**BACHELOR OF SCIENCE IN ELECTRONIC AND TELECOMMUNICATION ENGINEERING**

# IoT based Smart Water Management, Water temperature, PH and Soil Moisture Monitoring System for Indoor Farming


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July 2023

# Certificate of Approval

The thesis entitled as "IoT based smart Water management, Water PH and Soil moisture monitoring and controlling system for indoor agriculture." submitted by Gazi Md Rayhan Sadique, bearing ID No. T183016 respectively, to the Department of Electronic and Telecommunication Engineering (ETE) of International Islamic University Chittagong (IIUC) has been accepted as satisfactory for the partial fulfillment of the requirements for the Degree of Bachelor in Electronic and Telecommunication Engineering and approved as to its style and contents for the examination held on July 2023.


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# Declaration Of Candidate

All of the material displayed here is original and has not been simultaneously submitted as a candidate for any degree. What we have discovered about the thesis is entirely dependent on what we have learned about ourselves in the process of investigating it. Lecturer of electronic and telecommunication engineering at International Islamic University, Chittagong, supervised this project, and his name is Ahmad.

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# Acknowledgement

In the name of Allah, the Most Gracious, the Most Merciful. All praise and thanks are due to Allah, the Lord of all worlds. We begin this acknowledgement by acknowledging the infinite blessings and guidance bestowed upon us by Almighty Allah throughout this project thesis. We extend our heartfelt gratitude and appreciation to all those who have contributed to the successful completion of this project thesis on IoT-based smart water management, water pH, and soil moisture monitoring and controlling system for indoor agriculture. First and foremost, we express our sincere gratitude to our esteemed supervisor Ahmed, Lecturer Dept. of Electronic and Telecommunication Engineering, IIUC for their unwavering support, invaluable guidance, and profound insights. Their expertise, patience, and encouragement have played a vital role in shaping the direction of this project and ensuring its successful execution. We are sincerely grateful for their mentorship and scholarly advice.

# Abstract

The IoT-based smart water management system for indoor agriculture presented in this project thesis aims to address the challenges of water management, water pH monitoring, and soil moisture control in indoor agricultural settings. The project focuses on developing a cost-effective and efficient system that utilizes IoT technologies to enable real-time monitoring and control of water parameters crucial for optimal plant growth. The project begins with an extensive review of existing literature on smart water management, indoor agriculture, and IoT. This research provides the foundation for identifying suitable sensors, controllers, and communication protocols to be integrated into the system. By leveraging IoT capabilities, the proposed system offers accurate and timely data on water pH and soil moisture levels, eliminating the need for manual data collection and analysis. The system's design includes the integration of sensors, microcontrollers, and communication modules, all orchestrated by a cloud-based data management platform. A user-friendly interface is also developed to enable farmers to access real-time data and remotely control the system. The prototype undergoes rigorous testing and evaluation in a real-world indoor agriculture setting to assess its functionality, reliability, and accuracy. The outcomes of this project are expected to have several positive social and environmental impacts. The smart water management system can lead to improved access to healthy and fresh produce, reduced water wastage, increased food security, and improved livelihoods for farmers. Additionally, the system promotes sustainable farming practices by optimizing resource usage, reducing chemical usage, and improving soil health. The findings and insights gained from this project contribute to the growing field of IoT-based smart water management in indoor agriculture. By disseminating the project results through academic publications, workshops, and conferences, we aim to encourage the adoption of sustainable water management practices in indoor agriculture communities. In conclusion, the IoT-based smart water management system presented in this project thesis offers a promising solution to enhance water management practices in indoor agriculture. With its potential to improve crop yield, conserve water resources, and promote sustainable farming, this system can contribute to the development of a more efficient and environmentally friendly indoor agriculture industry.

