Overview of ESP8266 Wi-Fi module based Smart Irrigation System using IOT

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***Abstract*—This paper presents an innovative approach to integrating Internet of Things (IoT) into traditional agriculture, specifically focusing on efficient irrigation systems. The implementation utilizes ESP8266-based smart irrigation systems, which offer both cost-effectiveness and simplicity in deployment. A key feature of the system is its ability to monitor and control irrigation remotely. It incorporates sensors for temperature, humidity, and soil moisture, which provide real-time data. Based on this data, Relay Module autonomously operates the irrigation pump. The collected information is then transmitted wirelessly via an ESP8266 WiFi module to a dedicated application accessible through the internet.**

Through IoT-enabled monitoring and control, farmers can conveniently manage their irrigation systems from anywhere with an internet connection. The paper highlights the development of a user-friendly Blynk Application, which serves as the interface for users to access real-time sensor data and set reference values for optimal crop growth conditions. One of the system's notable advantages is its ability to empower farmers with greater control over irrigation processes, thereby potentially enhancing crop yield and quality. By adjusting irrigation schedules based on real-time environmental data and predefined thresholds, farmers can optimize water usage and create favorable growing conditions for their crops.

Overall, the integration of IoT technology into traditional agriculture holds promise for improving efficiency, productivity, and sustainability in farming practices. This paper contributes to this field by demonstrating a practical application of IoT for smart irrigation, offering a scalable solution that could benefit farmers worldwide.

***Index Terms*—Soil Moisture sensor, Temperature and Humidity Sensor, ESP8266-WiFi, Machine Learning, Internet, AgriTech.**

I. Introduction

In recent years, the integration of Internet of Things (IoT) technology into agriculture has revolutionized the way farmers manage their operations, leading to what is commonly referred to as ”smart agriculture” or ”precision agriculture”. IoT in agriculture involves the deployment of sensors, actuators, and other connected devices to collect, monitor, and manage data related to various aspects of farming, from soil health, crop conditions and environmental factors. This transformative approach to agriculture holds the promise of increasing efficiency, optimizing resource utilization, and ultimately enhancing crop yields and profitability, all while minimizing environmental impact.

In the current phase, one of the world's major problems is lack of water and it is consumed abundantly in agriculture. Therefore an appropriate water consumption system is required[1]. Currently,almost all irrigation systems are physically regulated. In these years, the rise of our cell phones, tablets, automobiles, ”smart” technology has expanded in the market and has transformed into another standard in the business [3]. Internet of things empower the specific interrelationship among several appliances, equipment, and services based on Internet and this technology also helps further to provide comfort to people to do work easily [9].Smart irrigation is an innovative scenario where many researchers are taking interest and for decades it is developing and emerging. Pressure on the water distribution system is increasing and the significance of water management has increased due to the sustainability irrigated farming [5].

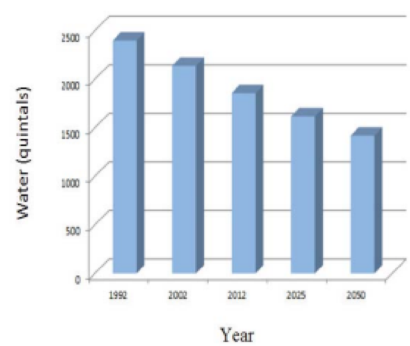

Fig. 1. Availability of water

Generally, the main purpose of smart irrigation is to reduce manpower, water resources and power consumption [3]. Tensiometric and Volumetric methods are used to manage the soil moisture based irrigation, which is nearly simple but this is similar to the characteristic curve of soil water which is different from the type of soil [1]. Routine maintenance is required for the legitimate performance of all sensors. Very smart irrigation system works automatic and use the moisture sensor to systematically water the plants without human observation [7].Therefore, the main purpose of the work is to design the irrigation system, which provides all the above quality with the traditional feature available in irrigation system such as measuring moisture analysis of the area to prevent crop damage issues. Temperature is observed so that the surrounding temperature can be examined as the crop temperature is sensitive. It has resilience in controlling the irrigation system anywhere from the Internet. Moreover, another benefit of this planned irrigation system is that it would give update of crops and alert the farmer before any unfavorable position come in the farms.It will grow rapidly to control and monitor the smart irrigation.

A. *Contributions*

In this research, our primary contribution lies in demonstrating the practical implementation and benefits of integrating Internet of Things (IoT) technology into traditional agriculture, specifically focusing on efficient irrigation systems.

