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Optimizing Water Management: An IoT-Driven Approach to Smart Irrigation

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OPTIMIZING WATER MANAGEMENT:AN IOT DRIVEN APPROACH TO SMART IRRIGATION

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ABSTRACT

The challenges of water management, temperature and humidity control, and soil moisture management in indoor agricultural settings are addressed by the IoT-based smart water management system for indoor agriculture presented in this project thesis. The project's main goal is to develop a reasonably priced and effective system that makes use of Internet of Things technologies to allow real-time monitoring and control of water parameters essential to healthy plant growth. The project starts with a thorough analysis of the body of research on agriculture, smart water management, and the Internet of Things. The basis for selecting appropriate sensors, controllers, and communication protocols for system integration is provided by this research. The suggested system makes use of Internet of Things capabilities to provide precise and timely data on soil temperature and moisture levels, doing away with the need for manual data collection and analysis. Sensors, microcontrollers, and communication modules are all integrated into the system design and are managed by a cloud-based data management platform. In order to provide farmers with remote control over the system and real-time data access, an intuitive user interface has also been developed.

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LIST OF ABBREVIATIONS

IoT	Internet Of Things
I/O	Input Output
DHT11	Digital Humidity and Temperature
LCD	Liquid Crystal Display
Wi-Fi	Wireless Fidelity
MCU	Micro Controller Unit
I2C	Inter Integrated Circuit
GDP	Gross Domestic Product
GSM	Global System for Mobile communication
RF	Radio Frequency
LoRa WAN	Long Rang Wide Area Network
UAS	Uncrewed Aircraft System
RSSI	Received Signal Strength Indicator
AI	Artificial Intelligence
LED	Light Emitting Diode
NIR	Net Intake Rate
RGB	Red Green Blue
pH	Potential of Hydrogen
PIC	Peripheral Interface Controller
MQIT	Message Queuing Telemetry Transport
ATMEL	Advanced Technology for Memory and Logic
UAV	Unnamed Aerial Vehicles
WLDM	Water Level Detection Module

SMDM	Soil Moisture Detection Module
TDM	Temperature Detection Module
CNM	Cloude and Notification Module
NPK	Nitrogen, Phosphorus, Potassium
UNO	Unless Noted Otherwise
PIR	Passive Infrared Sensor
PWM	Pulse Width Modulation
MHz	Mega Hertz
IDE	Integrated Development Environment
USB	Universal Serial Bus
AC	Alternating Current
DC	Direct Current
CPU	Central Processing Unit
V	Voltage
D0	Digital Pin 0
A0	Analog Pin 0
AVR	Automatic Voltage Regulator
ISP	Internet Service Provider
MacOS	Macintosh Operating System
Int	Integer
Float	Floating
Char	Character
Bool	Boolean
DIP	Dual In-line Package

MCU	Micro Controller Unit
ADC	Analog to Digital Convert
GPIO	General Purpose Input/Output
Vin	Voltage Input
GND	Ground
SoC	System on Chip
AIP	Analog Input Pin
UART	Universal Asynchronous Receiver/Transmitter
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
PCB	Printed Circuit Board
VCC	Voltage Common Collector
VEE	Voltage at Common Emitter
SCL	Semi-Conductor Laboratory
SDA	Serial Data
ICSP	In-Circuit Serial Programming
C	Celsius
NTC	Negative Temperature Coefficient
Bit	Binary Digit
TTL	Transistor-Transistor Logic
FOV	Field of View
EMI	Electro Magnetic Interference
RFI	Request for Information
IR	Infrared

CHAPTER 1
INTRODUCTION

1.1 Introduction

Technological advancements have caused a significant transformation in the agricultural industry in recent years. The need for sustainable food production and the world's population growth have made it necessary to look into cutting-edge solutions that optimize resource use and boost crop yields. In this regard, integrating Internet of Things (IoT) technologies with agricultural methods has shown to be a viable way to achieve intelligent and effective water management in indoor and outdoor farming settings [1].

Indoor agriculture, sometimes referred to as controlled environment agriculture, is the process of growing crops inside of enclosed structures like hydroponic systems, greenhouses, and vertical farms. Compared to conventional open-field farming, this method has a number of benefits, such as better control over environmental elements like temperature, humidity, and lighting as well as defense against outside pests and illnesses. However, due to ongoing water scarcity and the requirement for ideal irrigation techniques, efficient water management is still a major challenge in indoor/outdoor agriculture [2].

This project presents the findings from a thorough investigation and the creation of an internet of things-based smart water management system designed specifically for indoor/outdoor agriculture. Main objectives of the system are the water level and moisture content of the water, two crucial factors that affect plant growth and yield. It is made to track and modify these two parameters. By harnessing the power of the internet of things, This framework promises to offer continuous tracking, analysis of data, and autonomous decision-making skills. In the end, this will result in improved crop-growing techniques and higher resource efficiency. The device in question claims to give continuous surveillance, data evaluation, and smart ability to make choices by harnessing the power of IoT.

This will ultimately result in improved crop cultivation methods and increased resource efficiency. Using an IoT framework facilitates easy connectivity and communication between different parts of the agricultural ecosystem. This makes possible to combine actuators, sensors, and control algorithms to build an automated and intelligent water management system.

The board's Arduino microcontroller, which serves as the framework's centralized operational and command module for processing information, collection, and device integration, is a crucial part of the Internet of Things-based smart water management system. We decided to use the Arduino Uno for our needs because of its small size, flexibility, and reasonable cost. A wide variety of sensors and actuators may be attached to it thanks to its many input/output (I/O) ports, storage capacity, and computing capability [3].

The agricultural ecosystem's many components may more easily link and communicate with one another when an Internet of Things framework is put in place. At the heart of this system is the Arduino microcontroller, which acts as the main controller for data collecting, processing, and device synchronization. A vast range of sensors, including DHT11 temperature and humidity sensors, motion sensors, rain sensors, and soil moisture sensors, are integrated into the system to collect the necessary environmental data for precise analysis and decision-making. Appropriate soil moisture sensors that gauge the amount of water in the soil are used to track the moisture content of the soil. These sensors supply vital information for figuring out the plants' irrigation requirements and guaranteeing efficient water use.

The Arduino Uno processes the data gathered from the soil moisture sensors, pir motion sensor, rain sensor, and DHT11 sensor. The processed data is able to be displayed on an LCD for easy monitoring. Additionally, the information can be sent to an Internet of Things platform, allowing for remote access and management. With its built-in Wi-Fi, the NodeMCU makes it easier to transfer data wirelessly and enables users to monitor and manage the system with smartphones or other internet-connected devices. Key pieces, including relay switches, an Arduino Uno that supports the Inter combined Circuit (I2C) communications procedure, and a NodeMCU with the ability to connect to Wi-Fi, were selected with great care and combined to construct the envisioned smart water management system.

Based on the measured parameters, the relay switches allow Computerized management of fluid devices such as valves, pumps, and other systems, and the Arduino Uno makes data processing and control algorithm execution possible.

Through a decrease in water waste, the system encourages resource efficiency. Due to its continuous monitoring of the soil's moisture content, the system is able to precisely control the amount of water given to the plants. Water resources are preserved and the system is helped to avoid over-irrigation. Not only does this reduce the quantity of water used, but it also lessens the chance of waterlogging the soil and the accompanying plant diseases.

There are significant implications for indoor/outdoor agriculture if this IoT-based smart water management system is implemented successfully. Farmers may maximize the growth of plants, limit water wastage, and decrease ecological damage by fine-tuning irrigated agendas, fertilizer delivery, and multiple production procedures by continuously monitoring and adjusting soil moisture levels.

Furthermore, proactive decision-making is made easier by the combination of data analytics and intelligent algorithms, which makes it possible to implement adaptive control strategies, predictive maintenance, and early anomaly detection.

The potential of IoT for agriculture will be examined in this project book. It will go over the advantages of using IoT in agriculture, the issues that need to be resolved, and how IoT in agriculture will develop in the future.

There will be three sections to the book. An overview of Internet of Things technologies and their possible uses in agriculture will be given in the first section. In the second section, we'll talk about the issues that must be resolved before IoT is extensively used in agriculture. The third section will go over IoT's prospects in agriculture.

A discussion of the Internet of Things' implications for agriculture will round out the book. It will make the case that agriculture could undergo a revolution and become more sustainable thanks to IoT. I hope you have a clear idea of what the project book will cover from this introduction. I have no doubt that anyone interested in the application of IoT in agriculture will find this book to be a useful resource.

1.1.1 Benefits of Using IoT in Agriculture

Using IoT in agriculture has a lot of advantages. Among the most significant benefits are:

Increases crop yields: By giving farmers access to real-time information about the condition of their crops. IoT can assist farmers in raising crop yields. Pest management, fertilization, and irrigation can all be improved with the help of this data.

Reduced water usage: By irrigating only, when necessary, IoT can assist farmers in using less water. This can be achieved by tracking the moisture content of the soil with sensors.

Increased sustainability: By lowering their dependency on pesticides and herbicides, farmers can use IoT to increase the sustainability of their four operations. This can be accomplished by keeping an eye on illnesses and pests with sensors.

Enhanced productivity: Farmers can achieve greater productivity by automating processes like fertilization and irrigation, thanks to the Internet of Things. Farmers may have more time as a result to devote to other projects like marketing and sales.

1.1.2 Challenges of Using IoT in Agriculture

IoT applications in agriculture have many advantages, but there are a number of issues that must be resolved as well. Among the most noteworthy difficulties are:

Cost: The implementation of IoT technologies can be costly. This poses a significant obstacle for small farmers.

Security: Cyberattacks can target Internet of Things systems. Sensitive data theft, including the theft of financial and agricultural yield data, may result from this.

Lack of knowledge: A lot of farmers are not skilled in using IoT technologies. This is really important an obstacle to adoption.

1.1.3 Future of IoT in Agriculture

IoT in agriculture has a promising future. IoT offers many advantages, and its drawbacks are being addressed. IoT technologies are expected to be widely adopted in agriculture as they become more accessible and affordable. Better crop yields, less water use, and more sustainability will result from this.

The practice of agriculture is becoming more and more popular because it has several benefits over conventional outdoor farming. Indoor/outdoor farms are a year-round operation that can be situated anywhere, in any climate. Because of this, they are perfect for cities, where there is a shortage of space and an unsuitable climate for growing crops. Indoor/outdoor agriculture does, however, face a number of difficulties. Water management is one of the main issues[4]. Water usage in indoor farms is significant, so it's critical to use it wisely. Water quality presents another difficulty. Water used in farms must be pure and free of pollutants like pesticides and herbicides.

The problems of indoor agriculture can be addressed with the aid of an Internet of Things (IoT) based smart water management, rain sensor, motion sensor, heating issue and soil moisture monitoring and controlling system. The water quality and soil moisture content in the farm can be tracked by this system using sensors. After that, the system can make use of this data to regulate the irrigation system and guarantee that the plants receive the necessary amount of water [5].

The moisture level can also be observed with this system. The indoor farm's humidity and temperature can also be managed by the system. Plant growth depends on both temperature and humidity. Plants may suffer harm from excessively high or low humidity or temperature. With this data, the system can make the necessary adjustments to the indoor/outdoor farm's humidity and temperature to promote plant growth [6].

To sum up, this thesis project offers a ground-breaking strategy for utilizing Internet of Things technologies to transform indoor agriculture's use of water management. Through the utilization of connectivity, real-time monitoring, and intelligent control, the suggested system holds the potential to greatly improve crop productivity, resource efficiency, and sustainability in contemporary farming methods. The design, implementation, and evaluation of the system are covered in detail in the following chapters, which also offer a thorough understanding of the underlying technologies and their applications [6].

With this project, we seek to contribute to the burgeoning corpus of research in connected to the internet of farming practices and give farmers with the information and skills they need to tackle the obstacles of an environment who is evolving swiftly.

1.2 Problem Statement

- The key cause for these constraints is the expansion of population which is expanding at a quicker rate.
- The absence of automatic controlling of the system results in improper water control system.

- At present, there is emerging global water crisis where managing scarcity of water has become a serious job.

1.3 Motivation

- Effective and efficient irrigation system instead of Conventional flooding irrigation.
- 24/7 monitoring of plants using IoT and mobile application.
- As exact amount of water will be irrigated by our proposed system, substantial amount of water will be saved as well as less amount of energy will be required.
- Significant amount of farming time as well as money will be saved.

1.4 Objectives

- To design a system for the proper growth and development of plants using suitable irrigation for specific plant.
- To reduce the farming effort and save wasted water through flooding irrigation
- Proposing a comprehensive and cost-effective smart irrigation system.

By fulfilling these goals, this thesis project hopes to show that putting in place an Internet of Things (IoT)-based smart water management system for agriculture is feasible and could have advantages. It aims to offer a strong basis for the effective implementation of such systems, giving farmers the knowledge and resources, they need to improve crop growth, manage water resources more effectively, and advance sustainable farming methods in the face of escalating global challenges.

1.5 Report Outline

This project's design and construction have been broken down into six chapters. The following are the chapters and their contents:

• **Chapter 1 (Introduction)** The project's goal, inspiration, and outline are presented in this chapter.

• **Chapter 2 (Literature Review)** The preceding section discussed past work or study relating to this project.

• **Chapter 3 (Methodology)** The methods and procedures of this study have been described in details in this section.

• **Chapter 4 (Implementation and Result)** Analyze the implementation of the task and the outcome of the venture.

• **Chapter 5 (Conclusion)** The outline of this endeavor is covered in greater detail in this Book. The benefits of the endeavor, its value and the probable eventual completion of the initiative are discussed.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

A thorough examination of previous research and studies related to the IoT based Smart Irrigation System is provided in this project literature review section. The review looks at the idea of IoT in agriculture and looks at earlier research that made use of IoT technologies. for improved crop yields and resource management. It explores the field of smart water management, going over techniques, sensor technologies, and control strategies used to maximize water consumption. The review also looks at different sensing methods applied in agricultural settings and emphasizes the significance of tracking soil moisture. Additionally, it looks at how sensors and the Internet of Things are integrated into indoor agricultural systems for soil moisture monitoring. The literature review emphasizes the potential and difficulties in indoor agriculture while highlighting the contribution of Internet of Things-based systems to increased sustainability and efficiency. It fills in the gaps in the body of knowledge and provides support for this thesis, advancing IoT-based smart water management for indoor agriculture.

2.2 Review of Previous Work

In order to facilitate effective decision support in IoT-based smart farming systems, this paper proposes an IoT-based smart farming system in conjunction with an effective prediction method called WPART, which is based on machine learning techniques to predict crop productivity and drought. Farmers and agriculture executives place a great deal of importance on crop productivity and drought forecasts, which significantly benefit agriculturally impacted nations worldwide. Drought prediction research aims to improve our understanding of the physical mechanism of drought and predictability skill by fully utilizing sources of predictability. Drought prediction plays a significant role in drought early warning to mitigate its impacts on crop productivity [7].

The primary contributor to GDP in both developed and developing nations is agriculture. By 2050, it is predicted that there will be roughly 10 billion people on the planet. In order to feed the world's expanding population, food production must rise by at least 70%. Sustainable agricultural methods are essential to agriculture and are crucial to guaranteeing food security for the world's expanding population. The goal of sustainable agriculture is to increase total agricultural productivity while minimizing the harm that inefficient agricultural methods cause to the environment [8].

The irrigation system for home gardening that is developed in this article can be maintained without the need for human oversight. It monitors the soil moisture content beneath the tree and other plants in the home garden automatically. If the moisture content is low, it sends out a message and automatically irrigates the plants with water from the connected water storage. There might not be enough rainfall or there might be dry patches, so it's important to use the irrigation method precisely. Because of this, an automated irrigation system that works in all climates is employed. The water content will be detected by the soil moisture sensor, which will then indicate whether or not to pump water. In addition to helping plants grow even in the absence of humans, this will help to reduce water waste [9].

India is the world leader in agricultural product production, but the country also has significant issues with water availability and use. In order to make significant use of water resources, the government distributes water through rivers and dams. An efficient automation system must be created to meet this challenge since during a water crisis, farmers must use the available water very wisely in order to avoid losing their crops.

This paper suggests a programmed water system that will maximize crop productivity by reducing water consumption and optimizing human labor. An Arduino kit equipped with a moisture sensor and a GSM module is used to frame this system. We can communicate with the farmer via our mobile phone connected to our structure [10].

