcontroller, which acts as the central processing unit. The microcontroller's input pins are connected to various sensors, including temperature and humidity sensors, pH sensors, soil moisture sensors, and a photo cell sensor. The microcontroller is powered by a 5V power supply, which is also connected to an input pin.

The output pin of the microcontroller is connected to a motor drive and a water pump. This connection allows the microcontroller to control the operation of the water pump based on the data received from the sensors. The motor drive facilitates the motor's activation or deactivation, while the water pump is responsible for pumping water to the irrigation system.

Overall, the block diagram illustrates how the Arduino microcontroller serves as the central control unit, receiving data from sensors and controlling the water pump through the motor drive for efficient irrigation control.

The automatic smart irrigation system described in the statement includes a Wi-Fi control feature for the on/off switch of the motor pump set, which aims to minimize the time and labor involved for the farmer. The sensor network is connected to the Arduino board using wireless communication technology.

At the user's end, a smart irrigation application is used to control the pump-set through the GSM network. When the application receives messages on the user's mobile device, it triggers the corresponding actions to control the pump-set. This integration of wireless communication and mobile application functionality enables convenient and remote control of the irrigation system for the user.

VI. CONCLUSION

Based on the literature review of previously designed smart irrigation systems, it can be concluded that IoT-based smart irrigation systems are cost-effective solutions for farmers. These systems allow for automated switching on and off of the water pump set based on the soil moisture level, simplifying the irrigation process and saving time. By addressing real-time challenges faced by farmers, this type of system provides an effective solution.

The numerous advantages offered by smart irrigation systems contribute to their increasing popularity and demand in large-scale agriculture monitoring. The cost-effectiveness, convenience, and efficiency of these systems make them an attractive choice for farmers seeking to optimize their irrigation practices and maximize crop productivity.

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