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A Smart IoT-based Automated Irrigation for Farms Using Node MCU (ESP 32F ESP8266 MC) and A Humidity Sensor

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Abstract: Agriculture is one of the most important sectors of production in Iraq. Centralised agriculture suffers from a critical problem with regard to the provision of water. In this paper, an automated irrigation system, which could be operated automatically without human intervention, was developed using Internet technology to help farmers maintain soil moisture. Where many commands could be found to control parts of this system. Several controllers were connected to sensors, and the data were converted from one type to another while being transmitted from a wireless Wi-Fi to a wired transmission via a Blynk server that worked with the system. Therefore, the system was designed to achieve all the goals related to the use of water: reduction of labour, energy consumption, productivity, and rationing of the heavy utilization of water while maintaining soil moisture levels by relying on constant agricultural activities for each field. The work was carried out in a greenhouse, where a crop of cherry tomatoes was grown, and comparisons were then made to a field irrigated by the usual method. The results showed a saving of 48% in the use of water compared to the traditional method and an increase in the plant vegetative growth and productivity.

Keywords: Smart agriculture Internet of things (IoT) Smart irrigation

1. INTRODUCTION

Agriculture is the world's pulse. Farming is critical to the structural needs of the human race, especially in light of the rising population worldwide. Water is used in agriculture to irrigate crops. Every plant, person, and animal needs water to survive. One of the most severe issues in farming is water wastage. Therefore, the use of the IoT for irrigation management through intelligent farms will be one of the essential solutions to the above problem. The need for water resources in Iraq is constantly on the rise due to the growing population and the corresponding economic and social development. A decrease in water resources due to expanding investments in water resources in riparian countries situated along the rivers flowing into Iraq will cause a further deterioration in agriculture and production. The IoT, which enables farmers to overcome enormous challenges, is transforming agriculture. The "internet of things" notion has been introduced as a result of the rapid growth of Internet networks. The phrase "Internet of things" refers to a wide concept that outlines how different ordinary items may be connected to the Internet[1]. New creative IoT applications can address these concerns by improving the quality, quantity, sustainability, and cost-effectiveness of agricultural products. According to the data, agriculture consumes 85 percent of the available freshwater resources worldwide, and this will continue to rise due to the expansion of the population and growing demand for food. Smart agriculture is a well-established topic with broad business areas, such as water management, crop care, animal tracking, care and management, farm management systems, etc., as shown in Figure 1.The Internet and sensor network technology can be used to reduce water wastage and maximize scientific technologies in irrigation systems. As a result, water usage can be potentially enhanced and production improved significantly. Wireless communication ensures the convenient, fast, and efficient use of devices by people, and is able to provide coverage over long distances. The advantage of wireless communication is that it is now possible to communicate with people in dangerous or relatively remote locations [2].

Since 2011, renewable energy has been expanding faster than all other energy sources combined Therefore; renewable energy has been integrated into the Internet of Things in the implementation of intelligent systems. The effective use of water by means of appropriate irrigation mechanisms and by irrigating in a timely manner when water is needed by the plants will result in improved quality and productivity of crops and will also save water [3].

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Smart irrigation systems keep track of the soil moisture level and monitor it carefully because it is clear that the irrigation system did not water the soil when it was above the level needed for other uses or on rainy days. As a result, these systems are able to save water while avoiding flooding the plants or over-watering them [4].Also Hydroponics uses sensors and actuators to regulate the machinery and create a system that will provide all plant sectors similar development. This is a lucrative greenhouse technology.

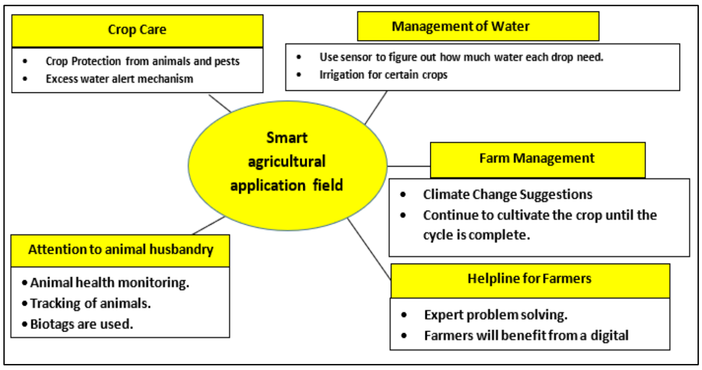

Figure 1. Smart agricultural application field

The following functions should be available in a well-functioning automated irrigation system:

- Identifying the crop that should be cultivated in a specific soil.
- Deciding when the crop needs to be watered.
- Monitoring the water level of the agricultural field.
- Automatically shutting down the motor pump or through the use of a mobile app. [5][6]

But a good smart irrigation system must provide Increase your production: Farmland productivity is rising as well , Cut down on water use , No labor force is needed, Minimize nutrient leaching and soil erosion.