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# Abbreviations

| | |
|---|---|
| SCL | Semiconductor Laboratory |
| SDA | Serial Data |
| I2C | Inter Integrated Circuit |
| DHT | Digital Temperature and Humidity |
| DC | Direct Current |
| AC | Alternating Current |
| VCC | Voltage Common Collector |
| GND | Ground |
| IC | Integrated Circuit |
| TX | Transmitter |
| RX | Receiver |
| SMPS | Switch Mode Power Supply |
| LCD | Liquid Crystal Display |

# CHAPTER 1
# INTRODUCTION

## 1.1 INTRODUCTION

In recent years, the agricultural industry has witnessed a significant transformation driven by advancements in technology. With the ever-growing global population and the need for sustainable food production, it has become imperative to explore innovative solutions that optimize resource utilization and increase crop yields. In this context, the integration of Internet of Things (IoT) technologies into agricultural practices has emerged as a promising avenue for achieving efficient and smart water management in indoor farming environments.

Indoor agriculture, also known as controlled environment agriculture, refers to the practice of cultivating crops within enclosed structures such as greenhouses, vertical farms, or hydroponic systems. This approach offers several advantages over traditional open-field farming, including enhanced control over environmental factors such as temperature, humidity, and lighting, as well as protection against external pests and diseases. However, effective water management remains a critical challenge in indoor agriculture, as water scarcity and the need for optimal irrigation practices continue to pose significant constraints.

This thesis describes the results of an extensive investigation and development of a smart water management system that is based on the internet of things and is built particularly for use in indoor agriculture. The levels of water pH and soil moisture, two key parameters that influence plant development and production, are the primary focuses of the system, which is designed to monitor and adjust both of these variables. This system intends to offer real-time monitoring, data analysis, and intelligent decision-making skills by utilizing the power of the internet of things. Ultimately, this will lead to better crop-growing practices and increased resource efficiency.

By leveraging the power of IoT, this system aims to provide real-time monitoring, data analysis, and intelligent decision-making capabilities, ultimately leading to enhanced crop cultivation techniques and improved resource efficiency. The utilization of an IoT framework enables seamless connectivity and communication among various components within the agricultural ecosystem. This allows for the integration of sensors, actuators, and control algorithms to create an intelligent and automated water management system.

The Arduino microcontroller, which serves as the system's central command and control unit for data acquisition, processing, and the coordination of devices, is an essential component of the Internet of Things-based smart water management system. We decided to go with the Arduino Nano 328p because of its small size, the fact that it can be used for a variety of projects, and its reasonable price. It comes with a generous supply of processing power, storage space, and input/output (I/O) pins, making it possible to connect a wide variety of sensors and actuators.

The utilization of an IoT framework enables seamless connectivity and communication among various components within the agricultural ecosystem. Central to this framework is the Arduino microcontroller, acting as the core control unit for data acquisition, processing, and device coordination. By integrating a wide array of sensors, such as analog pH sensors, soil moisture sensors, and DHT11 temperature and humidity sensors, the system can gather vital environmental data required for accurate analysis and decision-making.

To monitor water pH levels, an analog pH sensor/meter kit is utilized. This sensor measures the acidity or alkalinity of the water and provides real-time pH readings. The soil moisture level is monitored using appropriate soil moisture sensors that measure the amount of water present in the soil. These sensors provide essential data for determining the irrigation needs of the plants and ensuring optimal water usage.

The collected data from the pH sensor and soil moisture sensors are processed by the Arduino Nano and can be displayed on a Liquid Crystal Display (LCD) for convenient monitoring. Additionally, the data can be transmitted to an IoT platform, enabling remote access and control. The NodeMCU, integrated with Wi-Fi capabilities, facilitates the wireless transmission of data and allows users to monitor and control the system using smartphones or other internet-connected devices.

To realize the envisioned smart water management system, key components including relay switches, Arduino Nano, LM2596 buck converter, Inter Integrated Circuit (I2C) communication protocol, and NodeMCU with Wi-Fi capabilities have been carefully selected and integrated. The relay switches enable automated control of water pumps, valves, and other devices based on the measured parameters, while the Arduino Nano facilitates the processing of data and execution of control algorithms. The LM2596 buck converter ensures a stable power supply, while the I2C protocol enables efficient and reliable communication between the various system components. The NodeMCU, equipped with Wi-Fi connectivity, empowers remote monitoring and control of the system, thereby offering convenience and accessibility to the end-users.

