Internet of things (IoT) work and communication technologies in smart farm irrigation management: a survey

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Abstract. Iraq, the country of the two rivers, was affected during the past two seasons by drought as a result of the lack of rain, which led to a decrease in agricultural production.With the emergence and expansion of IoT, studies have taken a new approach to treat drought through smart agriculture that can preserve water that are wasted outside the needs of plants. This study aims at identifing scientific research on technologies related to smart irrigation using IoT. 35 research articles were reviewed after surveying 80 research titles, the parameters that are monitored and controlled by sensors and communication technologies were mainly and broadly analyzed, as well as expanded on some topics of specific challenges and recommendations in this field. This study will provide researchers with an opportunity to have a valid resource for them. In additional to communication technologies specialized in agriculture that will be required to accomplish a long-term vision in the development of smart agriculture.

Keywords: : IoT, Water Management, Smart Agriculture,, Sensors

1. Introduction

The agricultural sector is the life in the continuity of population societies, and agriculture is the backbone of the economy of any country. Accordingly, agriculture accounts for 70 percent of global freshwater drainage. In the past 30 years, food production has increased by more than 100 percent. The Food and Agriculture Organization (FAO) estimates that about 60 percent of food will be needed by 2050 to meet the nutritional needs of an expanding world population [1].

Irrigation systems play a major role in agriculture and production, in order to avoid a loss in production that occurs due to water pressure (low irrigation), where farmers apply sprinkler in more than what is planned (excess irrigation) and therefore this process not only reduces productivity and there is also the loss of water and energy [2], Agricultural precision is a smart agricultural model that improves and refines processes by giving each plant exactly what it needs for its growth, in addition to improving overall performance while reducing cost and fuel, as well as mitigating environmental pollution.

Precision (smart) agriculture is a modern and advanced technology that takes into account all the variables related to weather conditions. On the other hand, smart agriculture goes further by making the control and management duties not only based on GPS but also on field-specific information [3].

It has become necessary to improve the productivity of strategic crops and vegetables, so precision (smart) agriculture has taken a wide space in most countries of the world. In smart agriculture,IoT technology and robotics can perform extensive analyzes of the data obtained that actually address these challenges. The use of IoT technology in the agricultural sector through the control, management, and operation of the field is known as the Agricultural Internet of Things (Agri-IoT), and its most important function is to manage the data output from the agricultural field through the sensors in the field; After collecting the data, this data is transmitted through control devices and microcontrollers. These data are combined and processed to make the appropriate decision to act on time throughout plant maturity and production [4].

In modern wireless communication, the IoT can be considered one of the most important technologies in recent times. The IoT is a huge network based on the Internet to connect devices to provide better services. IoT technology has swept across different global locations such as smart healthcare, smart cities, agriculture, industry, transportation, etc[5].

In this paper, IoT communication technologies related to smart agriculture were summarized, as previous studies showed that introducing technology to the agricultural sector contributes to increased production and its quality while reducing wastewater quantities and protecting the soil from salinity, and this is reflected positively on plant health compared to traditional perfusion methods.

A table has also been organized showing the most important studies and research that have been established on smart agriculture, including (the type of plant that was planted, the type of system connection method, the cloud on which the data are raised and displaying the results of the work of the design system in the field, the types of sensors used, the method of work, and the type and action of what microcontroller, and the results achieved by each study.

Information became dispersed as research, on smart agriculture grew fast. Even though there are several publications on IoT-based smart agriculture [6].

This Paper will focus on evolution and the importance of IoT in agriculture, IoT platforms, and architecture.

IoT communication technologies, without a doubt, play a critical role in the agriculture business (both today and in the future).

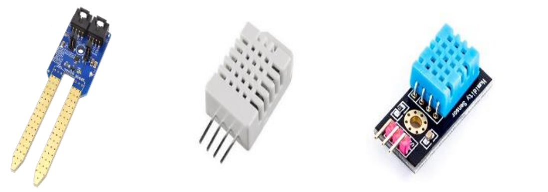
The remainder of this work is arranged in the following manner. Section 2 explains IoT tools used in the smart agriculture system; Section 3 explains the review methodology; Section 4 describes the results of the distribution of the reviewed; Section 5 discusses cost, system, device, and data challenges; Section 6 conclusion.

2. IoT tools used in the smart agriculture system

IoT agricultural systems are used in a broad range of disciplines including irrigation and management of the fields soil to name a few. Irrigation management takes up the majority of the budget. Modern irrigation systems assist farmers by installing several sensors that monitor weather and soil conditions, lowering monthly watering costs, and conserving water resources. In addition, soil management improves crop output while also advising farmers on fertilizing options. Precision agriculture and smart farming assist farmers in enhancing agricultural production and making cropping systems more intelligent by assisting them in improving and optimizing all possible directions.