We introduce an innovative approach utilizing ESP8266-based monitored and controlled smart irrigation systems. This system not only proves to be cost-effective but also remarkably simple to deploy, making it accessible to a wide range of farmers. By automating the irrigation process, farmers can conveniently manage their land, leading to increased efficiency and productivity.

Furthermore, our study showcases the incorporation of temperature, humidity, and soil moisture sensors into the smart irrigation system. These sensors provide essential real-time data, allowing a Relay Module to autonomously drive the irrigation pump. The integration of these sensors ensures precise and timely irrigation, optimizing water usage and creating favorable growing conditions for crops.

Another significant contribution of our research is the development of a user-friendly Blynk Application. This application serves as an interface for users to access real-time sensor data and set reference values for optimal crop growth conditions. By empowering farmers with remote control capabilities, our system enables them to monitor and adjust irrigation processes from anywhere with internet access. This capability not only enhances convenience but also facilitates informed decision-making, ultimately leading to increased production of quality crops.

Overall, our research highlights the practical benefits of IoT technology in agriculture and contributes to the advancement of sustainable farming practices. By demonstrating the effectiveness of smart irrigation systems, we aim to encourage further adoption of IoT solutions in traditional agriculture, thereby promoting efficiency, productivity, and environmental sustainability in farming operations.

II. LITERATURE REVIEW

Pushkar Singh and SanghamitraSaikia introduced the design and implementation of an Arduino-Based Smart Irrigation System. The Arduino-based communication has been created to ease the function, application, maintenance and the price[3].

S. Darshna, T.Sangavi, Sheena Mohan, A.Soundharya, SukanyaDesikan proposed Smart Irrigation System.Introducing IOT based smart irrigation system which preserves time and assures prudent uses of water. Furthermore, this design uses Esp8266 WiFi module and micro controller which assure a rise in system life by diminishing power consumption [1].

Ravi Kishore Kodali and Borade SamarSarjerao present the Low Cost Smart Irrigation System Using MQTT Protocol.Efforts have been made to make an easy water pump controller based on soil moisture sensor and are useful in the agriculture sector using Esp8266 NodeMCU-12E.Esp8266 NodeMCU-12E is inexpensive. Transport Layer Security (TLS) and Secure Socket Layer (SSL) cryptographic protocols provide system security. Soil moisture sensor is highly accurate which give analog readings and measures the value of soil moisture correctly [4].

G. Parameswaran and K.Sivaprasath introduced an Arduino Based Smart Drip Irrigation System Using Internet of Things.This irrigation system gives better production than prior and water usage is limited. It mitigates the human work, power and cost. The server updates farmers about the nature of the crop area and everything else [2].

PriyankaPadalalu, SonalMahajan, KartikeeDabir, SushmitaMitkar and DeepaliJavale proposed Smart Water Dripping System for Agriculture. The presented model control and monitor accurately the water necessity in the field automatically. The whole system is easy to operate by using the android system [5].

III. PROPOSED METHODOLOGY

The artificial method of watering crops in farms is irrigation. In the current scenario, water shortage due to increased exploitation has urged to develop a new technology which can save water from being wasted and since agriculture is the most cost-effective business, therefore there will be a smart way to check the loss of water in the irrigation system[6].

Pressure on existing water allocation has increased and the significance of water management has been raised for the sustainability of irrigated farming. The purpose of this idea is to make the irrigation system smart, autonomous and efficient, to optimize the water supply to the crops and to decrease manual intervention. It observes soil, climate, dehydration conditions and plant water consumption and automated adjustment of the water schedule. Hence, the need for smart irrigation solutions has grown significantly, as it equips farmers with essential tools to enhance the production of high-quality crops.

India, as an agriculture-driven nation abundant in water resources, the increased population and extensive utilization has resulted in a precarious imbalance: the demand for water surpasses its readily available supply. In the smart irrigation system, different types of sensors are used to make farmer updated about their land. Soil moisture, water flow, temperature and humidity sensors are used to measure the

water required by the area. A soil moisture sensor determines the moisture content in the field in order to forestall crops from water desertification problems and the temperature of the crops are monitored by the temperature sensor because crops are sensitive towards temperature.A smart irrigation system not only alerts farmers to crop temperature fluctuations but also offers actionable insights on mitigating heat stress by advising the strategic use of sprinklers. This proactive approach not only preserves crop health but also translates to cost savings for farmers. An attempt to create a system which can be operable from a longer distance, this can help farmers to monitor and control the area 24x7 during the whole year.
In our setup, the ESP8266 WiFi module serves as the central component for data transmission and reception, facilitating communication between the smart irrigation system and the user interface. Additionally, the relay module interfaces with the ESP8266 to control the water pump based on sensor readings. These sensors, including temperature, humidity, and soil moisture sensors, provide essential data inputs for optimizing irrigation processes. Our system effectively integrates these components to create a robust and efficient smart irrigation solution.