An economical technique, Production of crops of high grade and Birds and weather do not harm the system.[7]

1.1 Related Works

In 2012, S.M. Taslim Reza et.al [8] proposed the use of photovoltaic cells and an Arduino microcontroller to create an automated watering system, whereby a farmer can send a text message to regulate a pump. When there is no water, the motor pump will start automatically without requiring the farmer's permission.

In 2013, Lee et.al proposed system IoT-based agricultural production ensures that farmers will stay on their land in the future. IoT based agricultural production system has improved the quality of agricultural products because farmers observe the full cycle from sowing to selling with IoT based agricultural production system.[9]

In 2016, Pavankumar Nail, Arun Kumbi, Kirthishree, and Nagaraj Telkar[10] suggested a microcontroller-based irrigation control system with hardware and software, while employing moisture sensors in the soil and humidity sensors in the air. In the case of a malfunction, the approach is relatively straightforward to debug and is r-friendly.

In 2017, R. Nandhini et al. [11] presented an irrigation system that includes a pH sensor, moisture sensor, DHT1, pressure sensor, and other sensors. By using a GSM module, a farmer can obtain information on the status of his field, which will be updated on the web page.

A program by Elijah et al. in 2018 [12] is able to show the sensor readings and regulate the operation of the water pump. Applying IoT data analytics to the agriculture industry can improve operational efficiency and production. Smart agriculture, radio frequency identification, cloud computing, systems middleware, and various user applications have all benefited from the deployment of the wireless sensor network (WSN). This paper discusses the IoT ecosystem and how it can be used in smart agriculture as well as many of the advantages and problems of the IoT. Power consumption by cheap hardware, low hardware cost, and ease of implementation are all attractive ends of the proposed model.

Nurulisma Ismail et.al [13] presented an IoT-based system to regulate water use in the agricultural sector in 2019 through the use of a soil moisture sensor (YL-69). The DHT-11 humidity and temperature sensory device is Shiv used for the early detection of changes in temperature. At the same time, the BMP 280 pressure sensor is used to measure ambient pressure. The sensors are connected to a NodeMCU Wi-Fi device to increase the sensitivity of the irrigation system. The data is then transferred to the cloud (ThingSpeak.com and Firebase). The researchers confirmed that the project was able to successfully achieve its critical objective. The most important aspects of water are consumption, project expense, small station labour, and reliability.

In 2019, Shiv et.al [14] proposed the use of an Atmega328P, moisture sensor, rain sensor, and BOLT module to create an irrigation system. The BOLT module retains the sensed data and allows the remote management of irrigation systems through the Internet and a mega-controlled relay. The rain sensor detects rain. Hence, if the rain integrator is off, BOLT receives the input from a remote user through an HTML web page.

In 2020 , Sekaran et.al [15] suggest installing sensors in the agricultural field and monitoring variables like soil moisture, temperature, and humidity. The set-up consists of an Arduino IDE-connected laptop running Ubuntu 14.04.03, three humidity sensors, and a soil moisture sensor. Fields including paddy, sugarcane, banana, and peanuts were subjected to analysis. The outcome is related. The cloud is one of three architectural layers that addresses a lot of real-time problems by improving quality and production management, allowing farmers to access a ton of data in real-time.

In 2021, Gomathy et.al [16] proposed an intelligent system based on sensors (moisture sensor, humidity sensor, temperature sensor), all of which are connected to a microcontroller (Arduino UNO). The sensors detect soil conditions, and the land is automatically watered based on the percentage of moisture in the soil. This implies that the engine will be automatically turned on when the field requires water, and will be automatically turned off when the area has received sufficient water. These metrics and motor conditions will be detected and shown on user devices. The use of the IoT for professional and safe agricultural production significantly influences the efficient use of water resources, and the efficiency and stability of the farming sector.

Hasan et.al created a humidity measurement system in 2021[17] This system is able to track agricultural parameters, including temperature, humidity, and air quality. Automatic irrigation is implemented with the help of a motor pump. The IoT module collects and saves data obtained from sensors (temperature, humidity, and wetness) in the cloud. A Blynk server also powers the IoT. Expenditure on manual work is reduced because of these technological advancements. An Arduino Mega and Arduino UNO, a DHT22 temperature and humidity sensor, a soil moisture sensor, and an MCU have been incorporated into this system (ESP8266) with the goal of boosting agricultural output while cutting down on waste. This is a cost-effective and energy-efficient method.