2.1 IoT sensors in agricultural fields

Sensors were used in the majority of installations to track temperature, humidity, soil moisture, and light intensity. The temperature of the soil has a significant impact on crop productivity. Soil moisture and nutrient absorption are directly affected by changes in soil temperature. In addition, the air temperature measured may be utilized to monitor the agricultural environment in fields or greenhouses.
To sense and measure the relative humidity level, humidity sensors such as relative humidity, air humidity, or soli humidity are used. Humidity impacts plant leaf development, pollination, and photosynthesis in a variety of ways, both directly and indirectly.
Soil moisture is accustomed to determine the moisture content and quality of water in the soil. The resistance of a soil moisture sensor is inversely proportional to the moisture content of the soil, which is the most important element in plant development. Soil moisture is utilized to manage water amount and any other automated measures that are necessary throughout the field.
By reviewing the studies that were discussed in this study, it was found that the DH11, DHT22, and Soil Moisture sensors**,** which specialize in humidity, temperature, and water sensors, are used as shown in Figure (1).



a:Soil Moisture b: DHT22 sensor c: DH11 sensor

Fig 1. Some of the sensors of smart agriculture

2.2 IoT communication technologies

Sensors must provide sensory information to the control center. Wireless communication technologies make up the majority of the communication technologies addressed in this study. The most essential communication mechanisms utilized in the farming system are listed below.

2.2.1 WIFI Wireless Fidelity

WiFi in Fig (2) is based on the IEEE 802.11 radio frequency band standard, which is used in most research. The WiFi connection range is 20 to 100 meters, and it is usually utilized to talk from the gateway to the server or to contact the cloud to have real-time water quality monitoring. WiFi can be utilized for sensor-to-energy sensor connection, however, it shortens the network's lifespan. Low-power WiFi is utilized in data layers because of its power, low load, power-saving connectivity, improved synchronization, and popularity [7].

Fig 2. WiFi Device

2.2.2 LORA Long Range Radio

Another communication-enabled technology for agriculture is LoRa.
The cycle of Grenoble patented and developed LoRa, an enhanced data transmission technique in wireless technology, which was eventually taken over by Semtech.
The technique employed is spread spectrum modulation, which is derived from Chirp Spread Spectrum technology. This technology, which combines the advantages of a low-power area network with a wide-area network, is intended to connect wirelessly to the Internet of Things while also delivering end-to-end localization services.
In any wirelessly transferred data unit, security is paramount. The security between the end device and the application and network server is provided via a unique 128-bit network session and application session[8].
Lora's wide range allows it to be utilized for remote monitoring applications such as greenhouse monitoring, insect detection, and acoustic fish telemetry.

LoRaWAN Fig(3) is a LoRaWAN-based network. It can give connection over enormous agricultural areas while using very little energy[7].

Fig 3. LORA Device

2.2.3 ZigBee (Zonal Intercommunication Global-standard)

ZigBee Fig(4) is a wireless communication technology that is becoming increasingly popular in smart agriculture. It operates in the 2.4 GHz ISM (Industrial, Scientific, and Medical) band and is based on the IEEE 802.15.4 standard. End devices, routers, and coordinators are the three types of ZigBee devices defined by ZigBee. Sensors are ZigBee end devices that can provide data to parent nodes but do not have the ability to route data.

ZigBee has high scalability compared to other technologies, and it also allows for easier maintenance of linked sensor nodes that can interact with one another.

To receive data between nodes, ZigBee radio models were employed.

ZigBee is also the most extensively utilized intra-sensor communication technique[4].

Fig 4. ZigBee Device

2.2.4 RASPBERRY PI

Raspberry Pi Fig (5) is a small single-panel workstation created by the Raspberry Pi organization in the United Kingdom to promote mainframe discipline in schools and developing nations.

The PI RASPBERRY does not need much programming knowledge. Python, the programming language used by Pi, is less difficult to learn than other computer languages. The code is easy to understand, and the user may define concepts with fewer lines.

The Raspberry Pi is ideal for adaptive technology since it can show visuals or play movies in high-definition, which is ideal for prototyping embedded systems. This tool allows you to create complicated and effective structures at a lower cost. The product facilitates a great deal of experimentation and metamorphosis into something entirely new. The SD cards on the board can be switched out quickly, allowing you to adjust the device's capabilities without having to update the software.