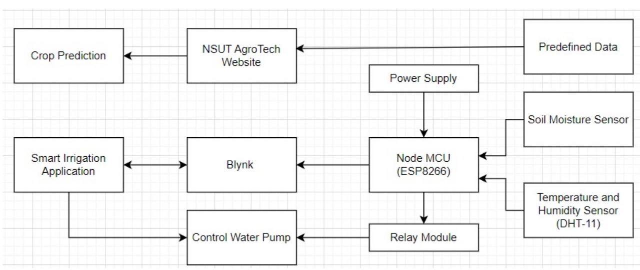

Fig. 2. Block Diagram of Smart Irrigation System

A. Circuit Diagram

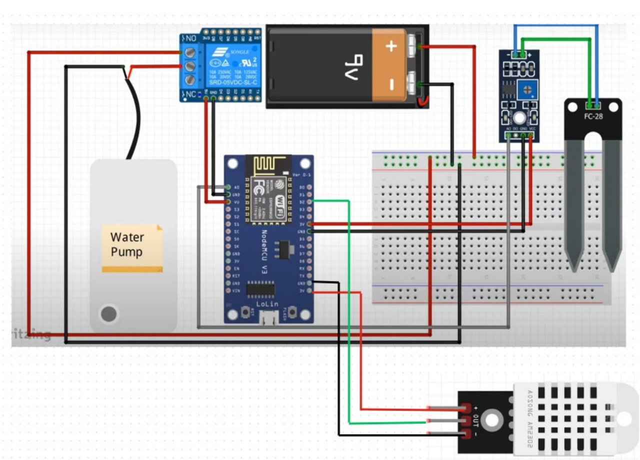

Fig. 3. Circuit Diagram of Smart Irrigation System

B. Project Diagram

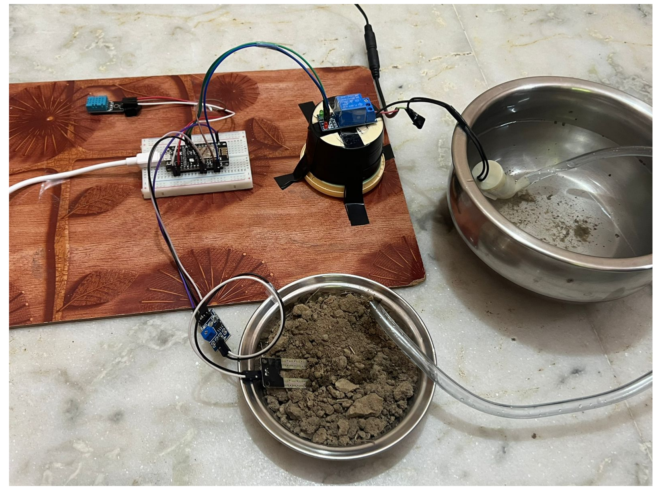

Fig. 4. Actual diagram of Implementation

Relay Module is connected to ESP8266 through:
1. VCC: Connected to the 3.3-volt power supply.
2. GND: Connected to the ground terminal.
3. Signal: Connected to pin D1 for signal transmission.

Relay Module	ESP8266
Vcc	3v3
GND	GND
Signal	D1

Fig. 5. Circuit connections of Relay module and ESP8266

Soil Sensor is connected to ESP8266 through:
1. VCC: Connected to the 3.3-volt power supply.
2. GND: Connected to the ground terminal.
3. A0: Analog input pin for soil moisture readings.

Soil Sensor	ESP8266
Vcc	3v3
GND	GND
A0	A0

Fig. 6. Circuit connections of Soil Moisture sensor and ESP8266

DHT-11 is connected to ESP8266 through:
1. Out: Connected to pin D2 for data transmission.
2. +ve: Connected to the 3.3-volt power supply.
3. -ve: Connected to the ground terminal.