Safwan et.al created 2021 [18] Proteus' Arduino simulator simulates the materials used in garden irrigation, with each component and gadget linked to the others and the moisture sensor represented by a resistive divider. The Arduino input receives the divider output voltage, which it then reads and displays on an LCD screen as the percentage of soil moisture. Depending on the moisture ratio limit in the program, the DC pump will either run (irrigate) or stop (do not irrigation) when the irrigation software has been uploaded to the Arduino chip. The soil moisture percentage restriction for allowing a DC pump to irrigate garden grass with water or for halting a DC pump is 50%. A monitoring system for automated garden watering will save human labor and burden.

Tajim et.al in 2022 [19] They developed a system that included a power source. One is used for the MCU, while the other is used to power the water pump with a SIM800L module and a temperature and humidity sensor at the bottom. The system gathers information on the farm's temperature, humidity, and water level and displays it on the screen while sending an SMS notice to a mobile device. This effort has produced an IoT-based system that would minimize wasting water and power by controlling the irrigation system intelligently depending on the data gathered.

All these studies will help one of the following: reduce power consumption, provide better control, and tackle problems efficiently. In this paper, all these points are taken into account and the results that will be achieved given a good contribution, which will maintain the durability of various devices and equipment.

1.2 The Used Current Systems

Farmers usually choose crops that are suitable for the season and for the type of soil that is available. Nowadays, they use a traditional irrigation system that is manually controlled by turning on and off a motor, which pushes water to the plants at regular intervals. Farmers have to monitor the water level in their fields and the amount of water they have in their water supply, such as in their wells. The disadvantages of this method are that it requires a lot of manual work, much time is spent in waiting for the plants to be watered, and a large amount of water may be used when it might not be needed by the plants.

1.3 Suggestions and Solutions

An automated water management control system using soil moisture sensors (MS) and microcontrollers (MCU) may be built, where the field is irrigated automatically based on water levels by rotation when the motor pump is turned on or off.

Advantages:

✓ Saves time, allowing the farmer to focus on other field-related tasks. The right amount of water is provided and no water will be wasted.

✓ Reduces the need for human participation.

Figure 2 shows the proposed system for the fieldwork in smart irrigation management and the components of this system with several microcontrollers after they were programmed and utilized for the progress of this study and to achieve the necessary results.

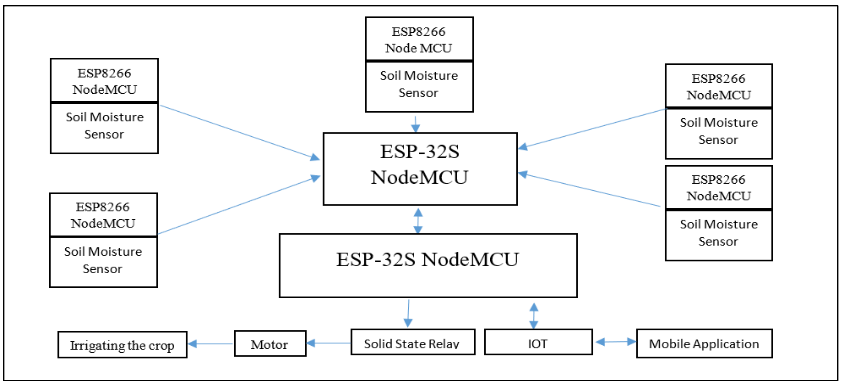

Figure 2. Architecture Diagram for the proposed smart irrigation system

One station contained five nodes, and these nodes were connected with moisture sensors and distributed to the planting lines. The spacing between the nodes was taken into account due to the broadcast ranges of the NodeMCU ESP8266 used in the design of the nodes.

We chose Blynk as the IoT data platform. It is a cloud-based system created for the IoT idea, offering a platform for simple data management and cloud storage, making it a component of IoT support technologies. Blynkis is utilized as a middleware in this project, allowing for full communication and data exchange [20].

1.3.1 ESP-32S NodeMCU of the ESP32:

This is a microcontroller with a Wi-Fi module and an open-source Internet of Things platform that is distinguished by its cost for a system-on-a-cheap chip and low power (SOC) [21]. Figure 3(a) shows the ESP32, which is a power-saving microcontroller developed for mobile devices, wearable electronics, and IoT applications. It has a fine resolution clock gating, various power modes, and dynamic power scaling to achieve ultra-low power consumption; the P32 uses a 32-bit CPU. It adds Bluetooth 4.2, among other features, to the popular ESP8266 WiFi microcontroller.