The demand for and use of freshwater resources worldwide is rising, necessitating the development of technologies that support environmental stewardship and water conservation in irrigated agriculture. In light of this, wireless soil moisture content sensors have proven to be valuable, as demonstrated by recent Internet of Things (IoT) sensor demonstrations. Nevertheless, a lot of the current wireless solutions use above-ground wireless communication modules that physically obstruct regular farming activities. A major obstacle to underground wireless network solutions is the significant radio-frequency (RF) propagation loss through soil. This paper presents a solution that uses fully subterranean IoT sensors and communication modules with LoRa WAN gateways mounted on UAS (uncrewed aircraft systems) to get around both issues. The

LoRa enabled sensors can now transmit data over short distances with very low energy consumption thanks to the UAS mounted LoRaWAN gateway, which also removes the need for any in-field base stations. This method was used to conduct field tests as a proof of concept. The suggested solution has much more communication range than is required for dependable operation and good communication link margin, as shown by the RSSI (received signal strength indicator). This solution can also be implemented in a highly power-efficient manner and is simple to construct, scalable, and affordable [11].

Agriculture has a significant impact on India's economy and is a major source of income for Indians. It is absolutely necessary to develop crops in order to deliver higher quality and yields. Thus, ideal circumstances and the right amount of moisture in crop beds can greatly influence output. Traditionally, irrigation has been accomplished by creating a stream flow from one end to the other. Different moisture levels may be left in the field by such a supply. The use of programmed watering frameworks can improve the management of the water system. The planned water system with framework for the terrains proposed in this paper will minimize manual labor while optimizing water use and raising crop productivity. An Arduino kit with a moisture sensor and Wi-Fi module is used to create the setup. We have connected our experimental setup to the cloud framework and collected data. After that, cloud service analyses the data and make the necessary recommendations [12].

Farmers have recently shown a great deal of interest in smart agriculture techniques. This is caused by a number of factors, one of which is the broad availability of low-cost, low-power wireless sensors based on the Internet of Things (IoT) that can be used to remotely monitor and report on crop, weather, and field conditions. This makes it possible to manage resources more effectively, reducing the amount of water needed for irrigation and the need for harmful pesticides. In order to reduce crop diseases and pest infestation, farmers can also use autonomous farming equipment and improve their forecasting skills by utilizing historical data and current conditions. This is made possible by the recent explosion in artificial intelligence. These two revolutionary technologies have transformed traditional agricultural methods. This survey paper offers the following: (a) a thorough introduction to the current state of smart agriculture system advancements made possible by IoT and AI techniques; (b) a critical evaluation of these two technologies and the obstacles to their widespread adoption; and (c) a comprehensive discussion of the technological and social trends that will shape the widespread adoption of smart agriculture systems by farmers worldwide [13].

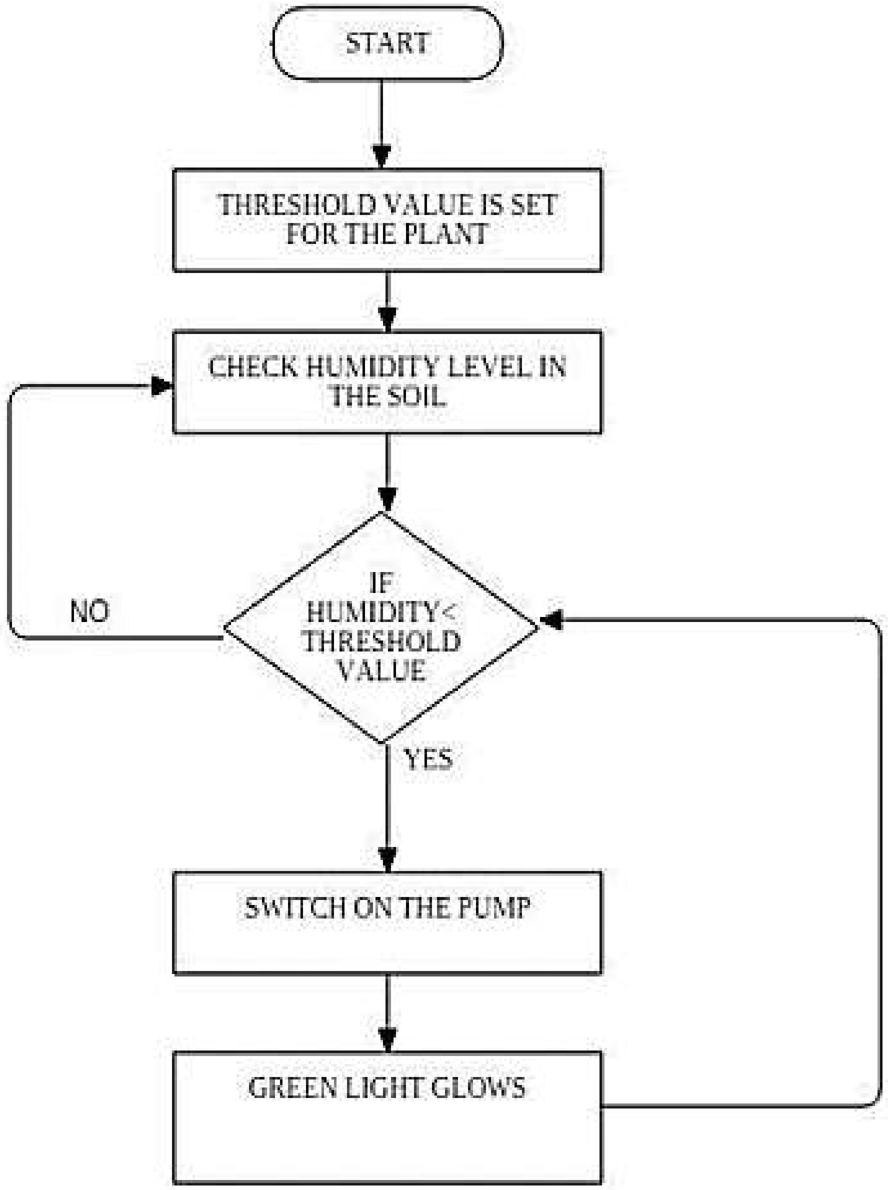


Figure 2.1 Flow chart of process used [12].

Countries are working together to combine new technologies to enhance agricultural practices and increase efficiency. Therefore, increasing irrigation efficiency in agriculture is essential to maintaining sustainable agricultural output. With the advent of wireless communication systems, monitoring tools, and improved control strategies for effective irrigation scheduling, smart irrigation techniques can increase irrigation efficiency. The study compared various research topics in order to look into scientific methods for intelligent irrigation. This led to a broad range of topics being covered in this project that were associated with technology, decision-making, and irrigation techniques. Data was collected from numerous scientific publications. Thus, a number of published documents—the most of which came out in the last four years—and writers from around the globe were the foundation of our research. Special attention was paid to various irrigation initiatives in the interim. After that, the assessment concentrates on the essential elements of smart irrigation, including energy harvesting, real-time irrigation scheduling, IoT, the significance of an internet connection, and smart sensing [14].

Currently, many countries are focusing their development efforts on agriculture automation. The world's population is growing quickly and will double in the next few decades, which will increase the demand for food. The best way to handle this quickly increasing demand is through automation in agriculture. Farmers' traditional methods are insufficiently effective to meet the growing demand. When nutrients, water, fertilizers, and pesticides are used improperly, agricultural growth is disrupted and the land becomes unfertile and barren. Various control strategies, including IoT, aerial imagery, multispectral, hyperspectral, NIR, thermal camera, RGB camera, machine learning, and artificial intelligence techniques, are presented in this research paper to automate agriculture. Using the various automated and control techniques mentioned above, problems in agriculture such as plant diseases, weed management, pesticide control, irrigation, and water management can be readily resolved. It has been demonstrated that automation of agricultural practices through sophisticated control strategies increases crop yield and strengthens soil fertility [15].

The Internet of Things (IoT) is a new wave of technology that is being used in almost every field. Everything is smarter when it is connected to the internet and to each other. Every aspect of our lives, including smart homes, smart cities, and smart retail, has made use of IoT. Much more. In order to meet this kind of demand, agriculture must produce even more quickly than the 9.6 billion people by 2050. The IoT in particular makes this feasible with today's cutting-edge technology. IoT makes labor-free farms possible. It can be applied to livestock management, greenhouse management, and agricultural land management in addition to large-scale agriculture. The sensor is the most important IoT tool. A sensor is a tool that gathers crucial information, which is then processed to provide the necessary analysis. The primary goal of sensors is to ascertain the physical properties of the soil and its surroundings. Control and supervision, safety, alarm, diagnostics, and analytics are the primary uses for sensors. The role of IoT applications in smart agriculture is described in this paper. Precision farming, another name for smart farming, is based on the use of precise data to determine results. It illustrates the various sensors, uses, difficulties, advantages, and disadvantages that support agriculture and the Internet of Things [16].

In the paper, the operation of the Internet of Things will be tracked, as well as how fog computing and IOT together can advance the field of smart agriculture. One of the main drivers of the economies of many nations, including China, India, and others, is agriculture. All other fields, with the exception of agriculture, are taking advantage of the emerging trends in the internet of things (IOT) due to the advancement of the internet. At a time when farmers are struggling to meet the increasing demand for their products as well as changing weather patterns, uneven soil composition, and other issues, integrating IOT into agriculture will accelerate its modernization. Fog computing can be added to IOT to improve its efficiency. This will allow us to monitor and predict production, rainfall, and other factors while also keeping track of all activities occurring in real time [17].

For people in a nation like India, agriculture provides their primary source of income. It makes a significant contribution to the national economy. The automated irrigation technology reduces the need for human intervention and high costs associated with traditional farming techniques. The technique of growing plants vertically while utilizing less space, water, money, and resources to produce higher yields is known as "vertical farming.

“The information is transferred through the internet of things (IoT) following crop sensing and ongoing monitoring. The primary motivation for implementing vertical farming is its ability to recycle water during periods of scarcity. Smart vertical farming uses sensors to measure temperature, humidity, light, and soil moisture content all of which are critical for plant growth and development.

It also uses a 3D printed gripper to harvest crops and artificial lighting to enable photosynthesis. The fenugreek crop was worked on by planting it in two distinct environments: a vertical farming module outfitted with smart technology, and a pot. Every ten days, observations are recorded. The BLYNK app on a smartphone displays the readings from numerous sensors [18].

Frameworks for smart water systems based on IoT technology may help achieve optimal water asset utilization in the precise agricultural scene. With the aid of trend-setting innovation, the agricultural documentation has transitioned from manual observation and control to automation, which results in increased efficiency and fewer interpersonal interactions. In order to screen and maintain the appropriate soil dampness content, a programmed water system framework in this study includes a programmed watering framework. The idea behind this project is to give farmers the ability to monitor and control the growth of their crops, as well as determine how much water is needed and at what level. Additionally, this suggested method keeps the crop from catching fire in the summer.

This is accomplished by using IOT smart sensors, solenoid water valves, and fire detection sensors to control water advancement based on soil moisture content and provide farmers who stay far from the ranches with ongoing surveillance. Additionally, this activity enables monitoring of the workforce and their yields to avert accidents in the event of a water flood. With the aid of a smartphone, anyone can easily operate this, and once installed properly, it doesn't need any maintenance [19].

One potential solution to problems facing the agriculture industry is the incorporation of Internet of Things (IoT) technology into smart agriculture management. An overview of integrated IoT system solutions for smart agriculture management is given in this abstract, along with an emphasis on the advantages and uses of the concept. Cloud-based platforms, IoT sensors, and devices are all combined in an integrated IoT system to facilitate real-time data collection, analysis, and decision-making in agriculture. Farmers can collect information on vital environmental parameters like soil moisture, temperature, and humidity by installing Internet of Things (IoT) sensors throughout their farm. With the use of this information, farmers are better equipped to decide on irrigation, fertilization, and pest management, which maximizes resource use and increases crop yields. Another important component of integrated IoT systems in agriculture is automation. Harvesting, spraying, and seeding can be automated with the help of IoT-enabled tractors, drones, and sensors. This automation lowers the amount of manual labor required, minimizes errors, and boosts productivity. The extraction of important insights from the gathered data is made possible by the integration of machine learning and data analytics algorithms in Internet of Things systems. These insights can be used by farmers for yield prediction, early disease detection, and proactive decision-making. In this study, tomatoes are grown in the spring and summer and peas in the winter, depending on the necessary temperature and relative humidity. Soil moisture sensors are also used in the field to measure the moisture content of the soil at different temperatures and relative humidity levels. There is a great deal of variation in soil moisture, humidity, and temperature. To sum up, the utilization of IoT technology in integrated IoT system solutions for smart agriculture management has the potential to greatly enhance farming practices, boost productivity, and advance sustainable agriculture. To fully utilize integrated IoT systems in agriculture and overcome obstacles, more study and technological developments are required [20].

IoT plays a major part in the advancement of technology. Its use is practically universal across all fields. Up to 9.4 billion people are expected to begin utilizing IoT in their farms for agricultural purposes. Farmers will make more money using IoT-enabled agriculture than they will with traditional farming techniques. In the farming field, this Internet of things uses sensors such as soil moisture, temperature, humidity, light, motion, and pH meters. This determines the pH of the soil and automates the lighting, irrigation, and animal alert systems. Solar energy is used to power these processes. The PIC microcontroller receives these data. Every system will function automatically based on its respective threshold level. This allows for easy and user-friendly farm monitoring. By using MQTT (Message Queuing Telemetry Transport), this is accomplished. This is a mobile application that can be used. Relays are used in this automation system to turn the system "ON" and "OFF." The irrigation system is activated if the moisture content drops. When there isn't much light available for the plants, the artificial lighting system is automated to use fluorescent or incandescent lights. Additionally, the motion sensor is used to detect animal movement, which triggers the alarm and illuminates the area. The animal will be captured by the field camera. The farmer can keep an eye on it at all times by receiving these updates and notifications on their mobile device. This is a traditional farming method that yields more with greater efficiency [21].

The most important prerequisite for effective plant growth, resource utilization, increased crop yields, and other outcomes is a suitable environmental condition. Automation of the soil condition data collection process enables easier plant growth. The user is informed about the state of the field through the current system. Such a system is costly, difficult to maintain, and not as widely accepted by workers with low technical proficiency. The goal of this work is to develop a simple, readily installable circuit using a microcontroller to monitor and record soil moisture content and fertilizer levels, which are adjusted and managed on a regular basis to maximize plant growth and yield. ATMEL's deployed microcontroller is an economical chip that uses less power. It communicates with the sensor modules in real time to control the irrigation process profitably in a field by turning on a motor in response to the crops' requirements. A liquid crystal display is installed to show the position of various components as well as the real-time data that has been accumulated from the sensor. The use of readily available devices further reduces the expense. The software's adaptable design allows for replacement at any time. Consequently, it can be made to match a particular need based on user requests. This results in an efficient structure that maximizes yield while using the least amount of water possible. Additionally, this system is convenient, affordable, and easy to use [22].

A dam is a structural barrier that was constructed by humans to store and manage water flow in lakes and rivers. However, extreme weather or poorly managed dams cause natural or man-made disasters, respectively. As a result, creating effective monitoring systems is essential to keeping dam water levels safe. In this work, we develop a monitoring system based on the Internet of Things (IoT) to automatically route the collected flood water dams into the canal. This system uses far-field communication to transmit the water level data to the base station. A command center will keep an eye on this data, which will be connected to the cloud. This command center has the authority to make decisions and provide instructions to raise the gates at the same time. Several factors, including command area and water requirement, will be taken into consideration when determining the proportion of river water distribution from dams to canals. Using Arduino, an integrated system is created to fulfil the aforementioned specifications. In order to efficiently manage water resources and avert both natural and man-made disasters, this paper designs an automated system for dams [23].

Agriculture in the modern era is more data-driven, exact, and intelligent than before. Smart agriculture has largely replaced traditional agriculture thanks to ongoing advancements in Internet of Things-based technologies. This revolution has altered current agricultural practices and opened up new, challenging opportunities. The potential of Internet of Things (IoT)-based devices in smart agriculture is highlighted in this article, along with the difficulties that may arise when incorporating these devices into conventional farming practices. A variety of sensors and Internet of Things-based devices are also available for specific agricultural applications, such as crop status monitoring, soil preparation, insect and pest control, and irrigation. This article also takes into consideration the use of unmanned aerial vehicles (UAV Drones) in agricultural field surveillance. Regarding Internet of Things-based Smart Farming, several recent review papers have been considered. An analysis of the application of smart devices in agriculture has been conducted.