Second, the system promotes the efficient use of resources by reducing the amount of water that is wasted. The system is able to precisely regulate the amount of water that is delivered to the plants because it continuously monitors the moisture levels in the soil. This helps the system avoid over-irrigation and conserves water resources. This not only lowers the amount of water that is used, but it also decreases the likelihood that the soil will become waterlogged and the plant diseases that are associated with that condition.

The successful implementation of this IoT-based smart water management system holds significant implications for indoor agriculture. By continuously monitoring and regulating water pH levels and soil moisture, farmers can fine-tune irrigation schedules, nutrient delivery, and other cultivation practices to optimize plant growth, minimize water waste, and reduce environmental impact. Moreover, the integration of data analytics and intelligent algorithms facilitates proactive decision-making, enabling early detection of anomalies, predictive maintenance, and adaptive control strategies.

This thesis book will explore the potential of IoT for agriculture. It will discuss the benefits of using IoT in agriculture, the challenges that need to be addressed, and the future of IoT in agriculture.

The book will be divided into three parts. The first part will provide an overview of IoT technologies and their potential applications in agriculture. The second part will discuss the challenges that need to be addressed before IoT can be widely adopted in agriculture. The third part will discuss the future of IoT in agriculture.

The book will conclude with a discussion of the implications of IoT for agriculture. It will argue that IoT has the potential to revolutionize agriculture and make it more sustainable.

I hope this introduction has given you a good overview of what the thesis book will cover. I am confident that this book will be a valuable resource for anyone interested in the use of IoT in agriculture.

**Benefits of Using IoT in Agriculture**

There are many benefits to using IoT in agriculture. Some of the most notable benefits include:

**Increased crop yields:** IoT can help farmers to improve crop yields by providing them with real-time data on the status of their crops. This data can be used to optimize irrigation, fertilization, and pest control.

**Reduced water usage:** IoT can help farmers to reduce water usage by only irrigating when necessary. This can be done by using sensors to monitor soil moisture levels.

**Improved sustainability:** IoT can help farmers to improve the sustainability of their operations by reducing their reliance on pesticides and herbicides. This can be done by using sensors to monitor pests and diseases.

**Increased efficiency:** IoT can help farmers to increase their efficiency by automating tasks such as irrigation and fertilization. This can free up farmers' time to focus on other tasks, such as marketing and sales.

**Challenges of Using IoT in Agriculture**

While there are many benefits to using IoT in agriculture, there are also a number of challenges that need to be addressed. Some of the most notable challenges include:

**Cost:** IoT technologies can be expensive to implement. This is a major barrier for small farmers.

**Security:** IoT systems are vulnerable to cyberattacks. This could lead to the theft of sensitive data, such as crop yields and financial information.

Lack of expertise: Many farmers lack the expertise to use IoT technologies. This is a major barrier to adoption.

**Future of IoT in Agriculture**

The future of IoT in agriculture is bright. The benefits of using IoT are numerous, and the challenges are being addressed. As IoT technologies become more affordable and easier to use, we can expect to see widespread adoption in agriculture. This will lead to improved crop yields, reduced water usage, and increased sustainability.

Indoor agriculture is a growing trend, as it offers a number of advantages over traditional outdoor farming. Indoor farms can be located anywhere, regardless of climate, and they can be operated year-round. This makes them ideal for urban areas, where space is limited and the climate is not ideal for growing crops.

However, indoor agriculture also has a number of challenges. One of the biggest challenges is water management. Indoor farms use a lot of water, and it is important to use water efficiently. Another challenge is water quality. Indoor farms need to use water that is free of contaminants, such as pesticides and herbicides.