Outside of its intended promotion, such as robots, innovative representation has become significantly more trendy than predictable sealing [9].

Fig 5. Respberry pi Device

2.2.5 Bluetooth technology

Bluetooth technology is a wireless communication system Fig(6).

Bluetooth is a low-power microwave wireless communication technology that allows phones, laptops, and other portable devices to interact with one another with little to no effort on the side of the user. The technology is based on existing wireless LAN approaches, however, it stands out for its compact size and low power consumption. The purpose of this technology is to insert small, low-cost short-range transceivers inside today's electronic gadgets. The radio operates on the 2.45 GHz unlicensed radio band, which is widely available and capable of data speeds of up to 721 Kbps and three voice channels. Each device is given a 48-bit address according to the IEEE 802 standard. It is possible to make point-to-point or multipoint connections. The maximum range is ten meters, however it may be extended to one hundred meters if necessary.

Ten meters is the maximum range, but by increasing the power, it may be increased to 100 meters. Frequency hopping, a technique used to protect Bluetooth devices from radio interference, allows them to change their frequencies at will up to 1600 times per second. Furthermore, Bluetooth gadgets do not deplete battery life. The Bluetooth standard aims to reduce the device's power consumption from 30 microamps in a hold mode to 8-30 milliamps in active transmitting mode [10].

Fig 6. Bluetooth Device

3. Methodology

This assessment aims to study and describe the place of IoT connectivity technologies in smart agriculture today. Some researches and studies between 2008 and 2021 have been tackled to find some research specialized in a smart agriculture that focused on water management in agricultural lands. 35 specialized papers were directed to this field.

The researchers' work and studies were reviewed in terms of their use of microcontrollers and sensors, as well as the type of cloud or web used to produce the work results.

The method of work of each study and the results that came out of that study were surveyed, and then a table was organized showing the details of the work and the results of each study, An An analysis of these studies has been provided according to the data of the study. The table that we have organized to come up with results will serve the researchers who will work in this direction.

4. Distribution results

Scientific research specialized in smart farm management was collected, which included irrigation management, plant monitoring applications, and plant disease risk assessment systems.

4.1 literature survey:

Malik Mustafa et al. presented in 2021 [11] system consisting of a humidity and humidity sensor, Arduino Uno, and central cloud storage. The start of the water system should be according to a pre-modified schedule based on the type of plant, its role of events, soil type and climate.

The researchers gave a high priority to connect the sensors in the root zone, as they noted the impact of these cuttings on the types of plants, soil, and environment. Using a normal volume of water allows the plant to germinate. This requires continuous monitoring of the soil moisture content in the root zone.

They also introduced a cloud-based and IoT-based water framework. The site will use the sensors to collect information and store it in the cloud, the owner of the information provides the arrangement and the appropriate transfer is made based on the generated result.

Researcher Nalendra AK. 2021 [2] presented a response study for the development of the Internet of Things to adapt to rapid technologies They employed the rapid application development (RAD) approach to construct a system, as well. RAD is a methodology that allows non-experts to benefit from high-performance computing while allowing skilled programmers to fully use the technology. This was accomplished with the assistance of a soil moisture sensor and Node Microcontroller Unit (NodeMCU). This system performed well in testing all of the equipment's capabilities and controls, with an average latency of 4.8 seconds between requests supplied from cellphones to the NodeMCU forwarded to the relay.

Hasan et al. presented in 2021 [12] a system developed in this study to measure humidity. It is useful for monitoring agricultural characteristics such as temperature, humidity, and air quality. The motor pump is used to introduce automatic irrigation. Sensor data (temperature, humidity, and wetness) is collected and saved in the cloud using the IoT module. IoT is also powered by the Blynk server. Technology reduces manual labor and labor costs. This system included an Arduino Mega and an Arduino UNO, as well as a DHT22 temperature and humidity sensor, a soil moisture sensor, and an MCU (ESP8266). Its purpose is to increase agricultural productivity while reducing wastage. It is inexpensive and consumes little energy.

Nurulisma Ismail et al. in 2019 [13] proposed a system to control water consumption in the agricultural field that depends on the IoT.The soil moisture sensor (YL-69) was used to detect the water level in the soil; the humidity and temperature sensor (DHT-11) was used to track early symptoms of temperature changes, and the pressure sensor (BMP 280) was used to measure ambient pressure. These sensors are linked to a Wi-Fi unit Node MCU and coupled to provide the irrigation system more sensitivity. The information gathered is then transferred to the cloud (ThingSpeak.com and Firebase), the researchers confirm the success of the project in achieving all its goals from several aspects, Water consumption, project cost minimization, labor reduction, energy consumption, and dependability are among the most significant. In circumstances where intervention is required, the application displays sensor readings and controls the functioning of the water pump.