Finally, we can identify the present and future trends of Internet of Things-based agricultural devices based on thorough reviews. The goal of this research is to determine how using Internet of Things (IoT) based devices can improve agricultural production. In order to achieve the necessary smart agriculture using contemporary Internet of Things (IoT) based devices, this article assists engineers and researchers in implementing IoT-based devices and technology. Finally, a sprayer that is automated is suggested to be used for applying pesticides in agricultural fields [24].

The main industry in Bangladesh that generates revenue is agriculture. It significantly affects the economy of the nation. However, people moving from rural to urban areas is making agriculture more difficult these days. Crop production cannot be naturally increased by monitoring environmental factors. Efficiency is significantly impacted by a number of factors. Therefore, automation in agriculture is necessary to address these issues. A farmer can use an automated irrigation device to save energy, money, resources, and time. Conventional agricultural irrigation techniques require human intervention. Automation in irrigation technology can minimize human intervention. In order to save farmers' time and resources, this research has designed and developed a dependable smart farming system (IoT). Our suggested system has the ability to remotely monitor the land crops and measure temperature, moisture content, and water level in the agricultural land. The suggested model divides into four sections: The Water Level Detection Module (WLDM) constantly measures the water level to prevent the destruction of drops; The Soil Moisture Detection Module (SMDM) measures the amount of soil moisture on the land and activates the water pump if the level drops; The Temperature Detection Module (TDM) continuously measures the air's temperature and humidity; if either is high, the fan will turn on; The Cloud and Notification Module (CNM) manages user notifications via messaging and remotely monitors the first three modules' data in order to take the appropriate action [25].

The agri-food sector is one that has benefited greatly from technological advancements; the use of various concepts, such as the Internet of Things, is anticipated to further improve the quantity and quality of agricultural products. Enhancing food quality and safety while meeting the growing demand for food can be achieved by implementing IoT technologies in the agricultural sector. Farmers will be able to gain insights and anticipate possible crop disease risk by using data analytics to process the vast amounts of data (temperature, humidity, and soil moisture, among other variables) that are produced by using sensors. This research paper aims to demonstrate the critical role that IoT system application in agriculture plays in improving the agricultural and food industries. This paper aims to investigate the primary applications of IoT in agriculture, the technologies and sensors employed in IoT-based systems to enhance agricultural practices, and the obstacles that impede IoT adoption in the agricultural sector [26].

The goal of this article is to describe a real-time soil monitoring system that may be used on agricultural farmlands in order to provide optimal and integrated data collection. This goal will be achieved by focusing the research on agricultural farmlands. Making decisions to increase crop output is greatly aided by real-time monitoring, which offers precise and current information on the condition of the crop and the soil. This is due to the fact that real-time monitoring provides precise and current information on the condition of the crop and the soil. Agriculture is dependent on many factors, including soil characteristics and climate parameters, among others, to boost crop yield. The range of forms that can be found within and between individual plants is one of these aspects. The data set for significant field parameters, such as temperature, humidity, soil pH, soil moisture, light intensity, and carbon dioxide, will be collected using this system component. An additional important field factor is the intensity of the light. Analyzing the crops' susceptibilities to the effects of adjusting the irrigation system's parameters was made easier with the help of the data sets that were collected and then put to use. The standardized ideal values that were established for every crop were taken into consideration when evaluating the collected data. These differences resulted from the inputs being customized to meet the needs of individual crops. The main goal of this study is to install a range of sensors in order to gather primary parameters that are important for plant growth. This goal will be accomplished through the acquisition of primary data. The ease of access to these sensors was the driving force behind this research project [27].

In the agricultural industry, issues like crop failures, soil erosion, and pest attacks are frequent. Moreover, losses for the farmers are unavoidable if the harvest's quality and quantity are subpar. The most effective and significant methodology for these issues is the Internet of Things (IoT), which is constructed from a number of components including sensors, applications, network elements, and other electronic devices. The development of innovative solutions and tactics to address issues in the agriculture industry is made possible by the Internet of Things (IoT). IoT-Agri was created to support farmers in tracking environmental, water, and soil data. Temperature, humidity, and pH are examples of soil data. The reservoir's pH, salinity, and water capacity are all included in the water data. Sunlight intensity, humidity, and temperature are examples of environmental data. The IoT-Agri device satisfies the need for data monitoring related to soil, water, and the environment in addition to managing the application of fertilizer mixtures and water to crops on agricultural land. Additionally, the goal of this research is to develop IoT-Agri to produce precise and intelligent agriculture through effective and efficient farming practices [28].

The Internet of Things (IoT) is a new wave of technology that is being used in almost every field. Everything is smarter when it is connected to the internet and to each other. Every aspect of our lives, including smart homes, smart cities, and smart retail, has made use of IoT. Much more. In order to meet this kind of demand, agriculture must produce even more quickly than the 9.6 billion people by 2050.

The IoT in particular makes this feasible with today's The sensor is the most important IoT tool. A sensor is a tool that gathers crucial information, which is then processed to provide the necessary analysis. The primary goal of sensors is to ascertain the physical properties of the soil and its surroundings. Control and supervision, safety, alarm, diagnostics, and analytics are the primary uses for sensors. Innovative agriculture is easier to use and more efficient thanks to sensors. The primary applications of the sensor in agriculture are the measurement of NPK (nitrogen, phosphorus, and potassium) levels, disease detection, and soil moisture content. Cutting-edge technology. IoT makes labor-free farms possible. It can be applied to livestock management, greenhouse management, and agricultural land management in addition to large-scale agriculture. Smart farming, which updates conventional farming methods, is the primary answer to this issue. The role of IoT applications in smart agriculture is described in this paper. Precision farming, another name for smart farming, is based on the use of precise data to determine results. It illustrates the various sensors, uses, difficulties, advantages, and disadvantages that support agriculture and the Internet of Things [29].

Advancements in advanced technologies have led to a rapid evolution of agricultural practices. The Internet of Things, or IoT, is a rapidly developing technology that is becoming one of the most well-known and promising fields in technology. Traditional irrigation methods often involve manual water management, which can be labor-intensive and ineffective. The purpose of this project is to develop an Internet of Things (IoT)-based water pump monitoring system that includes wireless sensors and a cloud server. The recommended system uses internet connectivity to control the water pump and communicate with the Blynk cloud server [30].

This study will cover Internet of Things (IoT)-based systems that use ESP8266 and Arduino for monitoring and analyzing soil nutrients. The foundation of agriculture is soil. The nutrients in the soil help a crop grow more quickly. Many chemical and physical properties of the soil, such as temperature, moisture content, and concentrations of nitrogen, phosphorus, and potassium, have a significant impact on crop yield. These features can be detected by the field-useable open-source hardware. Agriculture depends on a multitude of factors for higher yields, such as soil properties, climate, and plant inter- and intra-variabilities. Here, the system is designed to collect data on critical parameters such as soil temperature, moisture content, and soil nutrient levels (nitrogen, phosphorus, and potassium). All of these parameters can be wirelessly monitored by the farmer on a computer system or smartphone. The soil moisture content will be determined using a capacitive soil moisture sensor. The temperature of the soil can be measured with the DS18B20 Waterproof Temperature Sensor. In a similar vein, we plan to measure the soil NPK values using a soil NPK sensor. All of these sensor's interface with the Arduino platform with ease. This study also presents an irrigation system that is smart and maximizes water use. While distant sensor structures are used to monitor the living conditions, smaller scope controllers are used to motorize and regulate the field. Utilizing the collected data sets, the crop selection was studied. The results were compared with the standardized optimal values for the respective crops, and any discrepancies were used to modify the inputs for the crops. Because standard commercial agriculture irrigation system sensors are expensive, smaller farmers cannot afford to use this type of system. On the other hand, manufacturers are now offering low-cost sensors that can be linked to nodes to build irrigation control and agricultural monitoring systems at a reasonable cost. The article's main goal is to use a variety of sensors to gather the fundamental data needed for plant growth. The availability of sensors served as inspiration for the creation of this project [31].

The swift advancement of Internet of Things (IoT) technologies has caused a wave to sweep through nearly every industry worldwide, with agriculture being one of the most affected. The current agricultural practices are being shaken by these significant changes, which are also opening up new avenues for growth. By 2050, there will be a huge demand for agricultural products due to the 30% increase in the global population. Due to youth migration to large cities and the use of land for rapid development instead of agriculture cultivation, there are fewer human resources available for agriculture development. In order to meet the demand for food, the majority of agricultural tasks must be automated. The aforementioned problems with agriculture and food demand may be resolved by IoT and related technologies.

This paper will examine current trends in Internet of Things (IoT) applications for agriculture and will draw attention to problems and difficulties, especially with network and open-source software for smart agriculture [32].

In India, agriculture is vital to both the country's economy and population survival. The goal of this project is to provide an embedded-based system for irrigation and soil monitoring in order to decrease the need for manual field monitoring and to obtain data via a mobile application.

The idea behind the system is to assist farmers in raising agricultural output. Numerous sensors, including pH, temperature, and humidity sensors, are used to test the soil. Farmers can cultivate the right crop for the soil based on the outcome. The field manager receives the obtained sensor values via the Wi-Fi router, and the mobile application makes the crop recommendation. When the temperature of the soil is high, the irrigation system operates automatically. The field manager receives the crop image and uses it to recommend pesticides [33].The relationship between computer engineering and agronomy can help teachers and groups of students from various disciplines work together to investigate smart technologies for tracking objects, plants, or soils. Nevertheless, curricula rarely incorporate the blending of these disciplines.

This paper tackles this problem by providing a case study within the framework of research on higher education. In order to foster environmental awareness in the next generation of engineers, a project-based learning approach is therefore presented, in which students from both disciplines participate in the creation and optimization of Internet of Things (IoT) systems intended to track and monitor plants, soil, and environmental variables. According to this research, utilising particular sustainable development goals as a mediator, these disciplines should be integrated in a jigsaw classroom. By designing Internet of Things systems, the methodology presented here paves the way for multidisciplinary learning initiatives that integrate computer and agronomic sciences [34].

The technology that makes it possible for objects to exchange data through a variety of communication channels is known as the Internet of Things. The advancement of wireless communication technology has made it possible to remotely control data from the devices. The Internet of Things plays a significant role in the expansion of the IT industry and the advancement of technology because of the dynamic structure of the Internet. For the internet of objects, a wireless sensor network-based approach is suggested in this study. A vast network of wireless sensors has been created, and wireless access points in campus networks and ESP8266 devices are linked to one another. The wireless network in the campus area allows data from the temperature and humidity sensor connected to ESP8266 devices to be monitored. The study's ESP8266 modules provide data that are gathered, tracked, and reported in real time on a server. The suggested method's low cost and dynamic wireless sensor network constitute a major advantage. Given the benefits of the developed system's affordability and ease of use in current Wi-Fi networks, it is evident that a significant study has been done in the literature [35].

In the agricultural industry, issues like crop failures, soil erosion, and pest attacks are frequent. Moreover, losses for the farmers are unavoidable if the harvest's quality and quantity are subpar. The most effective and significant methodology for these issues is the Internet of Things (IoT), which is constructed from a number of components including sensors, applications, network elements, and other electronic devices. The development of innovative solutions and tactics to address issues in the agriculture industry is made possible by the Internet of Things (IoT). IoT-Agri was created to support farmers in tracking environmental, water, and soil data. Temperature, humidity, and pH are examples of soil data. The reservoir's pH, salinity, and water capacity are all included in the water data. Sunlight intensity, humidity, and temperature are examples of environmental data. The IoT-Agri device satisfies the need for data monitoring related to soil, water, and the environment in addition to managing the application of fertilizer mixtures and water to crops on agricultural land. Additionally, the goal of this research is to develop IoT-Agri to produce precise and intelligent agriculture through effective and efficient farming practices [36].

Since food is so necessary for human survival on this planet, agriculture is a practice that is required everywhere in the world. There will be a serious food-related issue in 20 years. Therefore, it is imperative that agriculture continue to advance. One amazing IoT application is crop monitoring, which can be done remotely thanks to popular technologies like Internet of Things (IoT). These technologies make it simple to monitor the environmental factors that have an impact on crops and make decisions based on that information. The world's farmers still primarily use traditional methods and rely on partially automated machinery, which causes them to suffer from water and rainfall scarcity. Numerous methods are available to automate agricultural tasks, improving their efficiency and yielding higher-quality crop yields. Reducing the amount of human intervention is made possible by agricultural automation. This review paper's primary goal is to provide an overview of the many strategies used in automated agriculture systems that help farmers save time, money, and energy. Based on their benefits and drawbacks, this paper also summarises the salient characteristics of the automated agriculture systems currently in use. The development of a system that will address the shortcomings of current automated agriculture systems will be aided by this paper [37].

CHAPTER 3
METHODOLOGY

3.1 Introduction

To achieve the intended results, this effort is project component is crucial. It consists of a comprehensive plan as well as an action plan direct the project towards completion. The components that are essential to the project's successful completion are all thoroughly described in this section of the project documentation. This chapter's goal is to give readers a thorough understanding of the project component, its significance, and how it fits into the overall scheme of things.

3.2 List of Components

We were used a number of equipment for complete the smart irrigation project. The components that are used in this project are given below:

TABLE I COMPONENT LIST OF THE PROJECT

Component List	
Arduino Uno	Rain Sensor
ESP32	DHT11 Sensor
16*2 LCD Display	PIR Motion Sensor
I2C Module	Relay
Soil Moisture Sensor	Heating Bulb
Wires	

3.2.1 Arduino Uno

The Arduino Uno is a board with a microcontroller. It uses an ATMega328p based microprocessor. The microcontroller board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards and other circuits. The board features 14 digital input/output pins (I/O) of which 6 capable of PWM output, 6 analog input pins, a 16 MHz ceramic resonator, a reset button, a power jack and is programmable with the Arduino IDE via a USB type B cable. To begin, just use a USB cable to connect it to a computer, or use an AC-to-DC adapter or battery to power it. For applications requiring a compact, reasonably priced, and adaptable microcontroller board, the Arduino Uno is an excellent option.

◆ **Elements Of Arduino Uno Board**

Elements of Arduino Board can be done into two categories.

◆ **Hardware:** Arduino is an open-source electronics platform based on easy-to-use hardware and software. The Arduino Extension Platform is made of an assortment of distinct pieces, all of which are essential for the whole thing to effectively carry off the tasks it was designed to perform. It is widely used in the maker and electronics communities for prototyping and creating various projects. The term "microcontroller" refers to a compact integrated circuit that combines a microprocessor with on-chip memory, I/O ports, and timers. It is designed to perform certain tasks and control electrical devices in a range of settings. The Arduino board's portion that is connected to many peripheral devices performs the functions of a minicomputer, receiving and transmitting commands as well as information.

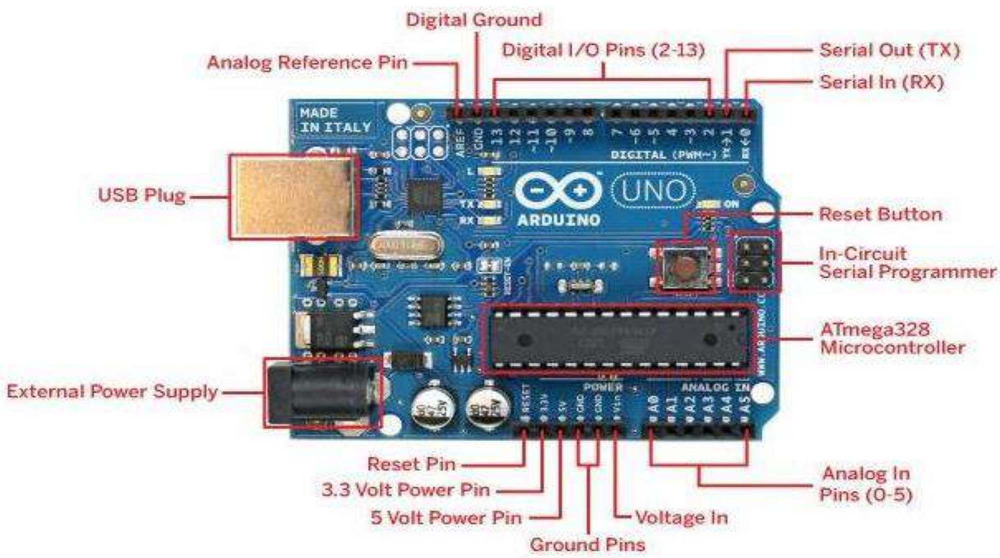


Figure 3.2 A Labeled Diagram of Arduino Uno [38]

- **Software:** The Arduino IDE is the main software tool used to program the Arduino Uno. It's a cross-platform (Windows, macOS, and Linux) program that offers an easy-to-use interface for creating, assembling, and uploading code to the Arduino board**.** The Arduino programming language, which is a condensed form of C++, is used to program the Arduino Uno.