An IoT based smart water management, water pH and soil moisture monitoring and controlling system can help to address the challenges of indoor agriculture. This system can use sensors to monitor the water quality and soil moisture levels in the indoor farm. The system can then use this information to control the irrigation system and ensure that the plants are getting the water they need.

The system can also be used to monitor the pH of the water. The pH of the water is important for plant growth. If the pH is too high or too low, it can damage the plants. The system can use this information to adjust the pH of the water to ensure that it is optimal for plant growth. The system can also be used to control the temperature and humidity in the indoor farm. The temperature and humidity are important for plant growth. If the temperature or humidity is too high or too low, it can damage the plants. The system can use this information to adjust the temperature and humidity in the indoor farm to ensure that it is optimal for plant growth.

In conclusion, this thesis project presents a pioneering approach to revolutionize water management in indoor agriculture through the adoption of IoT technologies. By leveraging the power of connectivity, real-time monitoring, and intelligent control, the proposed system has the potential to significantly enhance resource efficiency, crop productivity, and sustainability in modern farming practices. The subsequent chapters delve into the design, implementation, and evaluation of the system, providing a comprehensive understanding of the underlying technologies and their practical implications.

Through this research endeavor, we strive to contribute to the growing body of knowledge in IoT-based agricultural systems and empower farmers with the tools and insights necessary to navigate the challenges of a rapidly changing world.

## 1.2 MOTIVATION

The motivation behind this thesis project stems from the pressing need to address the challenges faced by the agricultural industry in the context of indoor farming. As the global population continues to grow at an unprecedented rate, conventional farming practices struggle to meet the increasing demand for food while minimizing resource consumption and environmental impact. Indoor agriculture, with its controlled environment and year-round production potential, presents a viable solution to these challenges. However, ensuring optimal crop growth and resource efficiency in indoor farming settings requires sophisticated monitoring and management systems.

Water, being a fundamental resource in agriculture, plays a pivotal role in plant health and productivity. Traditional irrigation methods often lead to inefficient water usage, resulting in water wastage, nutrient runoff, and suboptimal growth conditions. Moreover, maintaining the appropriate pH level of the water and monitoring soil moisture are critical factors in ensuring nutrient availability and preventing crop stress or disease.

The emergence of IoT technologies offers a unique opportunity to revolutionize the way water is managed in indoor agricultural systems. By integrating sensors, data analytics, and intelligent control algorithms, IoT-based systems can enable real-time monitoring, precise control, and informed decision-making, leading to improved resource management, enhanced crop yields, and environmental sustainability.

The motivation behind this thesis is to develop an IoT-based smart water management system that addresses the specific needs of indoor agriculture. By accurately monitoring and controlling water pH levels and soil moisture, this system aims to optimize resource utilization, reduce water waste, and create an environment conducive to healthy plant growth. Through the application of advanced technologies and the implementation of intelligent algorithms, this research project seeks to contribute to the advancement of sustainable farming practices and offer a valuable tool for farmers in the era of smart agriculture.

Furthermore, this thesis project seeks to bridge the gap between theory and practice by demonstrating the feasibility and practicality of implementing IoT-based smart water management systems in real-world indoor farming scenarios. By providing evidence of the system's efficacy and highlighting its potential benefits, this research aims to inspire further adoption of IoT technologies in agriculture and encourage the development of innovative solutions that address the evolving needs of the industry.

Ultimately, the motivation behind this thesis is rooted in the desire to contribute to the transformation of agriculture into a more sustainable, efficient, and technologically advanced sector. By harnessing the power of IoT, this research endeavor aims to pave the way for a future where smart water management systems play a vital role in ensuring food security, minimizing resource depletion, and fostering a greener and more resilient agricultural ecosystem.