Researcher Rehman et al. 2019 [14] indicated a study to calculate the quantities of water available inside the tank through the use of acoustic sensors and the (NodeMCU). Where the study showed the use of sound sensors in the “echo” theory, when sound effects are sent inside the tank, they return to the sensor without any obstacles. To measure the amount of water, after this procedure and measuring the humidity and sound sensor, then there can be a decision to operate the pump when the tank's water level is high and when the water level in the tank is low, the pump will be turned off. The researcher also controlled the system through the Adafruit server to monitor the water level in the tank.

The researcher Dany presented in 2019 [15] a proposal to develop an irrigation system for strategic crops through the use of soil moisture and temperature sensor. The article showed the researchers’ use of three units, which are an application in the mobile phone, an application on the web and the necessary devices. The data is process through the sensors installed in the soil and the decision to operate irrigation is either manual or automatic. The motives behind the research results were the use of the IOT in agricultural sciences to increase crop yields, reduce costs, improve quality and increase soil fertility.

Researcher Madushanki et al. presented in 2019 [16] a study on improving agricultural yields, reducing costs, and increasing production through the IoT technology. The study aimed to analyze the applications of the IoT that have been developed recently, not their use in the agricultural sector, both plant and animal. It provided an overview of sensor data and technologies such as optimal water management and strategic crop management. Researchers took sensor data from 60 scientific research papers published between 2016 and 2018 and made accurate decisions to make appropriate measurements on several axes. The results of these studies showed that smart agriculture is of great importance in the optimal management of irrigation and crops. The study indicated that the highest results recorded when measuring temperature, air humidity, and soil. These results also showed that optimal water management is the highest, followed by crop management using smart agriculture. As for sensor data collection, it was the highest result of measuring environmental temperature and humidity, as well as other sensor data related to soil moisture and soil potential of hydrogen (pH).

Researchers Maneesa & Madhuri in 2019 [17] suggested developing an advanced solar energy irrigation system using a rainwater detection sensor and soil moisture sensor. It showed that the task of these sensors is to detect humidity and temperature, as well as send signals to the Advanced RISC (reduced instruction set computer) Machine (ARM) controller, which in turn, the ARM board carries out operations internally, and then an alert message is sent through the Global System for Mobile (GSM). Where the study indicated that electricity is saved by using solar panels when the humidity level sensor drops, and the system sends a signal to operate the water pump. The researchers indicated in the study that after the humidity level reaches the upper threshold level, the pump will automatically stop working. When the pump stops, there will be a signal sent to the user via the mobile phone in the form of a text message.

Researchers Fachrul Kurniawan and others in 2018 [18] presented a paper in which they showed that agriculture is one of the most important issues in which the discussion cannot be completed because the agricultural sector is considered one of the most important means of subsistence for the living in the countryside and villages. The research showed the steps to establish a monitoring- based IoTs in a thorough manner for agricultural lands, with the application of prototyping techniques taken from the agriculture sector's expertise. A system that employs a combination of hardware and software wireless accuracy based on data communications (Wi-Fi) allows for clear and accurate monitoring of agricultural data here the monitoring will be more convenient for farmers for rapid intervention in the event of any emergency in the field. The researchers designed hardware and software program to demonstrate how the sensors function so that data on soil pH, water pH, and temperature can be read, and humidity in the planting area and send it to smartphones and server computers. Devices located in farming areas are Wi-Fi equipped that uses solar cells, seamlessly delivering Sensor data is sent to farmers' cellphones and servers.

The researcher Elijah et al. 2018 [19] suggested that the use of the Internet of Things and DA data analytics comes to enhance operational efficiency and productivity in the agricultural sector. The use of the Wireless Sensor Network (WSN) came as a major driver for smart agriculture, radio frequency identification, cloud computing, systems intermediates, and various user applications. In this paper, many benefits and challenges of the Internet of Things are identified. The Internet of Things (IoT) ecosystem was introduced and how IoT and DA can be blended in smart agriculture. The proposed model has interesting features, including low hardware power consumption, low hardware cost, and simplicity in implementation.

Researchers Alomar & Alazzam proposed in 2018 [20] a study on the increasing population growth and the dwindling of natural resources such as water. The study concluded that the agricultural sector is the pioneer in the use of water and its waste at the same time. Where the study indicated over-irrigation practices resulted in lower output rates.