- **Features Of Arduino Ide:**

  - An IDE with syntax highlighting, code suggestions, and auto-completion is included. It improves the efficiency and ease of writing Arduino code.
  - The .ino file extension is used to save project files and project drawings.
  - Like cut, copy, and paste are supported by this IDE.
  - The IDE includes a code editor with features like auto-indentation, code completion, and syntax highlighting to make coding easier.

Figure 3.3 A Labeled Diagram of Arduino IDE

- **Arduino Programming Basic**

Sketches: A program created with Arduino is referred to as a "sketch." The setup () and loop () functions are two essential components of a sketch. The main logic of the code is contained in the loop () function, which is called repeatedly after setup ().

Variables & Data Types: Integers (int), floating-point numbers (float), characters (char), and Boolean values (bool) are among the data types that Arduino supports. Within the program, variables are used to store and modify data.

Libraries: The .ino file extension is used to an extensive collection of libraries and built-in functions from Arduino make common tasks easier. Libraries increase functionality by offering pre written code for particular jobs, like managing sensors, LCD screens, or motors. save project files and project drawings.

3.2.2 ESP32

An IoT development board called the NodeMCU ESP32 features the ESP32 microcontroller with integrated Bluetooth and Wi-Fi. The phrase "NodeMCU" (micro-controller unit) is created by combining the terms "node" and "MCU". Because it is written in the Lua programming language, the firmware that is installed inside the NodeMCU is easy to program and interface with a wide variety of hardware components and sensors. Additionally supported is the 32-bit ESP32. Because dual in-line package (DIP) circuit boards combine a USB controller with a smaller surface-mounted board that houses the microcontroller unit (MCU) and antenna, they are frequently used in prototyping. It makes it easier to manage connected devices, send and receive data over the internet, and connect to Wi-Fi networks. ESP32 provides an easy-to-use and obtainable platform for developing IoT application. These are Internet of Things MCU development boards with pre-installed ESP32 chip modules. Before IoT devices are put into mass production, developers, manufacturers, and enthusiasts use them to test and prototype the devices.

Figure 3.4 NodeMCU ESP32 [39]

- **Esp32 Specifications & Features**: A well-liked microcontroller and system-on-chip (SoC) for embedded systems and Internet of Things (IoT) applications is the ESP32. The ESP32's features and specifications are as follows:

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16

- Analog Input Pins (AIP): 1
- UARTs: 1

◆ **Esp32 Pin Diagram**

The VIN pin and the 3V3 pin are the two power pins. If your 5V power supply is regulated, you can use the VIN pin to power the ESP32 and its peripherals directly. The on-board voltage regulator's output, which can provide up to 600mA, is located on pin 3V3. Ground pin is GND.

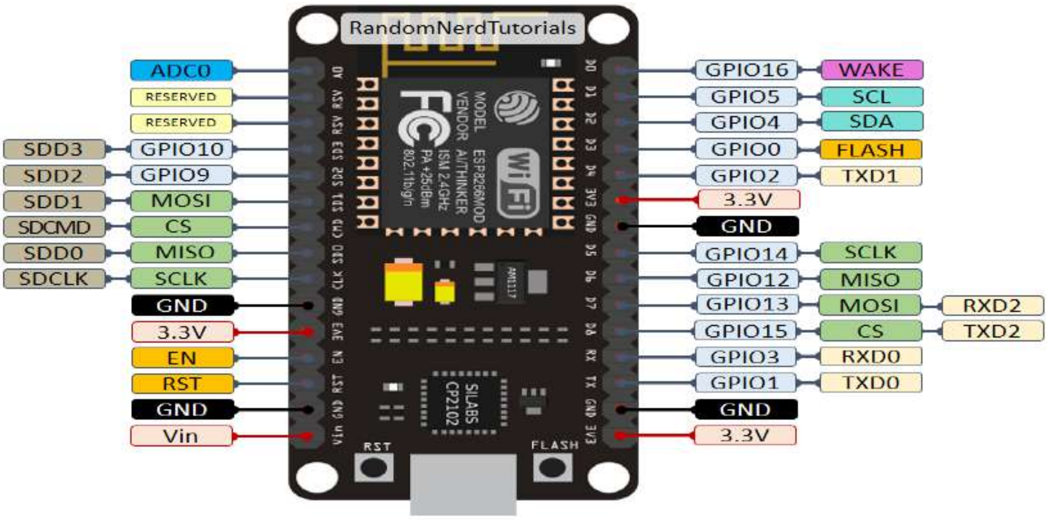


Figure 3.5 ESP32 Pinout Diagram [40]

3.2.3 16*2 Lcd Display

There are many uses for an LCD (Liquid Crystal Display) screen, which is an electronic display module. A 16x2 LCD display is a very basic module that is frequently found in many different kinds of circuits and devices. An LCD that is 16 by 2 can show up to 16 characters on each of its two lines. Every character on this LCD is shown as a 5x7 pixel matrix. There are 224 distinct characters and symbols that can be displayed on the 16 x 2 intelligent alphanumeric dot matrix display. There are two registers on this LCD: Command and Data.

◆ **16*2 Lcd Display Pinout**

Below is a pinout diagram for a 16x2 LCD:

Pin1 (Ground/Source Pin): This is a GND pin on the display that is used to connect the power source or the microcontroller unit's GND terminal.

Pin 2 (VCC/Source Pin): This pin connects the power source's supply to the display's voltage supply.

Pin 3 (V0/VEE/Control Pin): This pin is used to connect a changeable POT(Potentiometer) that can supply 0 to 5V and regulates the display's difference.

Pin 4 (Register Select/Control Pin): This pin connects to a microcontroller unit pin and toggles between the command and data registers, producing a value of either 0 or 1 (0 being data mode and 1 being command mode).

Pin 5 (Read/Write/Control Pin): This pin is connected to a microcontroller unit pin to receive either 0 or 1 (0 = Write Operation, and 1 = Read Operation). It connects the display between the read and writes operations.

Pin 6 (Enable/Control Pin): This pin is connected to the microcontroller unit and is held high at all times in order to carry out the Read/Write process.

Pin 7-14 (Data Pins): The data pins, pins 7–14, are used to transmit data to the display. Two-wire modes such as 4-wire mode and 8-wire mode are used to connect these pins.

Pin 15: This pin is connected to +5V.

Pin 16: This pin is connected to Ground (GND).

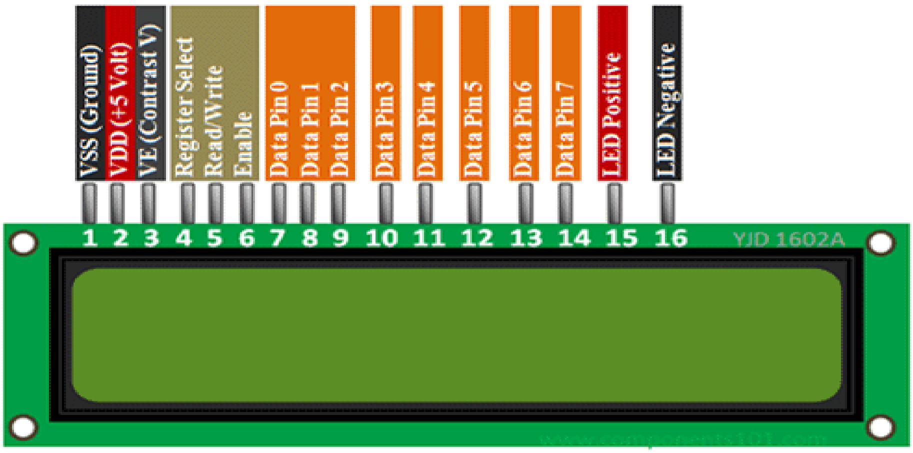


Figure 3.6 16*2 LCD Display Pinout Diagram [41]

3.2.4 I2C (Inter-Integrated Circuit) Module

A device that uses the I2C protocol to enable communication between a microcontroller and other peripherals, like sensors, displays, or other integrated circuits, is known as an I2C module. Because it only requires two wires to transmit data between devices the SCL, or serial clock, and the SDA, or serial data—this communication protocol is widely used. An I2C module is frequently used for LCD displays in order to streamline the wiring and minimize the number of pins needed to link the LCD screen to a microcontroller. When working with a microcontroller's limited number of GPIO pins, this is extremely helpful.

◆ I2c Module Features and Specification

A few of the I2C Serial Interface Adapter Module's features and specifications are covered in this section:

- Working Voltage: DC 5 volts
- I2C management with PCF8574
- able to fit Eight modules onto a single I2C bus
- I2C Address: 0X20~0X27 (you can use the onboard jumper pins to change the address yourself; it was originally 0X20).

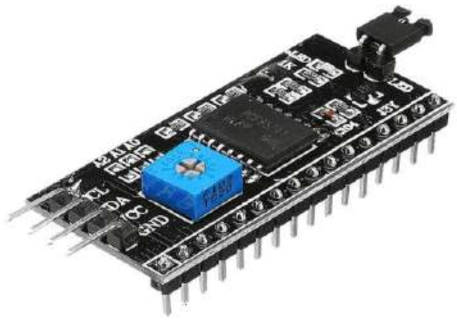


Figure 3.7 I2C Serial Interface Adapter Module [42]

◆ I2c Module Pin Diagram

Several pins on the module are available for using the I2C protocol for interaction with the MCU or CPU. The pin name, type, and functions are displayed in the table below:

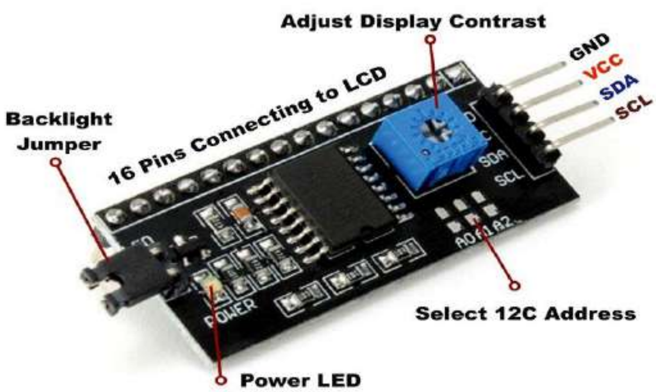


Figure 3.8 I2C Serial Interface Adapter Module Pin Diagram [43]

Uses for the I2C LCD component include those that call for textual or visual displays.

When a character display is required but it is not feasible to use seven consecutive GPIOs on a single GPIO port, this component is also utilized. If the project already has an I2C master, then no extra GPIO pins are needed.

3.2.5 Soil Moisture Sensor

A tool used to gauge the moisture content of soil is called a soil moisture sensor. It's frequently used to improve irrigation and water management in gardening and agriculture monitoring applications. Capacitance is the primary method used by this sensor to measure the soil's water content (dielectric permittivity). This sensor can be made to function by placing it into the ground, and it will then report the soil's water content status as a percentage.

◆ **Soil Moisture Sensor Pinout Configuration**

The soil moisture sensor includes 4 pins: i) VCC pin is used for power (3.3V to 5V). ii) A0 pin is an analog output. It's connected to Arduino A0 pin. iii) D0 pin is a digital output. It's connected to Arduino D0 pin. iv) GND pin is a Ground. Additionally, this module has a potentiometer that will set the threshold value, and the comparator, LM393, can determine the value. The threshold value will determine whether the LED turns on or off.

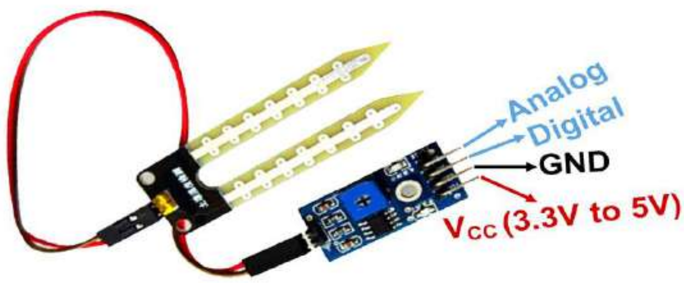


Figure 3.9 Soil Moisture Sensor Pinout Diagram [44]

◆ **Applications Of Soil Moisture Sensor**

The following are some of the uses for moisture sensors:

- Agriculture
- Irrigation of landscapes
- Research

- Easy-to-use sensors for gardener

3.2.6 Rain Detection Sensor

A rain sensor is a tool used to measure the amount and intensity of rainfall. It is sometimes referred to as a rain gauge or rain detector. These sensors are frequently used in many different applications, such as smart home automation, irrigation systems, and weather stations.

◆ **Rain Sensor Features & Specification**

- The double-sided material used in this sensor module is of high quality.
- Oxidation and anti-conductivity after extended use
- This sensor's dimensions are 5 cm by 4 cm and it can have a nickel plate built into the side.
- A potentiometer can be used to change the sensitivity.
- 5 volts is the necessary voltage.

Figure 3.10 Rain Sensor Module [45]

◆ **Working Principle of Rain Sensor**

The working principle of the rain sensor is quite straightforward. A group of exposed copper trades on the sensing pad function together like a potentiometer or variable resistor. Here, the amount of water falling on the sensing pad's surface will determine how much resistance it has. Thus, in this case, the resistance and the volume of water are inversely correlated.

◆ **Rain Sensor Pinout Diagram & Configuration**

With just 4 pins to connect, the rain sensor is incredibly simple to operate.

A0 Pin: The Analogue Output (AO) pin provides an analogue signal ranging from 5 volts to 0 volts from the voltage supply.

D0 Pin: This pin provides digital output for the internal comparator circuit and can be linked to a 5V relay or an Arduino board.

Ground Pin: This connection is to the earth.

VCC Pin: This pin supplies the rain sensor with a voltage between 3.3 and 5 volts. Here, the voltage applied to the sensor will determine how the analogue output changes.

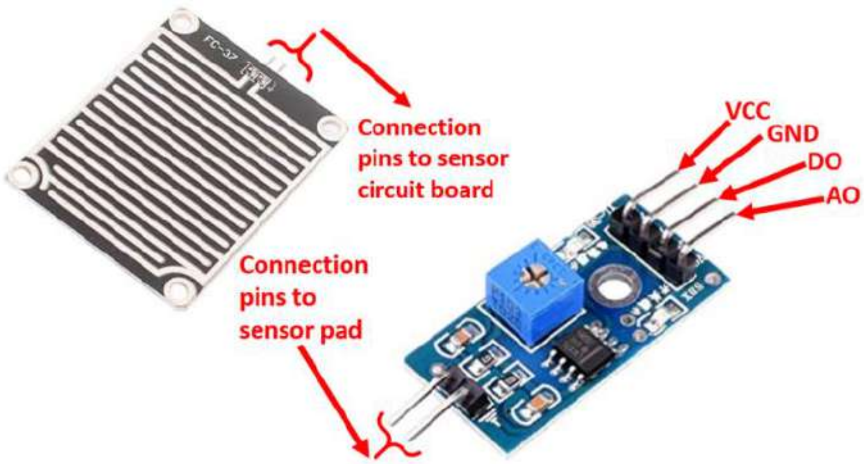


Figure 3.11 Rain Sensor pinout diagram [46]

◆ **Application Of Rain Sensor**

The applications of rain sensor include the following:

- This sensor is connected to the irrigation system to turn it off in the event of rain and is used as a water preservation de vice.
- This sensor supports both the standard windscreen wiper mode and protects an automobile's internal components from precipitation.