DHT-11	ESP8266
Out	D2
+ve	3v3
-ve	GND

Fig. 7. Circuit connections of DHT-11 sensor and ESP8266

C. Graphical User Interface

Designing a Graphical User Interface (GUI) for a smart irrigation system using Blynk and soil moisture, temperature and humidity sensors involves creating an intuitive interface that enables users to remotely monitor and control their irrigation setup. The first step in this process is to set up the **Blynk platform**, which serves as the backbone of the system. Users install the Blynk app on their smartphones and create a new project, obtaining an authentication token necessary for communication between the app and the hardware components.
With the backend functionality in place, attention turns to designing the GUI in the Blynk app. The goal is to create an interface that is both visually appealing and easy to navigate. Widgets such as gauges, sliders, buttons, and status indicators are strategically placed to provide users with real-time feedback on sensor readings and allow them to interact with the irrigation system seamlessly. The layout should be intuitive, with clear labels and instructions to guide users through the various features and functions of the app.

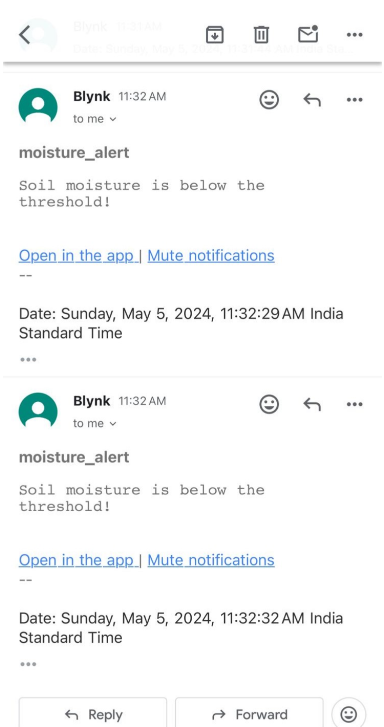

Fig. 8. Blynk Application Notification on G-mail

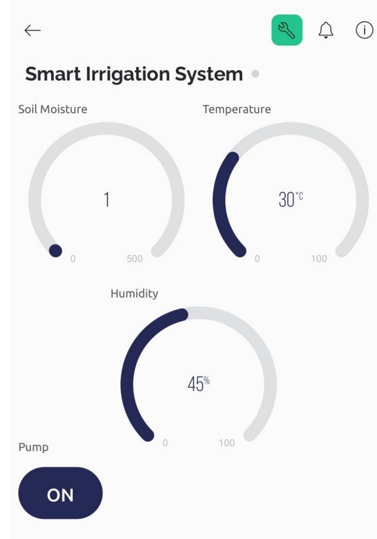

Fig. 9. Dashboard for users to watch readings of sensors

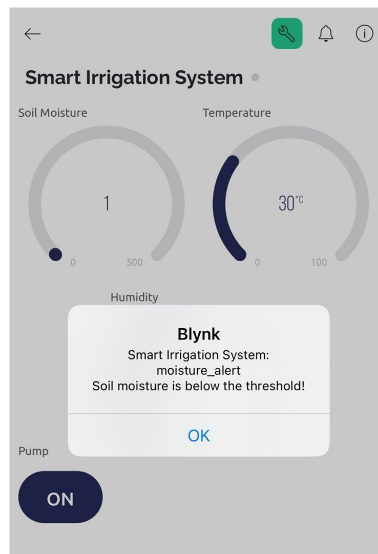

Fig. 10. Blynk application Notification to alert farmers.

IV. System Description

The ESP8266 module serves as the central component of our system. The ESP8266 module, an open-source electronics platform, is responsible for managing the complex electronics prototypes, including both hardware and software. It interacts directly with the user interface, creating a server that can transmit and receive data to and from the application. The system architecture can be outlined as follows:
ESP8266 module $\rightarrow$ Server $\rightarrow$ User

Step 1: Power initialization: Activate the system components, including the ESP8266 module, sensors, and other peripherals.
Step 2: System startup: Initialize the ESP8266 module, sensors, and user interface elements.