The goal of the project was to employ fuzzy logic to boost manufacturing rates. The system is made up of a field controller that gathers information from the environment via sensors installed in the field. The humidity and temperature levels inside the soil are measured, and then a water pump is controlled to irrigate the field when needed to reduce the frequency of water discharges in the irrigation process.

Researcher Caya et al. in 2018 [21], proposed a water distribution system that specifies the quantity of water that must be delivered in a certain region of the crop's production fields. Data collected from sensors in the system and environmental actuators installed on the farm calculates the amount of water consumption. They studied cabbage cultivation and recorded the highest, lowest, current, and average temperature and humidity sensor measurements. The researchers utilized the Hargreaves-Samani empirical method to calculate the daily reference evaporation rate Evapotranspiration in order to calculate the quantity of water needed for irrigation. When compared to standard irrigation methods, the data indicated that using the technology saves 53.45 percent of water. Furthermore, compared to conventional irrigation, the results demonstrated a difference in the number of leaves and plant height for system-based irrigation.

Vanaja et al. In 2018 [22] proposed a system, in which an intelligent framework for the monitoring platform and ecosystem structure of agricultural sites based on IoT is developed. The system created an incentive to move from traditional agriculture to advanced agriculture, which greatly affected economic development. It also provided an opportunity to create new technology to develop services in the sustainable agricultural sector. Advanced agricultural practices using IoT have shown that they work satisfactorily by successfully monitoring humidity and temperature values, by controlling pump operation through the Internet.

Researchers Deore & Patil in [23] 2018 introduced a wireless irrigation system to monitor to improve the use of the amount of water that should reach crops without wasting this water. Where a wireless network was used to control the field by soil moisture and temperature sensors. In this system, Zigbee technology was used to transmit data to the main control unit, where it controls the water valves. Then the obtained information is transmitted to the server via the Internet for monitoring. Finally, the dry circuit is used in the irrigation system to protect the water pump from damage during operation.

Researchers Kiani & Seyyedabbasi in 2018 [24] suggested a research on the usage of wireless sensor networks, which gather data from all sensors in a network with minimal power consumption and a wide range of connections. Monitoring of soil moisture and temperature in small farms is offered in this work. The study indicated to reduce water consumption while increasing production in small farms. The proposed system monitors soil moisture and temperature. It provides a report to the user via wireless sensor networks and the IoT. The weather forecast for the next ten days is included in the report, and thus the scheduling of harvesting, irrigation, and fertilization operations.

Researcher Pernapati explained in 2018 [25] that irrigation is a complex business, but when combined with the IoT and wireless sensors, It establishes a powerful management system. The study indicated that the DH11 sensor detects the amount of moisture in the air and the temperature of the area around the farm. If the moisture content of the plant-soil falls below the minimal requirements, water is fed from the tank through a relay, and an ultrasonic sensor monitors the water level in the tank before providing data to the ESP8266 NodeMCU.

The NodeMCU was utilized by the ESP8266 microcontroller researcher to operate the sensors in the field and send the data to a remote server for monitoring and issuing irrigation choices as needed from the tank, and also employing ultrasonography to measure the volume of water evacuated from the tank.

Roopa et al. presented research on thermal imaging and its usefulness in anticipating changes in water evaporation rates from the soil in 2017 [26] since this approach has shown to be useful in many aspects of smart irrigation management. Before discussing potential solutions, this study focused on the most pressing issues as well as the most important technical and legal requirements that servers must meet to perform those services that support the use of the Cloud of Things to manage data related to the presence of water sources, thereby increasing water savings and reducing the amount of water that is wasted.

Sureephong et al., [27] a team of researchers, published a study on a prototype of an integrated system for monitoring soil moisture in 2017. The IoT is at the heart of it. It is concerned with the development of field soil moisture sensors for use in a smart irrigation system. The study used two types of sensors: RFD (Radio Frequency Distribution) and resistor-based sensors. The first sensor integrated with the front humidification network Building on the Internet of Things

Water Framework Directive (IoT-WFD) was shown being the best in getting moisture values at different depths of the soil in this investigation.