3.2.7 DHT11 Sensor

A common temperature and humidity sensor found in many different applications is the DHT11. It is straightforward to use with Arduino microcontrollers as well as embedded electronic devices, featuring a 3-pin interface.

Figure 3.12 DHT -Temperature & Humidity sensor [47]

The DHT11 is a widely used temperature and humidity sensor. It has an 8-bit microcontroller to output the temperature and humidity values as serial data, along with a dedicated NTC for measuring temperature.

TABLE II DHT11 PINOUT CONFIGURATION

Number	Pin Name	Description
1	VCC	Power Supply 3.3V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	Ground (GND)	Connected to the ground of the circuit

A simple, incredibly affordable digital temperature and humidity sensor is the DHT11. It measures the ambient air using a thermistor and a capacitive humidity sensor before emitting a digital signal on the data pin (no analogue input pins are required).

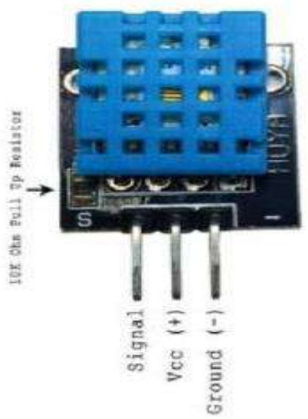


Figure 3.13 DHT11 Pinout Diagram [48]

3.2.8 PIR Motion Sensor

The presence of people nearby can be detected using a passive infrared sensor, or PIR. The door's motion can be managed via the output. In essence, motion detection uses light sensors to identify when an object blocks a beam of infrared light coming from another area of the device or when infrared light is absent from a warm object. An object that is heated emits infrared light, which is detected by a PIR sensor. It is made up of pyroelectric sensors, which convert temperature changes brought on by incident infrared radiation into electric signals

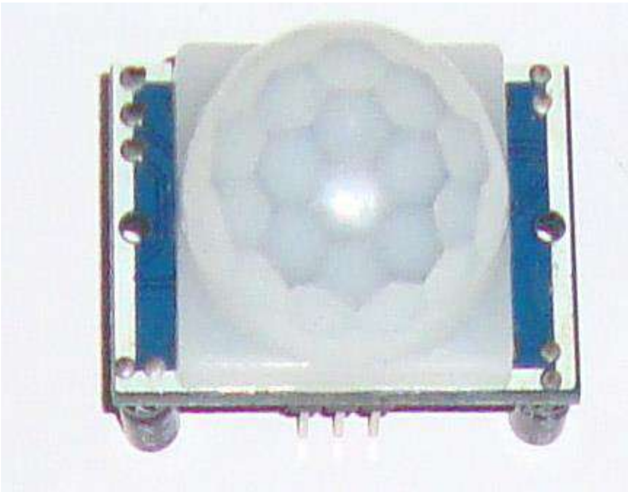


Figure 3.14 PIR Motion Sensor [49]

◆ **PIR Sensor Characteristics**

Important characteristics defining PIR sensor functionality and application include:

- ✓ The range of motion that can be detected; typically, this is between 10 and 20 feet. expanded through optical means.
- ✓ The total volumetric angle in which motion is detected is known as the field of view, or FOV. Diverse detection patterns are offered by different lenses.
- ✓ Zones of detection: For directional sensing, the field of view can be divided into distinct zones using adjustable mirrors.

◆ **PIR Motion Sensor Pinout Diagram**

A Fresnel lens and pyroelectric material make up a PIR sensor. The incoming infrared radiation is concentrated by a high-density polythene Fresnel lens, causing the radiation to fall on the pyroelectric material. An electronic sensor that measures infrared (IR)light emitted from objects within its field of view is called a passive infrared (PIR) sensor.

TABLE III PIR PINOUT CONFIGURATION

Pin Number	Pin Name	Description
1	VCC	Input voltage is 4.5V- 12V
2	High/Low Output	Digital pulse at 5 volts when motion is detected when not in use (no motion detected), digital low (0V)
3	Ground	Connected to ground of circuit

The most common application for them is in PIR-based motion detectors. PIR sensors are widely used in automatic lighting and security alarm systems.

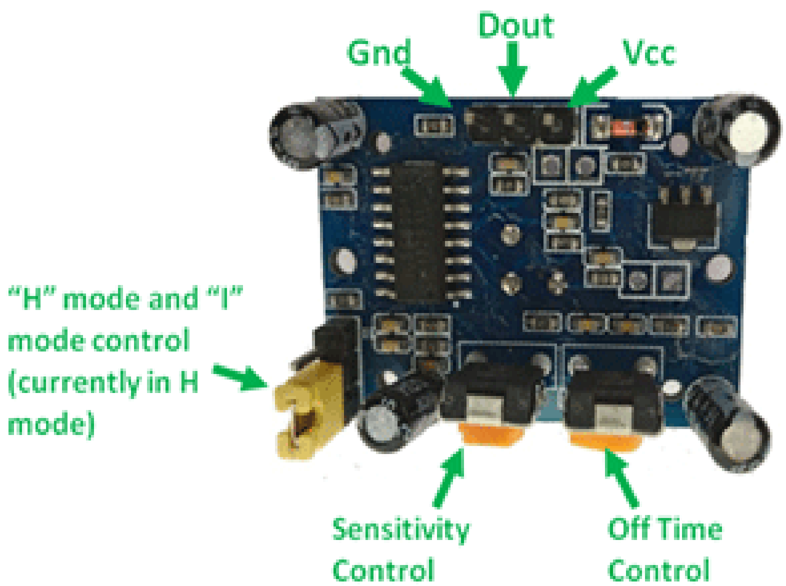


Figure 3.15 PIR Motion sensor pinout diagram [50]

◆ **Applications Of Pir Motion Sensor**

- All exterior lights
- Lift Lobby
- Common Staircases
- Basement or Covered Parking
- Shopping mall

- Garden lights
- Outdoor crops field

3.2.9 5V Single Channel Relay

Relays are low-voltage electrical switches that have the ability to be turned on or off, to permit or prohibit current flow, and may be managed by 5V Arduino pins. As we'll see later, using the Arduino to control a relay module is as simple as using it to monitor any other output.

The following are a few benefits of relay use:

• High power or high voltage circuits can be managed by relays in conjunction with low power circuits.

• Galvanic separation in both regulating and regulated circuits may be accomplished via relays.

• Relays are simple to use and reasonably priced.

• A broad range of sizes and types of relays are available to satisfy various needs.

Figure 3.16 5V Single channel Relay [51]

3.3 Methodology

The design strategy used to create the Internet of Things (IoT)-based smart water management, soil moisture monitoring and controlling system for agriculture is described in the methodology section of this project report. It outlines the essential actions required in the provides visual aids for the project's design process, such as block diagrams, flowcharts, and circuit diagrams.

3.4 Block Diagram

With the help of the Arduino ATMega328p microcontroller board, we have finished the project's block diagram. The Arduino Uno 328p is equipped with 14 digital I/O pins, including 6 PWM outputs, an ICSP header, a reset button, a USB port, a power connector, and a 16 MHz crystal oscillator. The project's block diagram is shown in the following figure (Figure 4.1). The ATMega328p microprocessor is used in this design to handle processing tasks. The ATMega328p's 256 KB of flash memory of which 8 KB are set aside for the bootloader can be used to store the code. The microcontroller also contains 4 KB of EEPROM that can be read and written using the EEPROM library, and 8 KB of SRAM for data storage. The input, Arduino Uno, and output are the three primary parts of the Arduino system that are shown in the block diagram (Fig. 3.16). The data flow and functionality inside the project's architecture are described in these sections.

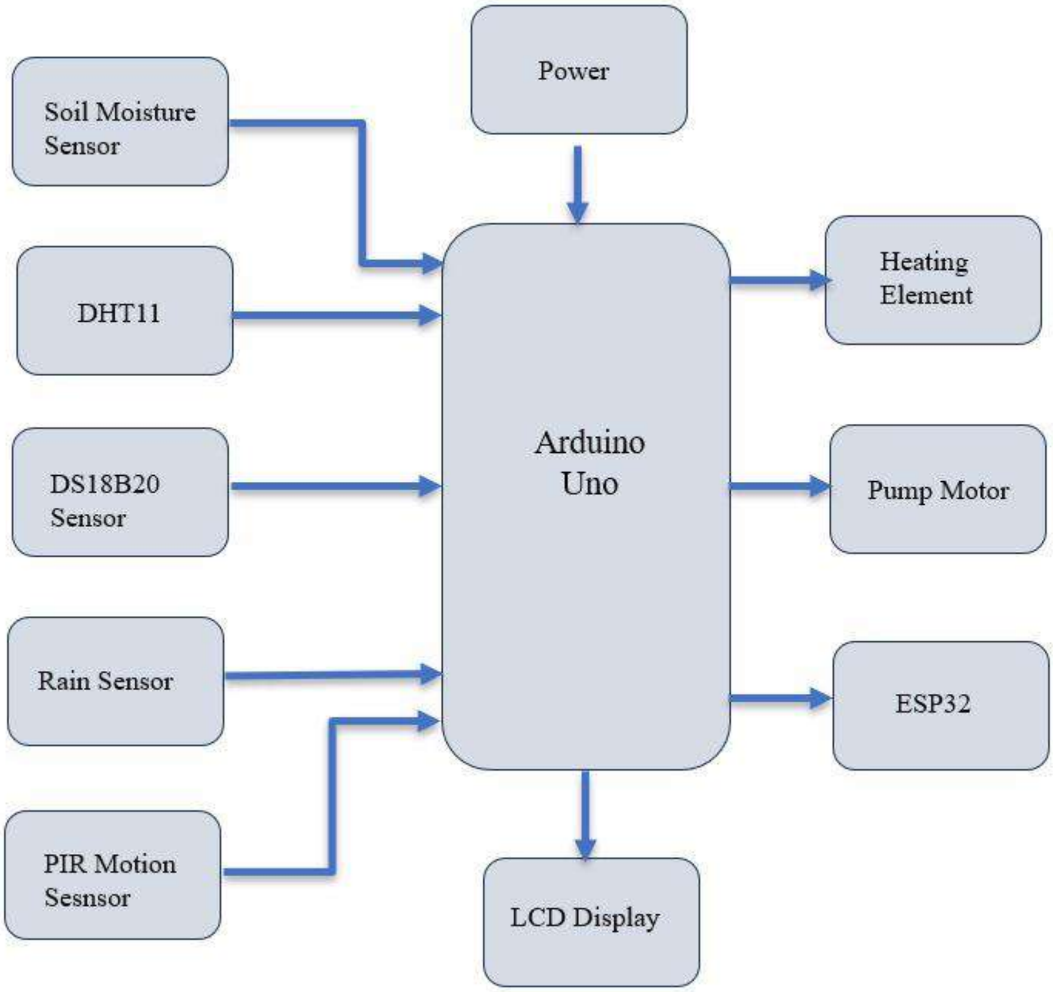


Figure 3.16 Block Diagram of this Project

The ESP32, rain sensor, PIR motion sensor, DHT11, ds18B20 sensor, and soil moisture sensor all send data to the Arduino Uno. The power supply block is how we are powering the Arduino Uno. All of the electrical parts and sensors are centralized around the Arduino Uno in this setup. Here, the Arduino Uno's input voltage range is 7 to 12 volts. The circuitry is powered and grounded by the ATMega328p pin A0, the soil humidity sensor, and the soil humidity sensor the result, in that order.

3.5 Flow Chart

The first stage in creating the system is the process of creating the system. Thanks to the flowchart, everything is simple to understand. As a result, we created a process flow diagram. In Fig. 3.18, the developed project flow is displayed.

Below is a discussion of how the flow chart operates:

• Step one is to start the program's algorithm.

• After that, a computer simulation will examine the temperature, humidity and moisture content of the soil.

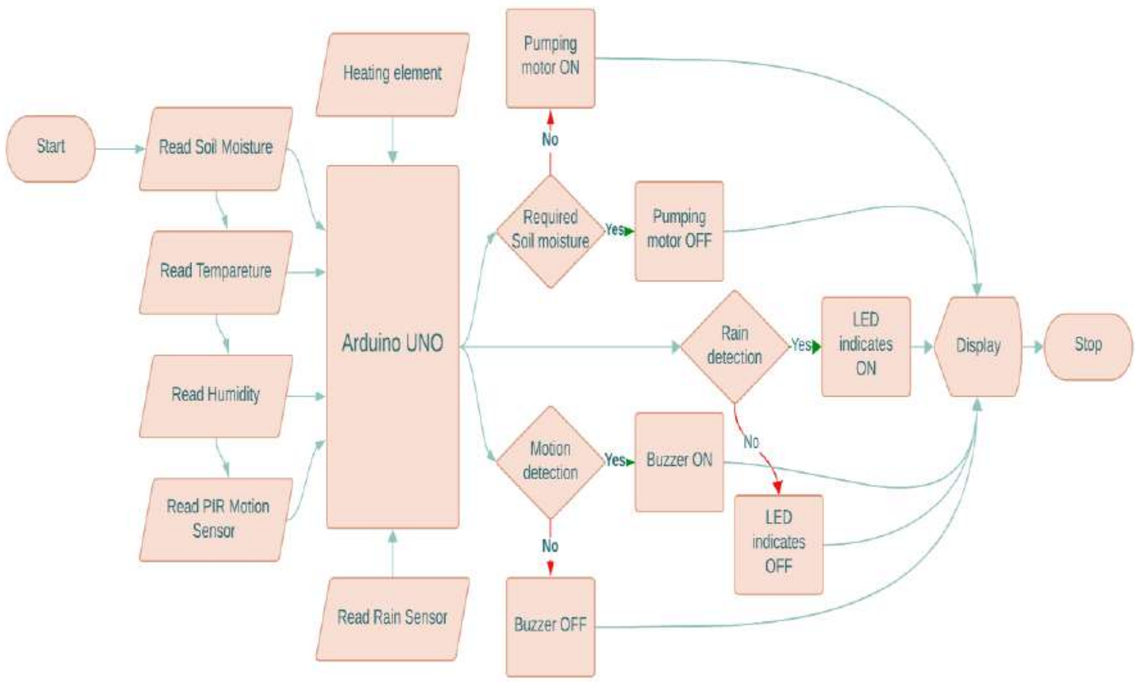


Figure 3.17 Flow Chart of this Project

- Next, every piece of data will be uploaded to the cloud server via ESP32.
- The motor will then be turned off by the algorithm if the soil moisture level is 50 or higher, indicating that the soil contains moisture.

- Additionally, the motor will activate and begin watering the ground if the temperature falls below 50.
- It will take a temperature reading in the interim. In that instance, the lightbulb will turn on if the temperature drops below 15 degrees; otherwise, it will turn off.

3.6 Algorithm

Step 1: Start

Step 2: Initialize Variables and get data from the sensors.

- Declaration of variables

- Soil moisture read: Integer

- Pumping motor activation: Integer

- Heating element activation: Integer

- PIR motion detection: Integer

- Temperature read: Integer

- Rain data read: Integer

- Humidity read: Float

Step 3: Checking if Arduino UNO is reading data from the

sensors correctly or not.

Step 4: Processing based on the data collected from the sensors.

- If soil moisture low, pumping motor should turn on.

- If soil is too much wet, heating element should turn on

- If PIR motion detects any motion, buzzer should beep.

- If rain sensor detects rainfall, an LED should turn on.

Step 5: Send all the data to the ThingSpeak platform to visualize.

Step 6: Stop

3.7 Circuit Diagram

The ATMega328p microcontroller in this system is connected to every component. Pins D2 and D3 of the NodeMCU are connected to pins 23 and 23 of the ATMega328p. There are a total of 16 pins available for use in various scenarios on the 16*2 display module. Although the display has four pins, we only required four because we were using I2C. The 5V power supply and ground are connected to the VCC and Ground pins respectively.

The electronic schematic for this project was created using Proteus software. The circuit architecture and its pin-to-pin connections are described underneath.