Step 3: Data interpretation: Process instructions from the configuration file and execute corresponding actions.
Step 4: Data collection: Gather sensor data, such as temperature, humidity and soil moisture levels.
Step 5: Data transmission: Transmit collected data to the user interface for remote monitoring and control.
Step 6: User interaction: Users receive alerts and can remotely control the system through the user interface, adjusting settings as needed.
The sensors using this prototype are as follows [5]:
A. **Temperature and Humidity Sensors**: The temperature and humidity sensors utilized in our system operate based on direct measurement of temperature and humidity levels. These sensors provide real-time data on both temperature and humidity, allowing for accurate monitoring of environmental conditions essential for effective irrigation management.
B. **Soil Moisture Sensor**: It is a low cost and user friendly gadget, which is used to observe soil moisture value. Since different crops needed a different level of moisture so that productivity increases. By using soil moisture value, farmers should know about how much water is present on the farm so that water is provided accordingly [8].
C. **Water Pump**:It is used to water the crops and the driver circuit operates it.
D. **5V Power Supply**: 5V power supply is used.
E. **ESP8266-WiFi Module**: The ESP8266 is a low-cost Wi-Fi module that has gained widespread popularity for its versatility and ease of use in IoT (Internet of Things) projects. Developed by Espressif Systems, the ESP8266 integrates a microcontroller unit (MCU) with Wi-Fi capabilities, making it an ideal choice for connecting electronic devices to the internet or local networks wirelessly.
F. **Relay Module**: A relay module is an electromechanical switch that is commonly used to control high-power electrical devices or circuits with low-power signals. They provide electrical isolation and protection to the control circuit, preventing damage from voltage spikes or other electrical disturbances in the load circuit.

V. Integrating With Machine Learning

A. *Irrigation Scheduling*

Smart irrigation systems employ advanced technologies to optimize water usage and enhance crop productivity through efficient irrigation scheduling. At the core of these systems lies **data collection** from various sensors strategically placed across fields, capturing vital information like soil moisture levels, temperature, humidity, and weather forecasts. This data forms the basis for informed decision-making in irrigation management. Utilizing algorithms and models, smart irrigation systems analyze these data points alongside crop water requirements and evapotranspiration rates to devise precise irrigation schedules. By integrating real-time and predictive analytics, these systems determine the optimal timing, duration, and amount of water needed for irrigation, tailored to the specific needs of different crops and soil conditions.
Overall, smart irrigation systems represent a significant advancement in agricultural technology, offering farmers the tools they need to maximize water efficiency, optimize crop production, and promote sustainable agricultural practices. Through **intelligent irrigation scheduling**, these systems empower farmers to make informed decisions, conserve water resources, and achieve better outcomes in crop cultivation while minimizing environmental impact.

Overall, we have achieved an accuracy of **91%** when we have used **Support Vector Classifier** and **Logistic Regression**.

	precision	recall	f1-score	support
0.0	0.91	1.00	0.95	853
1.0	0.00	0.00	0.00	85
accuracy			0.91	938
macro avg	0.45	0.50	0.48	938
weighted avg	0.83	0.91	0.87	938

Fig. 11. Classification Matrix

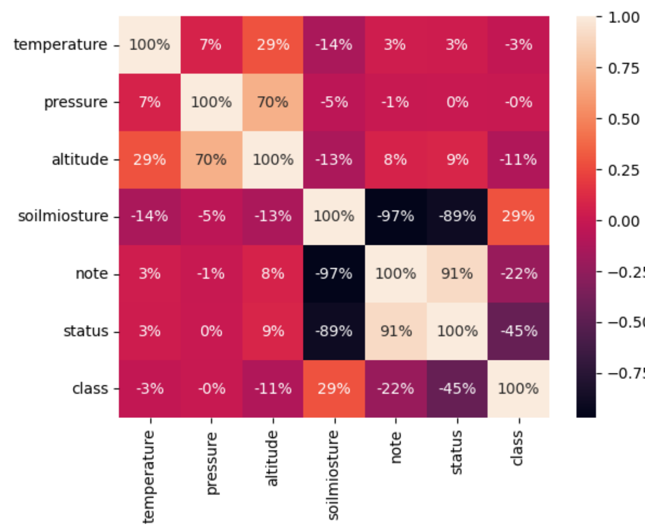

Fig. 12. Correlation among Datasets

B. *Extension-Crop Recommendation System (NSUT AgroTech)*

A crop recommendation system based on key environmental parameters such as **nitrogen, phosphorus, pH, rainfall, humidity, and temperature** holds immense potential in optimizing agricultural productivity. This system utilizes data-driven algorithms to analyze the interplay between these factors and recommend the most suitable crops for a given region or agricultural plot.
Nitrogen and phosphorus are essential nutrients for plant growth, influencing various physiological processes such as photosynthesis, protein synthesis, and energy transfer. pH level

plays a crucial role in nutrient availability and soil health. Different crops thrive in specific pH ranges, and deviations from the optimal pH can lead to nutrient deficiencies or toxicities. Rainfall, humidity, and temperature are climatic factors that significantly influence crop suitability and productivity. Crops have varying water and temperature requirements at different growth stages, and their performance is directly impacted by local climate conditions.