As an intermediary station, NodeMCU connects to the wireless network's access point, or router, using the SSID (Service Set Identifier) and the network password. It successfully establishes a connection to the access point, receives an IP address, and joins the network.[22]

1.3.2 Soil Moisture Sensor:

Figure 3(b) shows a soil moisture sensor that is used to determine the amount of water in the soil. It uses continuous dielectric contacts as moisture, electrical resistance, and neutron surrogates. Temperature, electrical conductivity, and soil type are all factors that might affect the relationship between the recorded values. Sensing involves obtaining information from network-connected objects and delivering it to a data warehouse, a database, or the cloud. Based on the services requested, the data obtained is examined to decide the best course of action [21].

1.3.3 Solid State Relay

Figure 3(c) shows the ordinary solid-state relay (SSR-100DA 100A Solid-State Relay Module 3-32V DC Input 24-380VAC) that was used in this work. It does not have a moving mechanical element and does not produce any sound when the circuit is opened and closed. as well as meeting the goals of power system protection by assuring the security of human life and the reliability of the power supply via phase selection of SSR [23].

1.3.4 HW-468 DC-DC Step-Down

Usage input: DC of 12V to 24V, the DC output of 5V/5A voltage is continuously adjustable; the maximum high-efficiency output current is 5A to operate the microcontroller on a 220v-12V transformer see Figure 3(d).

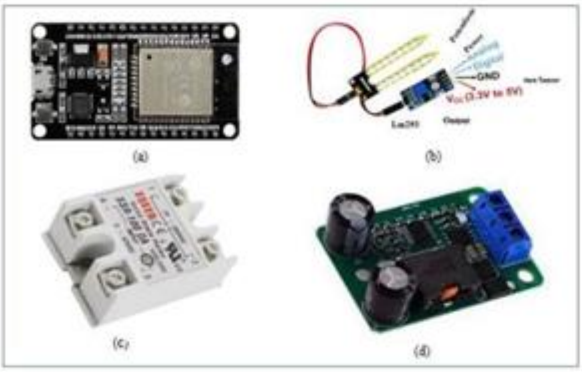

Figure 3: system components (a) ESP-32S NodeMCU, (b) Soil Moisture Sensor , (c) Solid State Relay and (d) HW-468 DC-DC Step-Down

2 METHOD

This study was carried out in an agricultural field affiliated with the Directorate of Agriculture in the Nineveh Governorate. This was a project for the cultivation of tomato and potato plants in typical alluvial silt soil during the season of spring in 2022. It was located 6 kilometres from the centre of Mosul City (36.32697233090495, 43.16851354394346). A sample of the soil in which cherry tomato plants were to be cultivated was taken and tested in the laboratories of the Directorate of Agriculture, where the following results were obtained:

Silt loam soil = 31.15% , Sand = 50.9% , Silt and clay = 17.95%

The soil was inserted into the soil texture triangle to calculate its hydraulic properties [24]. The permanent wilting point is the level at which water remaining in the soil is held so tightly by capillary action that it is not available to the plants. The water capacity of the field was also calculated based on the water content of the soil when the soil was saturated but not yet to overflowing. The drainage rate, which is the speed at which water travels through saturated soil. was also measured, where the higher the drainage rate, the faster will the soil dry up. The results extracted from the soil texture triangle showed that the threshold limit for moisture of the soil was 0.24% and the maximum limit for the moisture was 0.34%. These results were installed in the automatic irrigation system that was used. This experimental study was carried out inside a greenhouse field the dimensions of one are (1*26.6 meters)., which was connected to a drip irrigation system with a water flow pump beneath it. At the same time, a traditional irrigation method was also implemented in an adjacent field at the same dimensions, Two water tanks, one for the area with the automated control system and the other for the field with the traditional irrigation method, each with a capacity of 2000 litres, were connected to their respective irrigation systems to observe the difference in water consumption and adoption of solar energy to supply the components of the system with electrical power.

The components of the irrigation system were installed in field b, which is the experimental field of the system by five nodes executing in field b are wirelessly connected to the main gateway unit by the access point unit. Finally, 120 cherry tomato seedlings were planted on two lines (60 on each line) inside field B, where the smart irrigation system is implemented and the same in field A, but be irrigation by the farmer using the traditional method (See Figure 4). If you appear anticipated financial gains demonstrate the viability of IoT applications for managing resources and optimizing greenhouse environments, and any possible hazards are outweighed by the long-term gains in commercial agriculture[25].