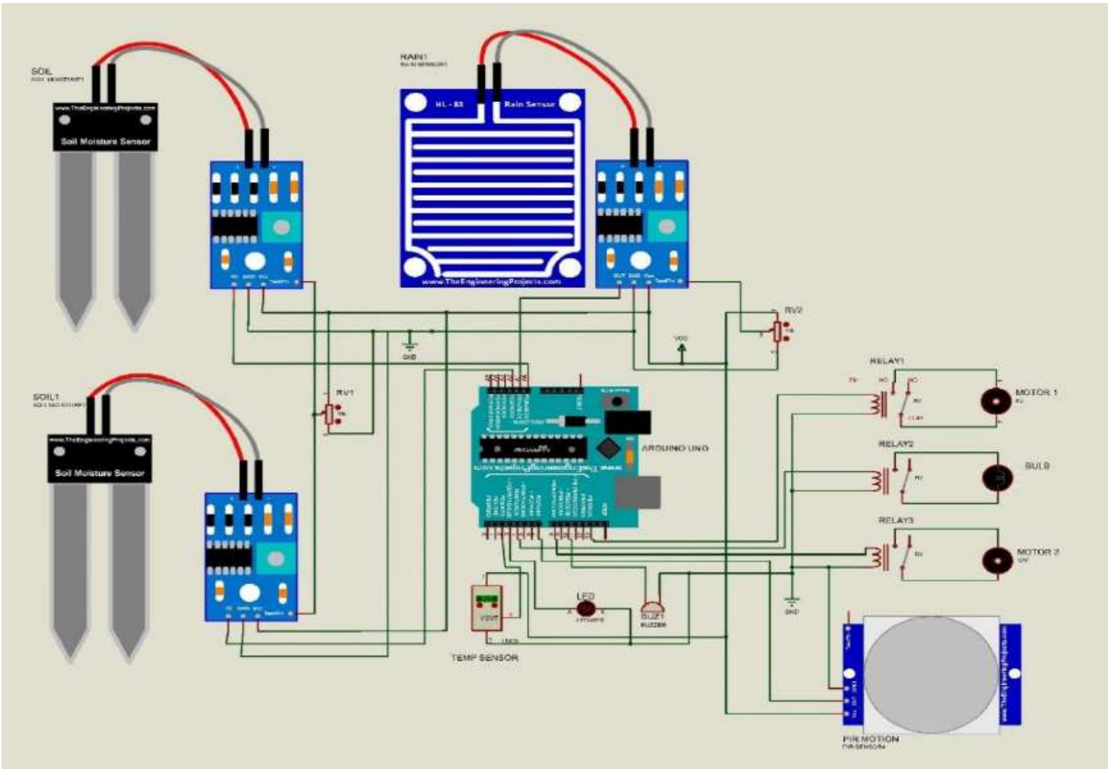


Figure 3.18 Circuit Diagram of Proposed Model

Pin number SDA of the microcontroller is connected to SDA, while pin number SCL is connected to SCL. The SDA and SCL pins are used for serial communication and are referred to as the I2C pins in this context. The device receives power and ground from the ATMega328p pin A0, the soil moisture sensor, and the soil moisture sensor output, in that order. For this experiment, infrared (IR) sensor modules were used twice.

CHAPTER 4
IMPLEMENTATION & RESULT

4.1 Introduction

This project aims to create a list of recommendations for an automated hydroponic garden. This project's code was written in Arduino. Using ESP32, we have created both an automated water management system and an improved debt management system.

4.2 Implementation

Each piece of hardware for the system is contained on a single wooden board. Numerous sensors, including temperature, humidity, motion sensor, rain sensor, soil moisture, and relays, are connected to the Arduino. Every component is connected to the Arduino board via connectors. Connectors are also used for a range of connections.

4.2.1 Complete Overview

Using Proteus, we were able to map out our entire project and create a circuit diagram that showed all of the connections between the various components. For this project, we used an infrared two soil moisture sensor, pir motion sensor, rain sensor a display that is I2C, ds18b20 sensor, a temperature sensor, two relay, two pumping motor, a heating element, a power supply, and some wires. Fig. 5.1 provides a schematic representation of the entire system.

4.2.2 Performance of The System

Using a programming cable, we must first download the software from Arduino IDE. Electricity will then be used to start the software. The pump motor will turn on when the soil moisture sensor detects a low moisture level. When the temperature drops below 15 the heating elements will activate.

The soil moisture sensor, rain sensor, temperature sensor, humidity sensor, motion sensor was measuring the real time value continuously and transmits the results in Thing Speak. A single wooden board served as the platform for all of the hardware in the system. First, using the Arduino IDE Software on a PC, the coding sketch is uploaded to the Arduino Board. After that, the parts are wired to the Arduino Board, making sure to connect to the designated pins listed in the coding algorithm. The components are then soldered together using an IC base and a soldering iron. The components' power supply connection has been established. A test run is done after every connection is finished. The ESP32 is used to store real-time data to a cloud platform.

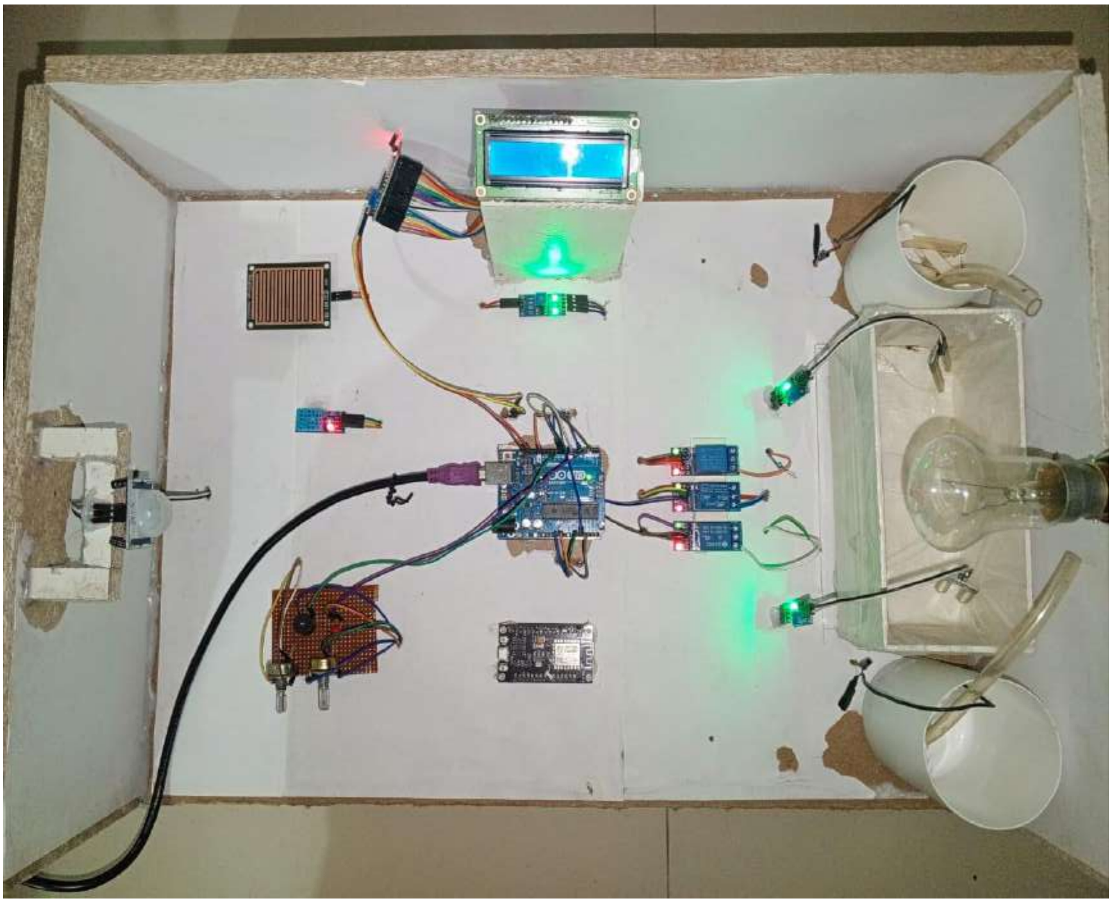


Figure 4.18 Total overview of the system

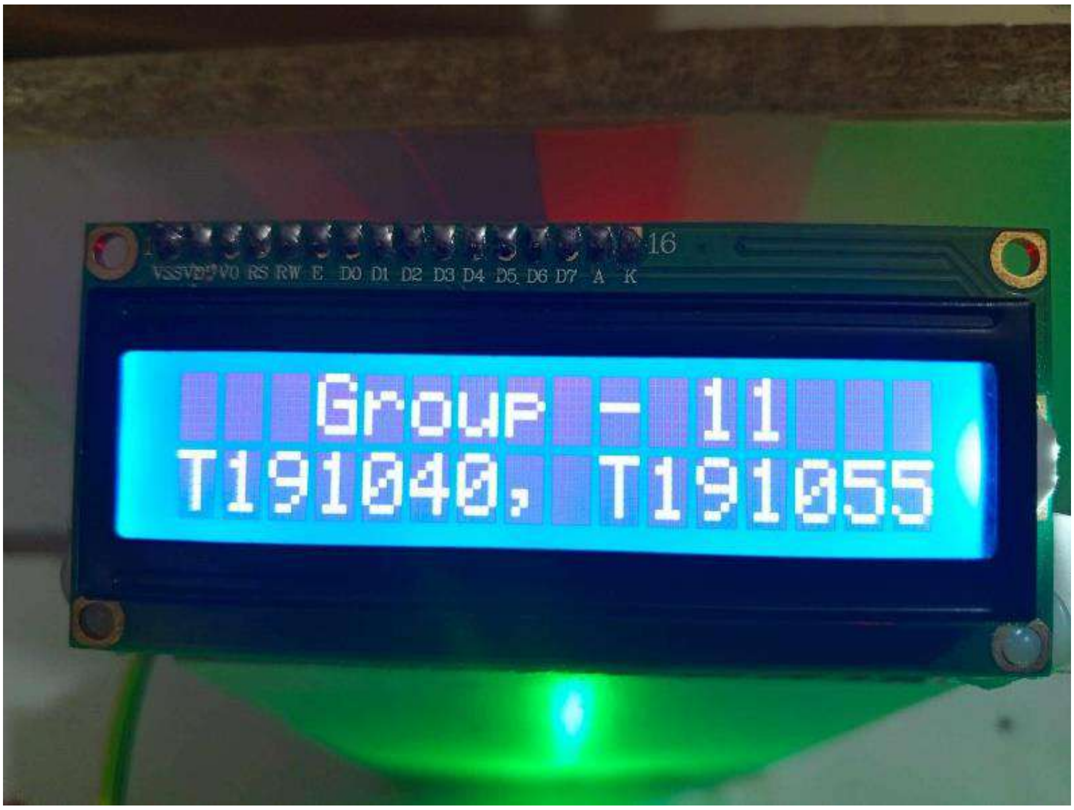
4.3 Demonstration and Result of The Project

We have successfully carried out the project under various conditions in order to test it. For instance, using soil moisture level, soil humidity level, soil temperature and so on.

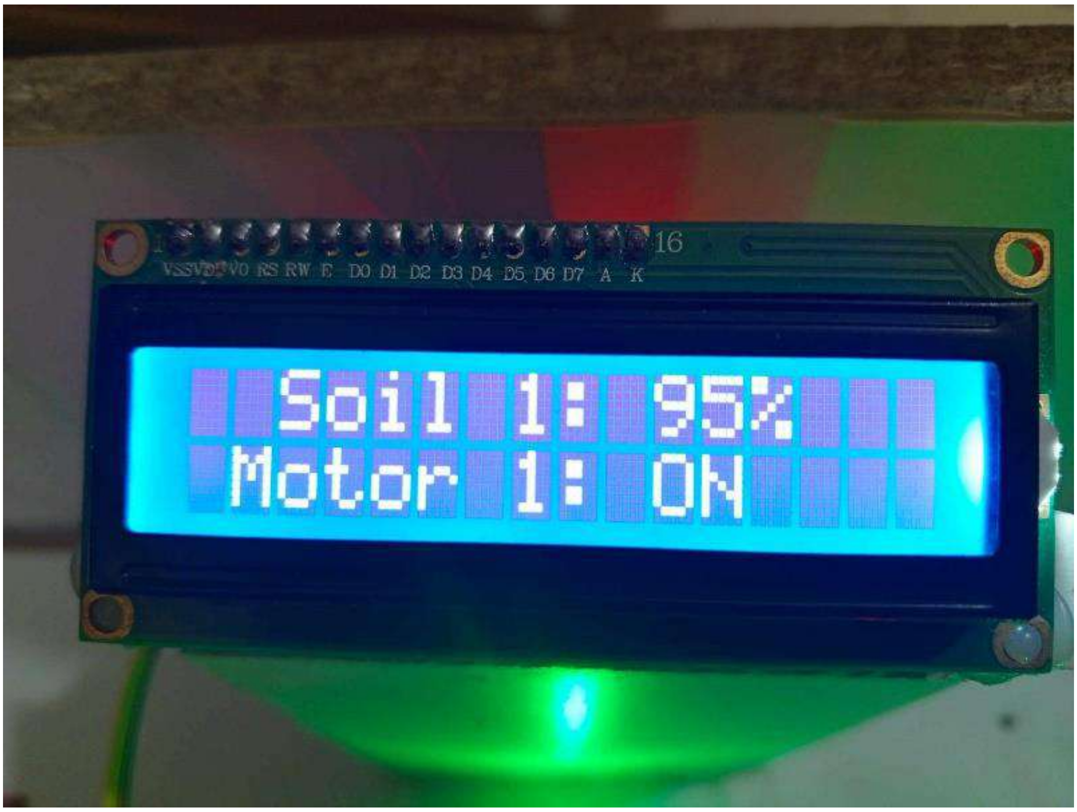
The project is initiated by providing electricity to the system. Once the power is supplied, the necessary components and software are activated to enable its functioning.

When soil moisture level is almost 70%, then the pumping motor is off. Because of that the soil was wet. On the other side, soil moisture level is up to 80% and below to 60%, that time the pumping motor was on. Because the soil moisture should be 60 to 80 for adequate yield of potatoes. Good potato yield depends on temperature, humidity and other factors besides soil. The figure below illustrates what happens when the power supply is connected and displays the initial message.