Developed a website that harnesses environmental parameters to predict suitable crops involves a harmonious blend of frontend and backend technologies, each playing a pivotal role in crafting a seamless user experience. At the forefront, HTML and CSS form the backbone of the website's visual representation and structure. On the backend, Python emerges as the driving force behind the website's predictive capabilities. The seamless integration of frontend and backend components culminates in a user-centric web experience where farmers and agricultural enthusiasts can effortlessly input environmental data and receive tailored crop recommendations in return.

We have achieved an accuracy of **99.45%** by using **Random forest Classifier**.

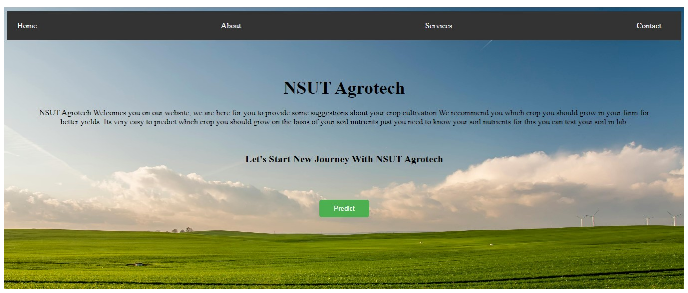

Fig. 13. Home Page Of NSUT AgroTech

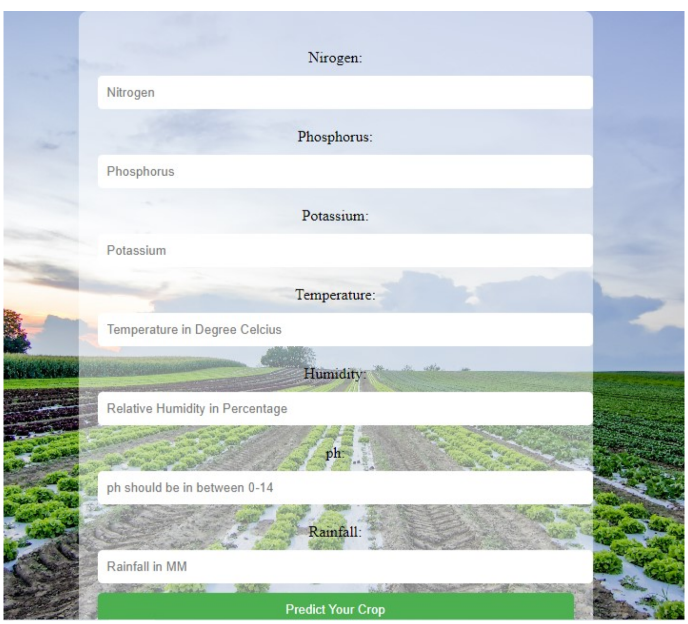

Fig. 14. User Interface Page of NSUT AgroTech

VI. Result Analysis

The performance evaluation of an ESP8266 Wi-Fi module-based smart irrigation system using IoT involves a comprehensive assessment of its functionality, reliability, efficiency, scalability and user experience. Firstly, the system's functionality is scrutinized to determine how well it monitors soil moisture levels, controls irrigation pumps and delivers alerts or notifications. Subsequently, reliability is gauged through the examination of factors such as data transmission consistency, connectivity stability, and system uptime. Efficiency is then measured to assess water usage optimization, energy consumption, and overall resource utilization, comparing it against traditional irrigation methods to quantify water savings. Scalability is evaluated to ascertain the system's adaptability to varying field sizes, crop types, and environmental conditions, including its ease of expansion or modification. Additionally, user experience is considered by collecting feedback on setup ease, interface usability, and overall satisfaction.

Through this thorough evaluation, researchers contribute valuable insights into the feasibility, effectiveness, and potential adoption of ESP8266-based smart irrigation systems, thereby advancing smart agriculture and promoting sustainable water management practices.

VII. Conclusion

Currently, farmers control irrigation method manually and irrigate their area at a systematic period.These mechanisms deplete high amount of water and the outcome is water loss. While dry areas have less rainfall and irrigation is challenging.Therefore, ESP8266 Wi-Fi based communication system has been taken because of the ease of application, maintenance and price. The gadget is automated that will accurately monitor and control the water requirement and reliability. The communication through the websites authorizes the user to interact with sensors from anywhere in the world in nanoseconds which is fruitful for the user. Besides, this design uses ESP8266 Wi-Fi module that diminish power consumption by ascending the system life and executes on large areas for relatively small investment.

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