Figure 4: Work location the proposed smart irrigation system

2.1 Electrical Connections and Communications

The client unit was taken into account as it was characterized by an electrical connection that was independent of the control centre in the Blynk server through the MQTT protocol. Bricks were needed for the construction of the structure. In other words, this was a completely self-contained device that was able to function on its own since it had a power source, which was comprised of a solar cell that generated the energy necessary to run the electronic circuit, a charger, and a battery that stored the operational power throughout the night or in an emergency. The device was also able to function independently of the central Blynk server. In the event of an Internet service outage, the NodeMCU ESP8266 microcontroller includes a specific algorithm that is able to pick the optimal value for the moisture content should it be disconnected from the central Blynk server. The client circuit depicted in Figures 5-6 explains how the client unit was constructed. The core of this device was the NodeMCU ESP8266 microcontroller, which was also responsible for communication between the microcontroller and the input (improving its share and supplying it with electrical power of 3.3 volts)). The basic data were displayed on a screen attached to the customer unit, which was a 0.96-type organic light-emitting diode (OLED). The screen was powered by a four-pole Inter-Integrated Circuit (I2C) protocol, two of which were connected to the power source for the screen (VCC.GND), while the others were connected to the digital entrance (D1.D3) of the microcontroller in that order. The client unit took the soil moisture readings and sent them to the access point, the Blynk server, through the gateway unit. In addition, if necessary, the water pump attached to it was run by connecting it to one of the digital exits. Finally, the client unit was linked to the gateway unit through the WiFi, and the gateway became the principal server for the field.

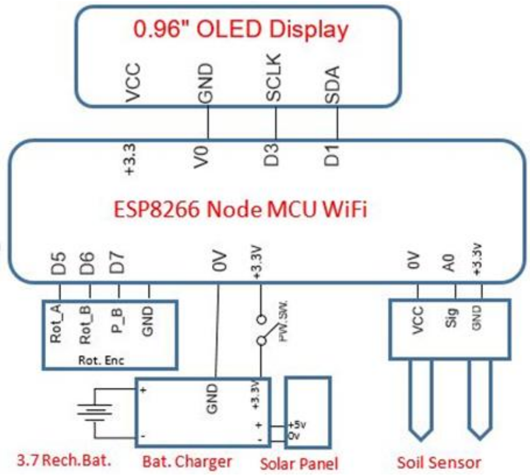

Figure 5: Client Unit circuit

Figure 6: Client Unit circuit

2.1 Design of Access Point for NodeMCU ESP-32S Microcontroller

An access point was created linking the remote nodes of the field. This access point functioned as the connection between the nodes surrounding the area and the node in the centre, on one side, and the gateway unit on the other. The data from the nodes were then collected using the sensor that was linked to the node and the Node-ID in the field. The data from each node was scheduled independently. They were then placed in a temporary storage facility before being prepped and framed evenly. The NodeMCU ESP-32S microcontroller was used to create and program the access point, which enabled it to communicate with the other nodes. It should be noted that the NodeMCU ESP-32S microcontroller had a Soft A.P specificity, which was used in the design. This feature allows the processor to be connected wirelessly to two places, essentially acting as a wireless bridge between any two devices, with data passing across this bridge. However, this situation has some limitations, as it is only able to handle a maximum of 8 TCP connections, implying it can only hold eight devices at once. However, only five machines were employed in this study, which took into account the frequency (160MHz) and transference speed (9600 baud) while transmitting and receiving.

When the devices were turned on, the access point prepared a connection with the other nodes. The sensors linked to the nodes also had to be examined to obtain the moisture readings. The access point also qualified for the screen type 1.44. A thin film transistor (TFT) was attached to the point. The data had to be secure, and thus, a private password was constructed to ensure that the data coming from the node was not tampered with. One of the critical responsibilities of the access point was to maintain a 1-port connection with the gateway unit to send more data at a faster rate. The serial exit of the access point was linked to the door between the two numbers (D16, which was dedicated to data reception and D17, which was devoted to sending data). The data coming from the nodes were managed by the access point, which showed some of their information, such as the IP and MAC addresses. In addition to the moisture values, there was also the Node ID. Finally, the data were framed into a single frame and delivered to the gateway unit as a mass of data, which was then stored and scheduled inside this unit, as can be seen in Figure 7(a),(b).