## 1.3 OBJECTIVES

The objectives of the project are given below:

1. Design and Development of an IoT-Based Smart Water Management System
2. Real-Time Monitoring of Water pH Levels
3. Continuous Soil Moisture Monitoring.
4. Integration of Data Analytics and Decision-Making Algorithms
5. Remote Monitoring and Control via Internet Connectivity

By achieving these objectives, this thesis project aims to demonstrate the feasibility and potential benefits of implementing an IoT-based smart water management system for indoor agriculture. It strives to provide a solid foundation for the practical application of such systems, empowering farmers with tools and insights to enhance water management, optimize crop growth, and promote sustainable farming practices in the face of increasing global challenges.

## 1.4 REPORT OUTLINE

Six chapters have been covered in the design and construction of this project. The chapters and their material are as follows:

- **Chapter 1** (Introduction) This chapter provides the outline, motivation and purpose of the project.
- **Chapter 2** (Literature Review) This chapter explored previous work or study related to this project.
- **Chapter 3** (Components) The components of this project have been addressed in detail in this chapter.
- **Chapter 4** (System Design) This section covers experimental setup of this project.
- **Chapter 5** (Implementation and Result) Discuss the execution of the project and the performance of the project.
- **Chapter 6** (Conclusion) The overview of this project is explored in more depthin this Chapter. The advantages of the project, the benefit and the possible future work of the project are addressed.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 INTRODUCTION

The literature review section of this thesis provides a comprehensive analysis of existing research and studies relevant to IoT-based smart water management systems, water pH monitoring, soil moisture monitoring, and indoor agriculture. The review examines the concept of IoT in agriculture, exploring previous studies that have utilized IoT technologies for resource management and enhanced crop yields. It delves into the domain of smart water management, discussing methodologies, sensor technologies, and control strategies employed to optimize water usage. The review also focuses on the importance of monitoring water pH levels and examines various sensing techniques used in agricultural settings. Furthermore, it explores soil moisture monitoring in indoor agriculture and the integration of IoT and sensors in these systems. The literature review highlights the challenges and opportunities in indoor agriculture, emphasizing the role of IoT-based systems in improving efficiency and sustainability. It identifies gaps in the existing literature and establishes the rationale for this thesis, contributing to the advancement of IoT-based smart water management for indoor agriculture.

## 2.2 REVIEW OF PREVIOUS WORK

In this section, we review previous work related to IoT-based smart water management systems, water pH monitoring, soil moisture monitoring, and indoor agriculture. The purpose of this review is to understand the existing research landscape, identify the advancements made in the field, and identify any gaps or limitations that the current thesis aims to address.

[1] R. S. Raja Aris, “Front-end development of nutrient film technique for hydroponic plant with IOT Monitoring System,” *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 9, no. 1.3, pp. 9–14, 2020. doi:10.30534/ijatcse/2020/0291.32020.

Soil salinity is a significant environmental stressor that adversely affects cultivated land, crop productivity, and quality. To overcome this issue, alternative methods such as hydroponics, specifically the Nutrient Film Technique (NFT), have been adopted for plant cultivation in a solution-based environment. This paper focuses on the front-end development of a hydroponic system that enables users to monitor and control two crucial parameters in plant growth: electrical conductivity (EC) and pH. Leveraging Internet of Things (IoT) technology, this project aims to provide an automated control system for optimizing leafy greens' growth. The EC and pH parameters are monitored and displayed on a Liquid Crystal Display (LCD) screen, while an ESP32 microcontroller board ensures the maintenance of optimal nutrient conditions. Through the Blynk application, users can remotely control and monitor the EC and pH values using their smartphones, facilitating real-time adjustments. This system offers the advantage of effortless monitoring and control, eliminating the need for physical presence in the farming area. With its built-in automatic control and monitoring features, the developed system effectively provides plants with sufficient nutrients for healthy growth.

[2] Chowdhury, M.E.H. *et al.* (2020) *Design, construction and testing of IOT based automated indoor vertical hydroponics farming test-bed in Qatar, MDPI*. Available at: https://www.mdpi.com/1424-8220/20/19/5637 (Accessed: 23 May 2023).