According to Shekhar et al. 2017 [28], Agriculture has a significant impact on the national growth. The IoT was used to create a smart automatic irrigation system in this article. Sensors collected data about humidity and temperature. The sensor data is then sent in sequence to the Raspberry Pi3 CPU, which uses the K-Nearest Neighbors (K-NN) machine learning technique to forecast the status of the soil using a training data set. The pump is then started by sending another signal to the controller. Farmers may access the training data set and prediction data via their mobile phones, which are stored on a server. This resulted in a completely automated irrigation system that makes use of IoT technology, in which devices interact with one another to anticipate the soil's state and water the area accordingly. As a result, it has been demonstrated that water consumption is lowered and that no water is wasted when compared to previous approaches. And that this approach is cost-effective in terms of improving agricultural water supplies. The necessity of water conservation supports the usage of this sort of smart irrigation system, As a result, this system was created using limited price tiny devices such as the Arduino Uno and Raspberry Pi3.

Saraf and Gawali proposed a novel irrigation system in 2017 [29] that communicates its components using a unique identifier without the need for human intervention. It combines the IoT network with controllers and sensors to find the most effective solutions to the challenges that controlled irrigation operations encounter. A cell phone is utilized to remotely monitor and control the sensor network. Zigbee technology was used to connect the nodes, sensor, and base station. Java has also designed a graphical interface for usage on the Internet that allows cloud computing monitoring to regulate the amount of data delivered to the network, schedule it, and then make the appropriate decision.

Kokkonis et al. published research on novel computational techniques for smart irrigation in the IoT networks in 2017 [30]. All of the detectors, motors, & micro - controllers that may be used in the development of an irrigation system are covered. In the constant monitoring of the temperature and humidity of the air and the ground, a fresh insight was offered. The data is then sent, and one of the algorithms is used to determine whether or not to run the water pump for irrigation. Monitoring has also been done using cloud computing.

In 2017, Rau, A. et al. released a study on the development of a smart irrigation system for rice crops [31]. Increased water availability caused a rise in agricultural pests, which caused the bulk of the farmer's problems. Its technique is designed to identify rice diseases and nutritional shortfalls by field monitoring and image analysis utilizing a Matlab program. Magnesium and nitrogen were the two elements he focused on in the material. Data was also recorded and sent to the server for monitoring using the Raspberry Pi3 CPU.

Namala et al. published a study on a potential smart watering system for blooming plants in 2016 [32]. He created an irrigation system that requires less human involvement by focusing on water waste reduction. It also helps to save time and money while also cutting system maintenance expenses. An open-source Raspberry Pi3 CPU was utilized in this study with a sensor to detect the quantity of moisture in the soil and to operate the solenoid valve connected with this system to make the proper decision when needed.

In 2016, researchers Kodali and Sahu released research [33] on the creation of a reduced agricultural monitoring program that continually detects the moisture content of the soil in the field and warns farmers by SMS or email if the moisture content is low. The ESP8266 NodeMCU, which is equipped with a WiFi module and a humidity sensor for recording data, is used in this microcontroller system, as well as the Losant platform, which is a cloud-based platform for displaying the results. Because it provides real-time data collection from sensors that can be monitored from anywhere in the world and followed via the Losant platform, a time graph is intended to illustrate the degree of humidity over time.

To accomplish successful irrigation, the researchers Garg et al. in 2016 [34] utilized electrical devices for soil moisture sensors. The researchers talked about how to keep track of how much water is in the soil in irrigation areas. Because various soil moisture sensors have distinct benefits and disadvantages, choosing a soil moisture sensor is an essential factor in detecting soil moisture. Because soil moisture sensors provide real-time information, they are widely employed nowadays. In this research study, an experiment was done to evaluate some of the available sensors, their specifications, features, application, benefits, and disadvantages to make an educated decision about which sensor to use. By giving information on when to irrigate crops, soil moisture sensors assist farmers in scheduling watering. The soil moisture sensor VH400 is a device that detects moisture in the soil. For example, when connected to a data logger through GSM, Bluetooth, or even memory sticks, is a simple and portable gadget that provides real-time soil moisture measurements for rapid reaction.

Vellidis et al. demonstrated a prototype of a set of real-time smart sensors to measure soil moisture content and cotton plant temperature in 2008 [35]. A field-installed row of sensors and a central receiver connected to a computer make up the system. Radio Frequency Identification (RFID) was used to send data to the computer. The radio frequency used determines the density of the WaterMark. It can also be used in the field at water locations. This research paper created a set of smart sensors that function in a closed-loop to construct a ground-based watering system.

4.2 Distribution by Table

Table 1 shows a review of numerous IoT-based agriculture initiatives in chronological order, with explanations of project objectives, monitoring parameters, and communication methods employed.