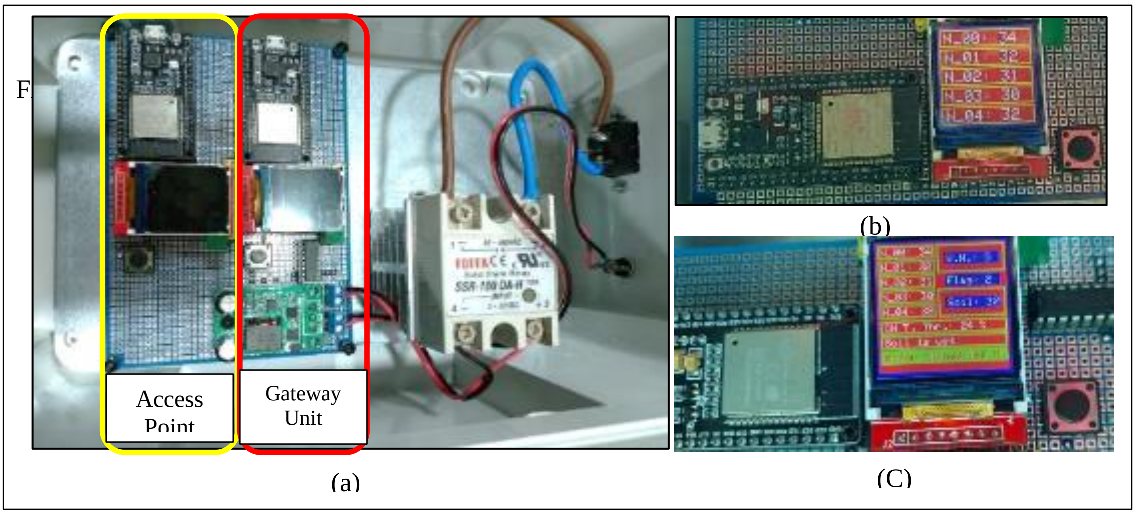

Figure 7**:** (a)Access Point and Gateway Unit, (b) Access Point , (c) Gateway Unit

2.2 Design of a Gateway Unit (NodeMCU ESP-32S)

The irrigation system, designed to be a primary decision-making and control centre, was the heart and foundation upon which the rest of the system was constructed. Furthermore, while the machine was operating, it sent data throughout its departments. It was the link between the Internet and the irrigation system, which was comprised of microcontrollers and sensors, on one side, and sensors on the other. The gateway device, which connected the Internet directly to the access point and the field nodes to detect and upload soil moisture levels, was built using the Node MCU ESP-32S microcontroller. The gateway unit created the route and maintained the Blynk server initially, thus, enabling the server to be reached through the Internet. This contact was responsible for timely data updates, bearing in mind that the system was in real-time. The access point scheduled the data obtained from the field nodes. The data were then transferred to the gateway unit, stored in a table in the EEPROM memory of the gateway unit that had been specifically modified to make judgments or anticipate new values. This gadget also prepared the water pump and, if required, started it after sequentially making the proper selection on a 1.4 TFT colour screen. The gateway unit was powered by a separate resource that was not linked to the power supply for the nodes, as can be seen in Figure 7 (a),(c).

2.3 Decision after Uploading Data to the Blynk Server

Before transmission, the client unit uploaded the soil moisture data with the Node ID to be scheduled sequentially in this unit. The connection between the gateway unit was secured at the start of the process by placing the NodeMCU ESP8266 microcontroller in a loop that could only exist in the event of a connection, and this loop was repeated every 0.5 sec. The microcontroller would reset if the connection were not established. The link had to be tested and repaired every 1 second. An IPv4 type Static IP was assigned to this device to enable it to stay connected to the Blynk server when the Dynamic Host Configuration Protocol (DHCP) was being utilized, to prevent losing the connection due to a change in IPs from time to time. When connecting the client and gateway units through the access point representing the Blynk server, the appropriate transmitting and receiving speeds were limited to a rate of 9600 baud, and the number of exit ports was limited to 80. This device uploaded the Node ID and moisture values to the Blynk server see Figure 8 (a) and (b), which was scheduled and updated every 0.5 seconds. Should the server fail, this unit may make judgments using the objective algorithm to transmit the essential data to the client unit so that the decision of the Blynk server can be carried out.

(a) (b)

Figure 8 (a) work of the irrigation system in the Blynk server

3 RESULTS AND DISCUSSION

During a two-month study of greenhouse-grown cherry tomatoes, the quantity of water used for irrigation was recorded according to the estimates of farmers using the traditional method in field A and according to the proposed smart irrigation system applied in field B. The vegetative growth and productivity in both fields were also recorded to evaluate the effects of each irrigation method.