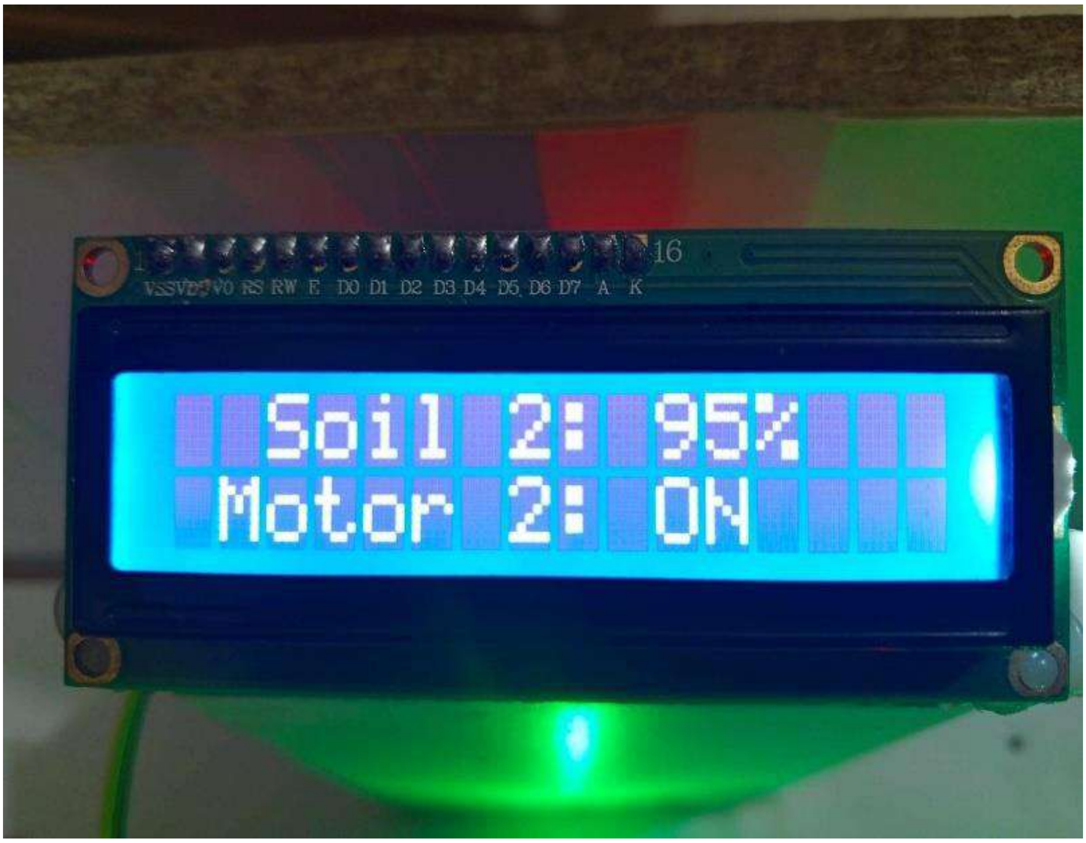
(a)



(b)


16
VSSVDDV0 RS RW E D0 D1 D2 D3 D4 D5 D6 D7 A K
Soil 1: 95%
Motor 1: ON

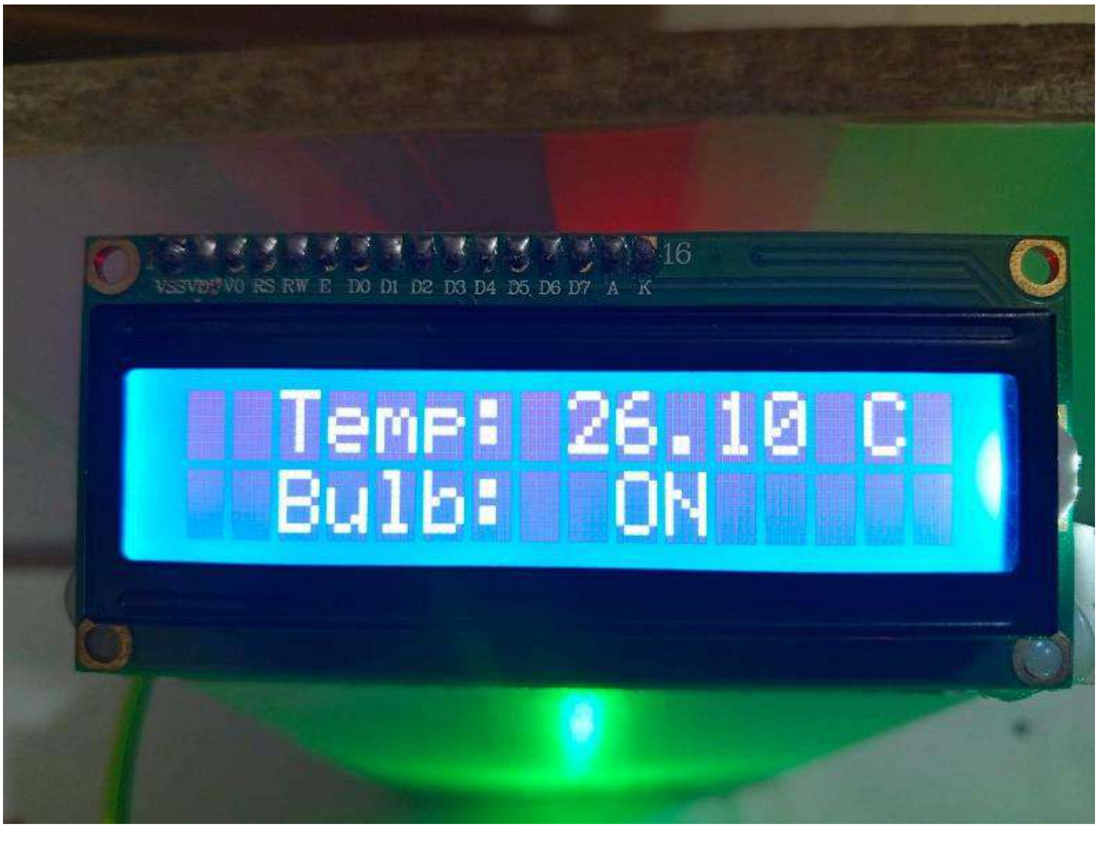
(c)


16
VSSVDDV0 RS RW E D0 D1 D2 D3 D4 D5 D6 D7 A K
Soil 2: 95%
Motor 2: ON

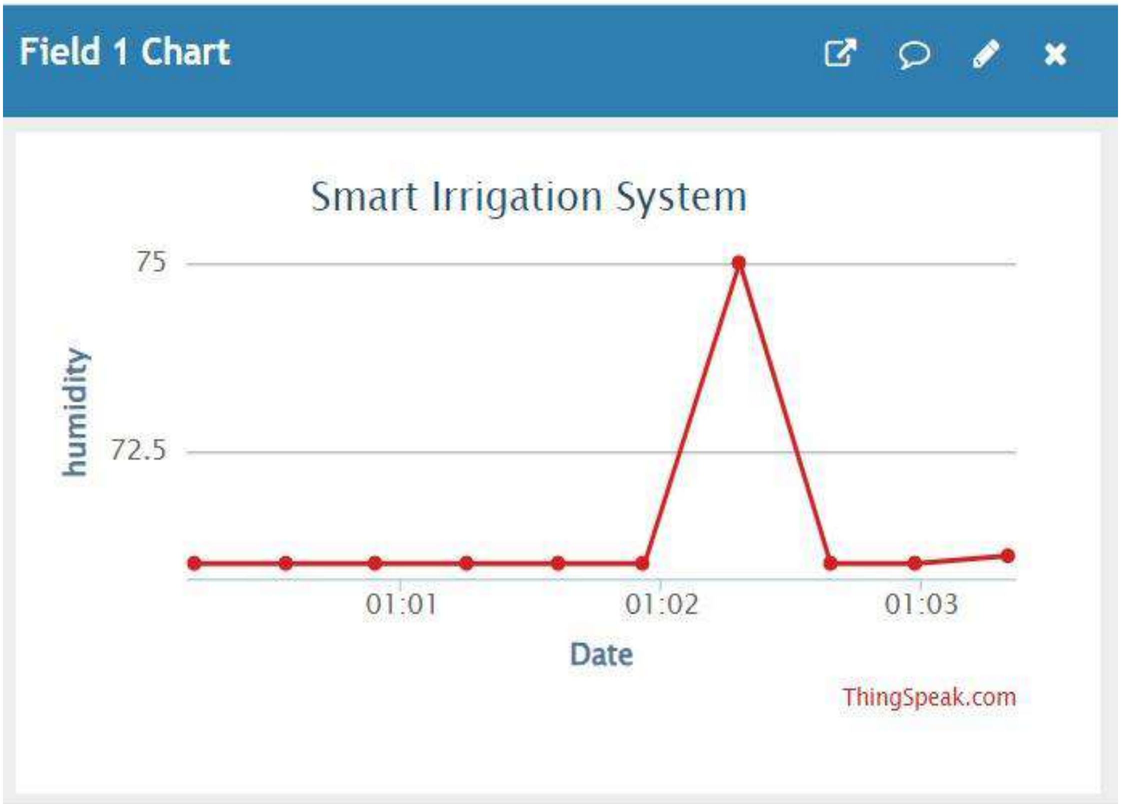
(d)


16
VSSVDD VO RS RW E D0 D1 D2 D3 D4 D5 D6 D7 A K
Temp: 26.10 C
Humid: 71.00%

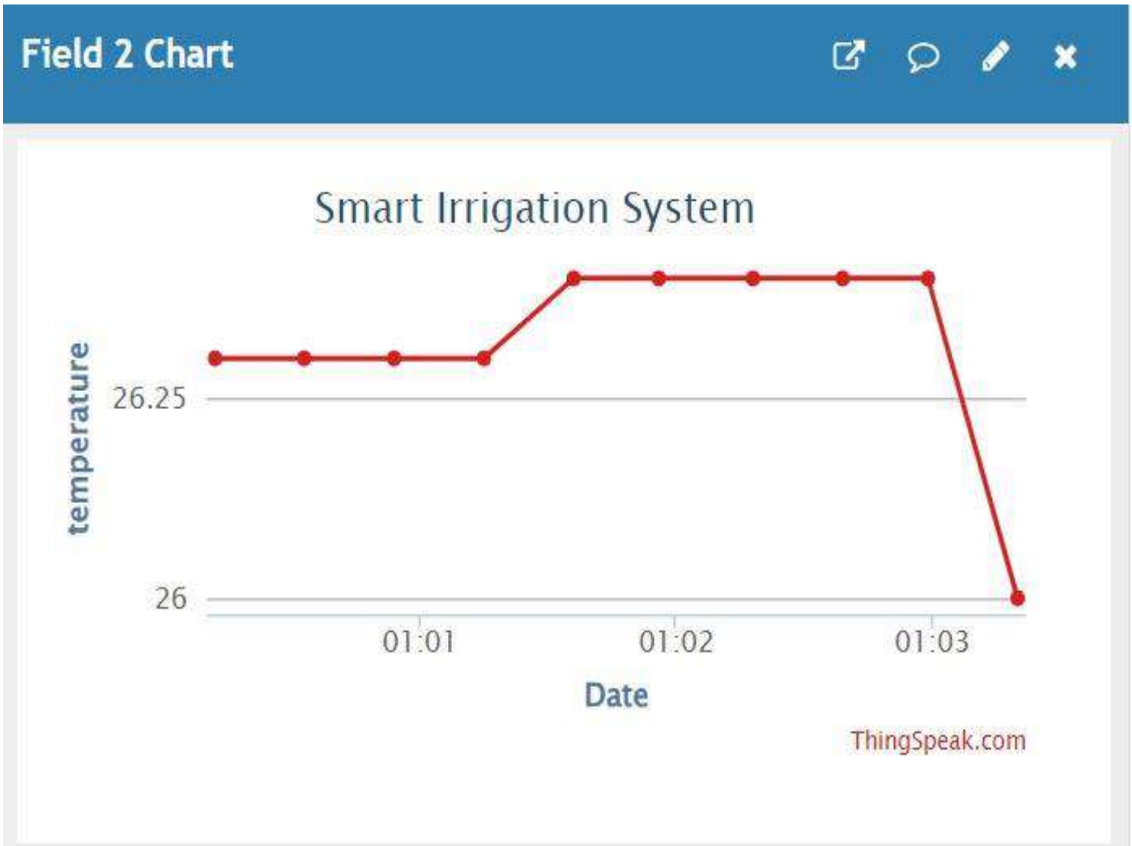
(e)


16
VSSVDD VO RS RW E D0 D1 D2 D3 D4 D5 D6 D7 A K
Temp: 26.10 C
Bulb: ON

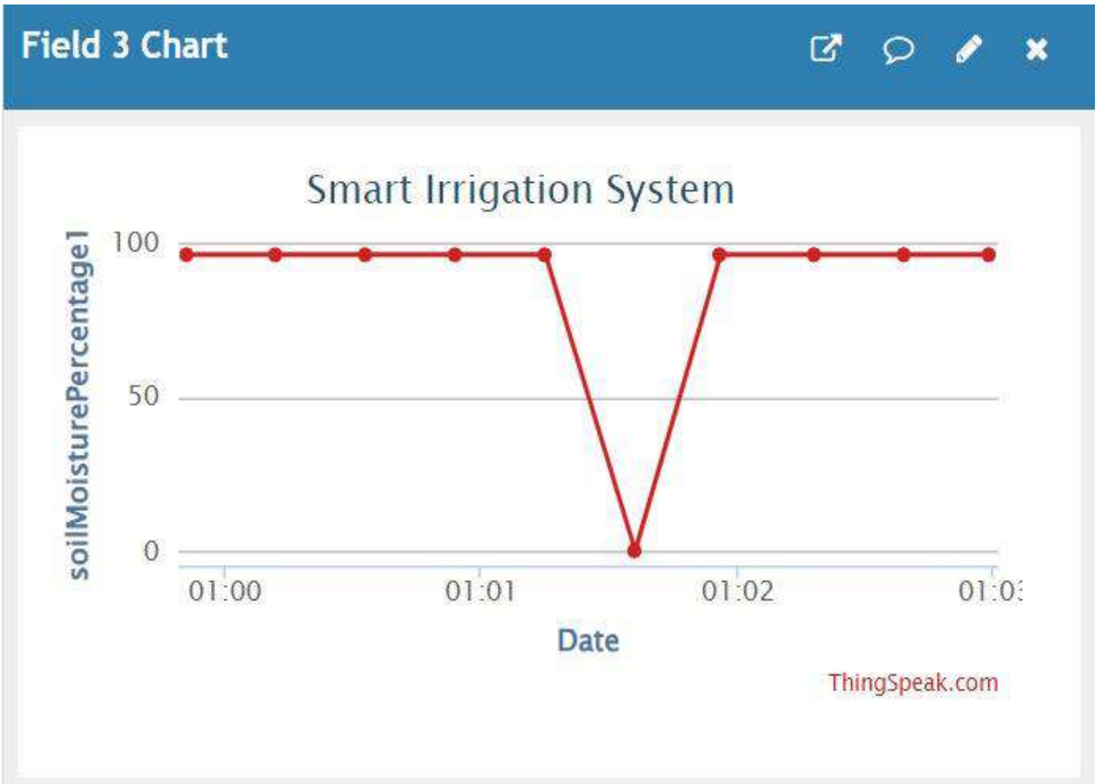
(f)


Field 1 Chart
Smart Irrigation System
75
72.5
humidity
01:01
01:02
01:03
Date
ThingSpeak.com

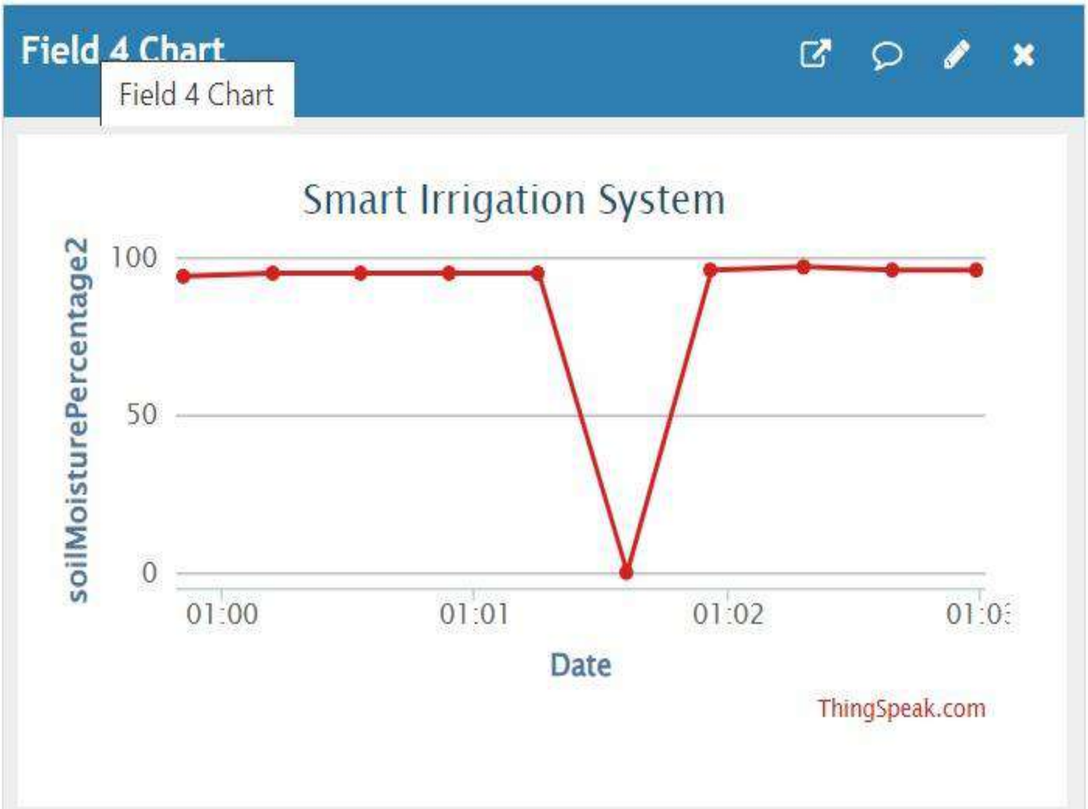
(g)


Field 2 Chart
Smart Irrigation System
26.25
26
temperature
01:01
01:02
01:03
Date
ThingSpeak.com

(h)



(i)



(j)

Figure 4.2 Figure of Project Outcome (a), (b), (c), (d), (e), (f), (i), (j)

4.5 Total Cost of The Project

Our project will cost a bit of money because it is usually used in industrial settings. This project will cost almost 2500 Takas. We could cut costs by selling or donating some of the less necessary equipment. But as a result, the project's output will suffer. The project's total budget is displayed in Table 5.1.