Table (1) review of numerous IoT-based agriculture

Ref No.	Year	plant type	Cloud	sensors	Classification	Tools	Results
2	2020	Chilli	Non	Soil moisture	Rapid Application Development	Node MCU	When instructions are given from cellphones to Node MCU and forwarded to the relay, there is an average delay of 4.8 seconds.
11	2021	green fodder for livestock	Rancher 2.0	Soil moisture & Humidity	a cloud-based and web of things-based water system framework	Arduino UNO	This framework utilizes sensors to assemble continuous water system information, saves it in the cloud, the information proprietor gives order and fundamental activity is finished relying upon the outcomes.
12	2021	undefined	blinky mobile app	Temperature and Humidity (DHT22), soil moisture	Designing a smart farming robot that uses the Internet of Things to measure humidity and temperature and upload it to a mobile app.	Arduino Mega and Arduino UNO	It is intended to increase agricultural productivity while reducing waste. It is inexpensive and uses little energy. This system's use in the field has the potential to boost harvesting and worldwide production.
13	2019	undefined	Thing Speak and Firebase	sensor YL-69 (DHT-11) (BMP 280).	Set up the app to show sensor readings and manage the water pump in the event of an emergency, as well as send a notification to the farmer.	Node MCU	The objective of controlling the water consumption field which is based on IoT where all information is viewed and contact the led at fingertips
14	2019	undefined	Adafruit	Sensors that detect sound	The sound sensors work on the principle of "echo." When the sound effects start to work.	Node MCU	This provides the users with flexibility and allows them to modify the amount of water thresholds in real-time.

15	2019	undefined	LINE application	DHT22 sensor	Mobile apps, online applications, and hardware of the three modules are used	NodeMCU	The results showed that the implementation was beneficial to cultivation. For plant development, cost reduction, and higher agricultural yield, a sufficient soil moisture capacity has been maintained.
17	2019	vegetable	GPRS	TEMPERATURE SENSOR, SOIL MOISTURE SENSOR	In this project (soil moisture sensor, temperature sensor, rainwater detection sensor, a crystal oscillator, ARM, solar panel, LCD, water sprinkler, fan, motor shelter, RS-232 and GSM devices are used.	ARM microcontroller	In this project, advanced solar irrigation system is introduced which gives effective and reliable results. The system will operate automatically and be tested depending end on the sensors. The moisture the sensor will determine the water content in different plants.
18	2019	undefined	undefined	pH sensors for water, temperature and humidity sensors for air, soil pH sensors for soil pH, and groundwater level sensors for groundwater	open source use thinger.io(platform is an Open Source platform for the IoT), PHP programming language, and MATLAB	Arduino	The development of an advanced solar irrigation rainwater detection sensor and soil moisture sensor is proposed. detected the harm signals by ARM. Hence the proposed system gives effective results.
20	2018	undefined	undefined	soil moisture	The system is made up of a fuzzy controller that uses certain sensors to collect environment identifiers such as soil moisture and outdoor temperature. MATLAB is used to develop and construct the fuzzy controller.	ZigBee	use of fuzzy control prevents frequent system run-off and saves water and energy by maintaining soil moisture above a pre-set value with smooth changes.

21	2018	Chinese Cabbage	undefined	DHT22 sensor	This project focuses on an irrigation system that regulates water distribution and calculates the quantity of water needed for a certain farm area.	raspberry pi	While compared to regular irrigation, there is a 53.45% water savings when growing Brassica Rapa. Furthermore, the number of leaves and plant height for system-based irrigation were equivalent to traditional irrigation.
22	2018	undefined	blinky mobile app	DHT1 sensor	They share a single motor between two farms. By sensing the moisture levels in their soil, the solenoid valve regulates the flow of water. We employ two moisture sensors for two farms, each of which is connected to a microcontroller and provides moisture levels in real-time.	NodeMCU ESP8266 & Arduino Nano	They concluded that an automated irrigation system is more efficient than a planned irrigation system.
23	2018	undefined	Thing speak	Temperature Sensor LM35) Soil Moisture Sensor	GSM modem, serial communication, and power supply are all included.	Arduino Uno Zigbee S2C Pro	Allows farmers to schedule the farm cultivation according to save electricity and reduce water consumption.
24	2018	undefined	undefined	humidity, temperatures, and soil moisture	Sensor-based gadgets are used to perceive and gather data in the environment.	RASPBERRY PI 3 Arduino Nano	The application can give time and water savings. Furthermore, this program is trustworthy since it receives weather data from the central stations in real time.