Table 1 shows the total volume of water used for irrigation in both regions. As shown, area A, which was irrigated using the traditional farming method, used 1,870 Liter of irrigation water during April and May. On the other hand, area B, which was irrigated according to the smart irrigation system, used only 910 Liter or 48% of the irrigation water that was used traditionally. In other words, the scheduled irrigation using the smart irrigation system saved 1090 litres of water in the tank, which had a capacity of 2000 Liter. This proved that the scheduled irrigation system was effective in saving water. In addition, Increasing the percentage of water drainage in field A (the traditional method) led to an increase in the plant's vegetative total compared to the plant's vegetative capacity in field B (Smart proposed method). However, the rise in water in the flowering stage pointed to decreased production compared to the plants irrigated in Field B. This is one of the goals of the proposed smart irrigation system, as shown in Table No. (1-2-3) and Figure (9 -10-11-12).

Figure 13 shows the work of the system within 24 hours, data recording, the process of irrigating the crop and extinguishing the proposed system after reaching the field capacity of the plant

Table 1: Quantity of water used to irrigate the crops in field A,B

Date	field A				field B			
	The amount of water vailable inside the tank/litre	The height of the water inside the tank/cm	The amount of water lost /litre	The difference in the amount of water inside the tank from its fullness/cm	The amount of water available inside the tank/litre	The height of the water inside the tank/cm	The amount of water lost /litre	The difference in the amount of water inside the tank from its fullness/cm
15/04/2022	1394	90.6	606	39.4	1708	111.0	292	19.0
25/04/2022	1337	86.9	663	43.1	1682	109.3	318	20.7
05/05/2022	1110	72.1	890	57.9	1574	102.3	426	27.7
15/05/2022	1073	69.7	927	60.3	1552	100.9	448	29.1
25/05/2022	900	58.5	1100	71.5	1541	100.2	459	29.8
05/06/2022	831	54.0	1169	76.0	1428	92.8	572	37.2
15/06/2022	819	53.2	1181	76.8	1431	93.0	569	37.0
25/06/2022	822	53.4	1178	76.6	1439	93.5	561	36.5
05/07/2022	802	52.1	1198	77.9	1422	92.4	578	37.6

Note: Each reading process involves refilling the two tanks with 2000 liters of water

- ✓ Are there any statistically significant differences in "the amount of water available inside the tank/litre" between field A and field B?
- ✓ Are there any statistically significant differences in "the height of the waterinside the tank/cm" between field A and field B?
- ✓ Are there any statistically significant differences between "the amount of water lost/litre" between the field A and field B?
- ✓ Are there any statistically significant differences in "the amount of water inside the tank from its fullness/cm " between field A and field B?

To answer these questions, the standard deviation and the mean were calculated for both field A and field B, and independent T-tests were applied, as shown in Table 2.

Table 2 Results of the independent T-test for field A and field B

Test	Group	N	Mean	S.D.	t value	Sig
The amount of water available	field A	9	1009.77	231.18		
			1530.77	110.38	-6.101	.000
	field B	9				
"The height of the water inside the tank/cm"	field A	9	65.61	15.03		
			99.48	7.17	-6.101	.000
	field B	9				
"The amount of water lost /litre"	field A	9	990.22	231.188	6.101	.000
	field B	9	469.22	110.382		
The difference in the amount of water	field A	9	64.38	15.03	6.101	.000
	field B	9	30.51	7.17		

Table 2 shows the statistically significant differences between field A and field B using the independent T-test for the two independent groups at a significance level of 0.01.

Table 3 Results of the independent T-test for field A and field B

Location	Yield weight / kg	Vegetative weight / kg	Number of plant branches
Field A (Conventional method)	44.50	19.6	6
Field B (Smart proposed method)	36.6	25.4	7

Figure 9: Vegetative growth between fields A and B

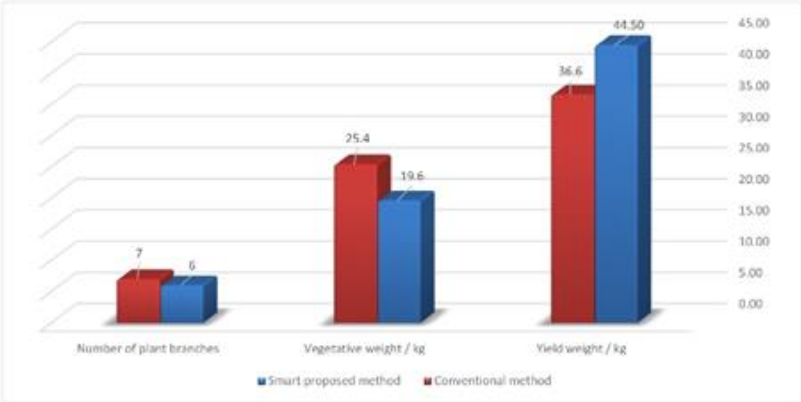

Figure 10: Productivity and vegetative growth of plants in the two fields A and B