TABLE IV COST ANALYSIS

Equipment Name	Quantity	Price (TK)
Arduino Uno	01	1000
Arduino Uno	01	1000
DHT11 Sensor	01	150
Soil Moisture Sensor	02	200
LCD Display	01	190
I2C	01	120
PIR Motion Sensor	01	120
Rain Sensor	01	120
Relay	02	160
Pumping Motor	02	180
Heating Element	01	80
Wire		100
Total		**2420**

CHAPTER 5
CONCLUSION

5.1 Introduction

This concludes the project report. We will discuss the project's completion in this chapter. We will also discuss the project's limitations, prospective advancements, uses, and advantages.

5.2 Conclusion

To sum up, our Internet of Things (IoT) smart water management and monitoring system for agriculture provides an economical and effective way to maximize plant growth. Through vigilant monitoring of soil moisture content and soil temperature, the system guarantees that plants obtain the essential nutrients and hydration required for robust growth. With the help of our system, farmers and amateur gardeners can maximize crop productivity while reducing resource consumption and water waste by utilizing technology. Users can easily manage their indoor agriculture setup thanks to the convenience and flexibility that come with being able to monitor and control the system remotely.

We are enthusiastic about this project's possible influence on farming's future as we come to an end. We want to encourage people to investigate clever farming techniques and contribute to a more sustainable and productive agricultural ecosystem by fusing innovation and sustainability.

Throughout this journey, we have seen firsthand how technology can revolutionize conventional farming methods and open the door to a more fruitful and sustainable future. We anticipate that IoT-based agricultural solutions will continue to expand and that they will have a positive effect on both food production and environmental preservation.

5.3 Applications

The following are some real-world uses for our project:

- Indoor farms: Precise management of soil moisture and water pH for optimal crop development.

- Urban Gardening: Easy indoor gardening made possible by Internet of Things monitoring and control.
- Research and Education: A platform for examining the effects of water management on plant development.
- Commercial Greenhouses: Constant observation leads to increased output and resource management.
- Community Gardens: To create successful communal gardens, pooled plots are managed cooperatively.

5.4 Advantages

The following are some of the benefits of our project.

- Optimal management of water and nutrients results in greater agricultural production, which in turn increases crop yield.
- Resource Efficiency: Sustainable agriculture through reduced water and resource consumption.
- With the help of the Internet of Things (IoT), you can easily monitor and operate the system from any location.
- Possible monetary gains from less water and resource use; thus, cost savings.

5.5 Limitation

There are limits to everything in this world. Thus, certain guidelines pertaining to this undertaking are provided below. Because it's easy job, it cannot be applied in the corporate sector. More sophisticated modules are used for the portions that are utilized in the corporate sphere.

5.6 Future Improvement

This project may undergo some modifications in the future, some of which are covered below: Integration of Advanced Sensors: The system can gain from the addition of more sophisticated sensors that can gather additional information about the atmosphere, light intensity, and nutrient levels, among other things.

This would make it possible to monitor and manage the indoor growing environment more thoroughly. Artificial Intelligence and Machine Learning: Adding AI methods and machine learning algorithms can improve the system's performance. The system may learn and adapt to optimize fertilizer and water management techniques depending on particular crop requirements by assessing the data that has been gathered. Automation and Robotics: Agricultural processes can be made even more efficient by incorporating automation and robotics into the system. robotic harvesters, automated nutrient delivery systems.

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APPENDIX

// Arduino Code

```
#include <DHT.h> // temperature and humidity library
#include <Wire.h>
#include <LiquidCrystal_I2C.h> // library for I2C module
#include <OneWire.h>
#include <DallasTemperature.h> //ds18b20 library
#define DHTPIN 2 // define the Arduino pin no 2
#define DHTTYPE DHT11 // define the Arduino pin no 11
#define LED_PIN 3 // define the Arduino pin no 3
DHT dht(DHTPIN, DHTTYPE);
LiquidCrystal_I2C lcd(0x27, 16, 2);
int motorRelayPin1 = 13; // The digital pin connected to the relay's control signal
int heatRelayPin = 4; // define the Arduino pin no 4
int motorRelayPin2 = 8; // define the Arduino pin no 8
int soil_sensor_pin1 = A0; // define the Arduino pin no A0
int soil_sensor_pin2 = A2; // define the Arduino pin no A2
int calibrationTime = 10; // Set Calibrating Time
long unsigned int lowIn;
long unsigned int pause = 5000;
boolean lockLow = true;
boolean takeLowTime;
int pirPin = 7; // define the Arduino pin no 7
int buzzerPin = 10; // define the Arduino pin no 10
float temp = 0.0;
int oneWireBus = 12;
OneWire oneWire(oneWireBus);
DallasTemperature sensors(&oneWire);
void setup() {
  Serial.begin(115200); // begin the process
```

```
  dht.begin(); //dht will work
  lcd.begin(16, 2); //lcd will start
  lcd.init();
  lcd.backlight(); //display light will on
  sensors.begin(); //sensor will on
  pinMode(A0, INPUT); // soil moisture sensor as an input
  pinMode(motorRelayPin1, OUTPUT); // motorRelayPin1as an output
  pinMode(motorRelayPin2, OUTPUT); // motorRelayPin2as an output
  pinMode(heatRelayPin, OUTPUT); // heat relay pin as an output
  pinMode(LED_PIN, OUTPUT); // led pin as an output
  pinMode(pirPin, INPUT); //pir pin as an input
  pinMode(buzzerPin, OUTPUT); //buzzer pin as an output
  digitalWrite(motorRelayPin1, LOW);  // Initially turn off the motor
  digitalWrite(motorRelayPin2, LOW); // Initially turn off the motor
  digitalWrite(heatRelayPin, LOW); // Initially turn off the bulb
  digitalWrite(pirPin, LOW); // Initially turn off the pir
  Serial.println("----------System Starting----------"); // print the value
  Serial.println("Bas on Tech - 1-wire temperature sensor"); // print the value
  //give the sensor some time to calibrate
  Serial.print("calibrating sensor...");
  for (int i = 0; i < calibrationTime; i++) {
    Serial.print(".");
    delay(1000); // will take time for 1 second
  }
  Serial.println(" DONE"); // print out to done
  Serial.println("SENSOR ACTIVE"); // all sensor will active
  delay(50); // will take time for .05 second
}
void loop() {
  float humidity = dht.readHumidity(); // measure the humidity
```

```
float temperature = dht.readTemperature(); // measure the temperature
int soilMoisture1 = analogRead(soil_sensor_pin1); // measure the soil moisture level
int soilMoisture2 = analogRead(soil_sensor_pin2); // measure the soil moisture level
// Map the soil moisture reading to a percentage
int soilMoisturePercentage1 = map(soilMoisture1, 0, 1023, 0, 100);
int soilMoisturePercentage2 = map(soilMoisture2, 0, 1023, 0, 100);
lcd.clear(); // clear the lcd
lcd.setCursor(3, 0); // set cursor on first row
lcd.print("Group - 11"); // display the value
lcd.setCursor(0, 1); // set cursor on second row
lcd.print("T191040, T191055"); // display the value
delay(2000); //take brake for 2 seconds
lcd.clear(); // clear the lcd
lcd.setCursor(0, 0); // set cursor on first row
lcd.print("Smart Irrigation"); // show display
lcd.setCursor(5, 1); // set cursor on second row
lcd.print("System"); // show display
delay(2000); // take brake for 2 seconds
lcd.clear(); // clear the lcd
lcd.setCursor(2, 0); // set cursor on first row
lcd.print("Soil 1: "); // show the value on display
lcd.setCursor(10, 0); // set cursor on first row
lcd.print(soilMoisturePercentage1); // show the value on display
lcd.setCursor(12, 0); // set cursor on first row
lcd.print("%"); // show the value on display
if (soilMoisturePercentage1 < 60 && soilMoisturePercentage1 > 80) { // detection
  lcd.setCursor(1, 1); // set cursor on second row
  lcd.print("Motor 1: "); // show the value on display
  lcd.setCursor(10, 1); // set cursor on second row
  lcd.print("OFF"); // show the value on display
```

```
} else {
  lcd.setCursor(1, 1); // set cursor on second row
  lcd.print("Motor 1: "); // show the value on display
  lcd.setCursor(10, 1); // set cursor on second row
  lcd.print("ON"); // show the value on display
}
delay(2000); // take brake for 2 seconds
lcd.clear(); // clear the lcd
lcd.setCursor(2, 0); // set cursor on first row
lcd.print("Soil 2: "); // show the value on display
lcd.setCursor(10, 0); // set cursor on first row
lcd.print(soilMoisturePercentage2); // show the value on display
lcd.setCursor(12, 0); // set cursor on first row
lcd.print("%"); // show the value on display
if (soilMoisturePercentage2 < 60 && soilMoisturePercentage2 > 80) {
  lcd.setCursor(1, 1); // set cursor on second row
  lcd.print("Motor 2: "); // show the value on display
  lcd.setCursor(10, 1); // set cursor on second row
  lcd.print("OFF"); // show the value on display
} else {
  lcd.setCursor(1, 1); // set cursor on second row
  lcd.print("Motor 2: "); // show the value on display
  lcd.setCursor(10, 1); // set cursor on second row
  lcd.print("ON"); // show the value on display
}
delay(2000); // take brake for 2 seconds
lcd.clear(); // clear the lcd
lcd.setCursor(2, 0); // set cursor on first row
lcd.print("Temp: "); // show the value on display
lcd.setCursor(8, 0); // set cursor on first row
```

```
lcd.print(temperature); // show the value on display
lcd.setCursor(13, 0); // set cursor on first row
lcd.print("C"); // show the value on display
lcd.setCursor(1, 1); // set cursor on second row
lcd.print("Humid: "); // show the value on display
lcd.setCursor(8, 1); // set cursor on second row
lcd.print(humidity); // show the value on display
lcd.setCursor(13, 1); // set cursor on second row
lcd.print("%"); // show the value on display
delay(2000); // take brake for 2 seconds
lcd.clear(); // clear the lcd
lcd.setCursor(2, 0); // set cursor on first row
lcd.print("Temp: "); // show the value on display
lcd.setCursor(8, 0); // set cursor on first row
lcd.print(temperature); // show the value on display
lcd.setCursor(13, 0); // set cursor on first row
lcd.print("C"); // show the value on display
if (temperature < 15) { // detection
  lcd.setCursor(2, 1); // set cursor on second row
  lcd.print("Bulb: "); // show the value on display
  lcd.setCursor(9, 1); // set cursor on second row
  lcd.print("ON"); // show the value on display
} else {
  lcd.setCursor(2, 1); // set cursor on second row
  lcd.print("Bulb: "); // show the value on display
  lcd.setCursor(9, 1); // set cursor on second row
  lcd.print("OFF"); // show the value on display
}
delay(2000); // take brake for 2 seconds
// Check soil moisture level and control the motor
```

```
if (soilMoisturePercentage1 && soilMoisturePercentage2 < 60) { // detection
  digitalWrite(motorRelayPin1 && motorRelayPin2, HIGH);  // Turn on the motor
} else {
  digitalWrite(motorRelayPin1 && motorRelayPin2, LOW);  // Turn off the motor
}
int rainsensorValue = analogRead(A1); // define the Arduino pin no A1
Serial.println(rainsensorValue); //print out to lcd
if (rainsensorValue < 700) { //detection
  analogWrite(LED_PIN, 50); // turn on the light
} else {
  analogWrite(LED_PIN, 0); // turn off the light
}
sensors.requestTemperatures();
temp = sensors.getTempCByIndex(0);
Serial.print("Temperature is: "); // print out to serial monitor
Serial.println(temp); // print out to serial monitor
if (digitalRead(pirPin) == HIGH) { // detected
  digitalWrite(buzzerPin, HIGH);  //the buzzer visualizes the sensors output pin state
  if (lockLow) {
    //makes sure we wait for a transition to LOW before any further output is made:
    lockLow = false;
    Serial.println("---"); // print out to lcd
    Serial.print("motion detected at "); // print out to lcd
    Serial.print(millis() / 1000); // print out to lcd
    Serial.println(" sec"); // print out to lcd
    delay(50); // take break for .05 seconds
  }
  takeLowTime = true;
}
if (digitalRead(pirPin) == LOW) { // detection
```

```
    digitalWrite(buzzerPin, LOW);  //the buzzer visualizes the sensors output pin stat
    if (takeLowTime) {
      lowIn = millis();     //save the time of the transition from high to LOW
      takeLowTime = false;  //make sure this is only done at the start of a LOW phase
    }
    //if the sensor is low for more than the given pause,
    //we assume that no more motion is going to happen
    if (!lockLow && millis() - lowIn > pause) {
      //makes sure this block of code is only executed again after
      //a new motion sequence has been detected
      lockLow = true;
      Serial.print("motion ended at ");  // print out to lcd
      Serial.print((millis() - pause) / 1000); // print out to lcd
      Serial.println(" sec"); // print out to lcd
      delay(50); // take break for .05 seconds
    }
  }
  // Send data to NodeMCU via serial communication
  Serial.print("Data: "); // print out to serial monitor
  Serial.print(humidity); // print out to serial monitor
  Serial.print(", "); // print out to serial monitor
  Serial.print(temperature); // print out to serial monitor
  Serial.print(", "); // print out to serial monitor
  Serial.print(soilMoisturePercentage1); // print out to serial monitor
  Serial.print(", "); // print out to serial monitor
  Serial.print(soilMoisturePercentage2); // print out to serial monitor
  Serial.print(", "); // print out to serial monitor
  Serial.println(rainsensorValue); // print out to lcd
}
```

// ESP32 Code

```
#include <WiFi.h>
//#include <ESP8266WiFi.h>  //Uncomment this if ESP12f is used
#include <ThingSpeak.h> // library for thingspeak
const char* ssid = "Connected, No Internet"; // name for internet connection
const char* pass = "01876207989"; // password
const char* thingSpeakApiKey = "FWNNIEVGK0TDZD6K"; //API key of
thingspeak
const char* thingSpeakChannelID = "2100607"; // thingspeak channel id
const long updateInterval = 5000;  // Update interval in milliseconds (15 minutes)
WiFiClient client;
void setup() {
  Serial.begin(115200); // print out to serial monitor
  WiFi.begin(ssid, pass);
  while (WiFi.status() != WL_CONNECTED) { // detection
    delay(1000); // take break for q second
    Serial.println("Connecting to WiFi..."); // print out to lcd
  }
  Serial.println("Connected to WiFi"); // print out to lcd
  ThingSpeak.begin(client);
}
void loop() {
  // Read data from Arduino Uno via serial communication
  if (Serial.available()) { // detected
    String data = Serial.readStringUntil('\n');
    if (data.startsWith("Data:")) { // detected
      data.remove(0, 5);  // Remove the "Data," prefix
      float humidity = data.substring(0, data.indexOf(',')).toFloat();
      data.remove(0, data.indexOf(',') + 1);
      float temperature = data.substring(0, data.indexOf(',')).toFloat();
      data.remove(0, data.indexOf(',') + 1);
```

```
      int soilMoisturePercentage1 = data.substring(0, data.indexOf(',')).toInt();
      data.remove(0, data.indexOf(',') + 1);
      int soilMoisturePercentage2 = data.substring(0, data.indexOf(',')).toInt();
      data.remove(0, data.indexOf(',') + 1);
      int rainsensorValue = data.toInt();
      // Update ThingSpeak fields
      ThingSpeak.setField(1, humidity); // field of thingspeak
      ThingSpeak.setField(2, temperature); // field of thingspeak
      ThingSpeak.setField(3, soilMoisturePercentage1); // field of thingspeak
      ThingSpeak.setField(4, soilMoisturePercentage2); // field of thingspeak
      ThingSpeak.setField(5, rainsensorValue); // field of thingspeak
      // Write to ThingSpeak
      int status = ThingSpeak.writeFields(2100607, thingSpeakApiKey);
      if (status == 200) { // detected
        Serial.println("Data sent to ThingSpeak successfully"); // print out to lcd
      } else {
        Serial.println("Failed to send data to ThingSpeak"); // print out to lcd
      }
      delay(updateInterval);
    }
  }
}
```

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