25	2018	undefined	Cayenne	Humidity and Temperature Sensor with Ultrasonic Sensor	The sensors feed data to the ESP8266 NodeMCU from their respective placements. The received analog data may be processed by the controller and then sent to end users through MQTT server, such as a web server or a mobile phone.	ESP8266 NODEMCU	This type of irrigation system in agriculture provides farmers with better convenience in terms of time savings and correct water utilization without waste.
26	2017	Undefined	webpage	Temperature and Moisture sensor	The sensor data is then sent in sequence to the Raspberry Pi3 CPU, which uses the K-Nearest Neighbors (K-NN) machine learning technique to forecast the status of the soil using a training data set.	RASPBERRY PI 3 Arduino Nano	The feasibility and cost-effectiveness of this irrigation method for maximizing water resources for agricultural output were discovered.
29	2017	Undefined	Web-based java graphical user interface	Temperature and Moisture sensor water level sensors	It consists of a DHT11 ambient temperature and humidity sensor, LM 393 soil moisture and M116 water level sensors, AtMega328 microcontroller, Zigbee transceiver, and relay switching unit.	AtMega328 Zigbee	It demonstrates that using a soil-moisture-based automatic irrigation system reduces water use.
30	2017	Undefined	webpage	Water flow sensors. Soil moisture sensors Temperature sensors. Air humidity sensors	The amount of opening of the irrigation system's central servo valve is determined using a fuzzy computational technique.	Raspberry	An integrated system that increases agriculture production quality and quantity.

31	2017	Rice	webpage	DHT11	They chose to build the prototype considering the temperature and humidity. as it was relatively easier and practical. DH11 sensor was used for this purpose, and the digital readings from the sensor were sent to the raspi.	RASPBERRY PI 3 Arduino Nano	Its system is for field monitoring and image processing using Matlab application to detect and treat rice diseases and nutritional deficiencies by providing adequate water.
32	2016	flowering plants	webpage	Soil moisture sensor	The soil moisture sensors in the system monitor the moisture content of the soil.	RASPBERRY PI Xbee Arduino Nano	Because wireless is more compact than cable, it appears to be more flexible and dependable. Furthermore, the system may be accessed from anywhere, at any time, using any device with internet connectivity.
33	2016	Farm	Losant	Soil moisture sensors	Designing a Low-Cost System for Continuous Soil Level Measurement on the Farm	Esp8266 Node MCU	Graphs obtained to display humidity levels over time By sending SMS or e-mail

5. Discussion

It has been noticed through recent publications in the field of automatic irrigation control the use of Microcontroller Node MCU has been geared towards many reasons including low price, Wi-Fi availability, Bluetooth availability, and other advantages..

There are many self-described Node MCUs available, all with wireless fidelity, but the distinction of the ES8266 microcontroller is a common characteristic of the devices described as NodeMCU, as well as the ESP32. Their potential drawback is that they are two 3.3V devices, so if they are the only powered device in the circuit, they work fine, but they are not "plug" alternatives to Arduino 5V devices in some situations.

So most of the researchers cited in the study used the Node MCU of type (ES8266-ESP32) almost exclusively and programmed it with the Arduino IDE. For many reasons including, two faster processors, more memory, Wi-Fi, Bluetooth, more ports, more built-in hardware ports for serialization, I2C and SPI, lower power mode, larger NVRAM, more I/O ports, cheaper and smaller. All sensors that are used work fine with 3.3V.

The Raspberry Pi is ideal for adaptive technology as it can display visuals or play movies in high definition, ideal for embedded systems models. This tool allows you to create complex and efficient structures at a lower cost.

Even while the Raspberry Pi can perform a variety of activities, its hardware has significant limitations. It is unable to run X86 operating systems due to its CPU. Some popular operating systems, such as Windows and Linux, are not compatible. Moreover, some applications that place a large demand on CPU processing are prohibited.

Most of the researchers pointed out that they use sensors, the most important of which is to sense moisture in the soil, and one of its most important advantages is its simple method of measurement and delivers results immediately, very low-cost tensile meters, provides accurate results.

As for the other sensors, they can be used according to the business need to reduce the financial and energy costs.

6. Conclusion

In recent years, the Internet of Things has grown dramatically, and a range of IoT-based frameworks have been developed in a variety of industries, including agriculture. The present state of IoT in automated irrigation is examined in this article by evaluating certain specialized studies, analyzing current IoT research trends, and looking into IoT sensors, devices, and agricultural applications based on IoT. The majority of planned studies, innovations, and Innovative initiatives known as the Internet of Things in the field of smart agriculture will assist farmers' livelihoods as well as the agricultural sector's development.

According to the research, an automated irrigation system will be practical in enhancing water systems in agricultural output as well as enabling cultivation in water-scarce places which will improve sustainability.

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