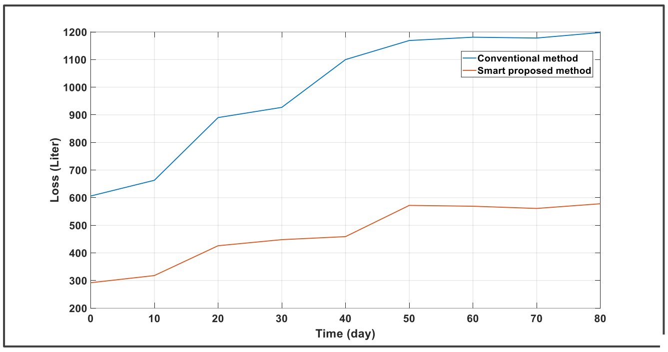

Figure 11: Amount of water consumed

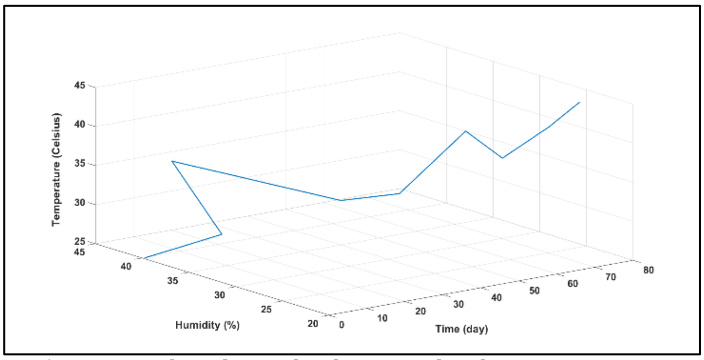

Figure 12: The relationship between the change in humidity and temperature with time during the work of the proposed system

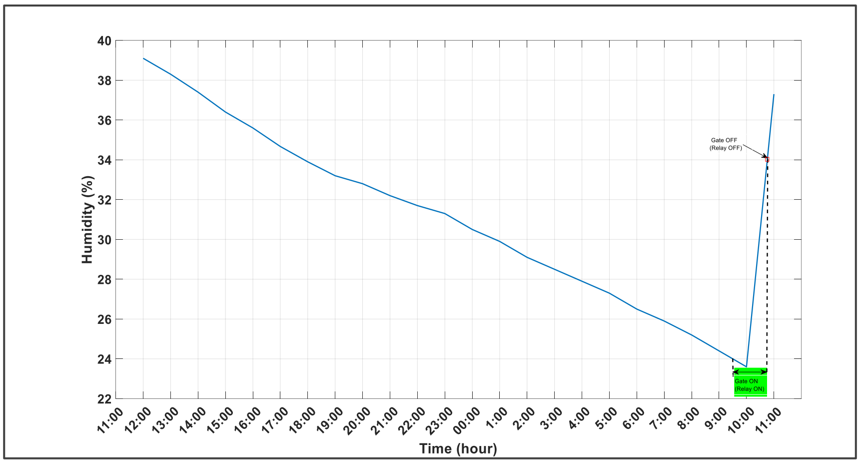

Figure 13: The recorded humidity degrees and the work and extinguishment of the proposed system within one day

4 CONCLUSION

One of the important agricultural issues is excessive irrigation, which wastes water and reduces the quality and production of various crops, which leads to soil salinity and the impact of production. Farmers in developing countries sometimes practice excessive irrigation and this irrigation leads to reduced root growth as well as negatively affects the water in the region, especially after the lack of rain. To address this, 1090 litres of water were saved in one of the greenhouses with increased vegetative growth of the plants. This enabled 48% of the irrigation water to be conserved for two consecutive months. Thus, an automated and effective irrigation system has been secured, which is highly reliable and easy to maintain and operate.

The IoT-based automated irrigation system was successfully created and tested by integrating all the hardware components. The primary objective of the automated irrigation system was to replace the current traditional method of irrigation with a better, more innovative and user-friendly approach to agriculture.

This system, which includes a sensor network, data collection, and water management function, enables farmers to interact with the server. It arose from the need to design an intelligent irrigation system that relies on the average moisture levels in the field to determine when irrigation is required. The client unit is built to last for long periods in the field and to constantly record humidity levels through a wireless connection provided by data resources. In addition, the power required to operate the customer contract is provided by a combination of solar panels and small batteries, ensuring that the entire device is not connected wirelessly to any power source.

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