The Gulf region poses challenges for plant growth due to its predominantly desert environment and dry climate. While a few plant species can thrive in such conditions, they are not suitable as a food source. Therefore, the objective of this project is to design and construct an indoor automatic vertical hydroponic system that operates independently of the external climate. This system enables the cultivation of common crops suitable for consumption within homes, eliminating the need for large outdoor spaces.The system design was based on a comprehensive study of various vertical hydroponic systems, considering factors such as cost, power consumption, and suitability for indoor automation. A microcontroller serves as the central control unit, communicating with different sensors to regulate system parameters and minimize human intervention. An open Internet of Things (IoT) platform was employed to store and display system parameters, providing a graphical interface for remote access.The designed system effectively maintains optimal growing conditions for plants with minimal user input. The functionality of the system was confirmed through the evaluation of individual components and monitoring their performance on the IoT platform. During peak summer, the system consumed 120.59 kWh without air conditioning control and 230.59 kWh with air conditioning control, equivalent to running costs of 13.26 Qatari Riyal (QAR) and 25.36 QAR, respectively.Despite circulating around 104,000 gallons of nutrient solution monthly, the system consumed only 8-10 liters of water. It offers real-time notifications to alert users of unfavorable conditions, enabling remote monitoring of multiple parameters without the need for laboratory instruments. Additionally, the system provides valuable information that can aid plant researchers in understanding the correlation between key hydroponic parameters and plant growth.The proposed platform holds significant potential for people in the Gulf region to produce food according to their requirements. It not only offers opportunities for quantitative optimization of indoor farming setups but also automates labor-intensive maintenance tasks. Furthermore, the monitoring system can facilitate high-level decision making once sufficient data is collected. This work opens up possibilities for sustainable food production in the Gulf region, addressing the unique challenges of the local environment.

[3] Changhui Deng, Yanping Gao, Jun Gu, Xinying Miao, "Research on the Growth Model of Aquaculture Organisms Based on Neural Network Expert System," Sixth International Conference on Natural Computation (ICNC 2010) pg.no 1812-1815.

There is full use of Bio-floc Technology and the system parameters, but pH and temperature are crucial. To handle, analyze, and store data from our Wi-Fi module, we use a Thingspeak website server. Using these resources and doing in-depth research into water quality parameters distinguishes us from the competition, As the world's population is expected to grow by another 2 billion people to 9.6 billion people by 2050, feeding the earth and maintaining its natural resources for the next generation will be a monumental task for humanity. Aquaculture is vital to end hunger, improve health, reduce poverty, and open up new economic opportunities. Since the effluents generated by aquaculture include excessivevolumes of organic environment matter, nitrogenous compounds, toxic metabolites and elevated chemical and biochemical oxygen demand rates, it has been labelled as a non-renewable resource. Aquaculture. Bio-floc, a method of aquaculture based on in situ microorganism growth, is an environmentally favorable option. A lot of space is devoted to raising fish and shrimp (minimum 300 g of biomass per square meter). To encourage the creation of macroaggregates (bio-floc), water flow must be continuous throughout the water column (see above).

[4] Sheetal Israni, Harshal Meharkure, Parag Yelore, "Application of IoT based System for Advance Agriculture in India, "International Journal of Innovative research in Computer and Communication Engineering Vol. 3, Issue. 11th November 2015.

It is possible to use Biofloc technology to enhance water quality, remove waste, and prevent disease (BT). Aquatic animals, heterotrophic bacteria, and other water-dwelling microorganisms may all cohabit peacefully thanks to biofloc. Humans and aquacultured aquatic animals benefit from eating bio floc when used as a supplement to their diet. So, to be clear, this shows that environmentally friendly aquaculture may employ BT as a great substitute. Due to an imbalance of numerous essential parameters, primarily pH and Temperature, Bio-Floc Technology has been unable to develop and sustain heterotrophic microbial communities. Bio-floc Technology's performance has been harmed by high pH, as documented in several research and reports. A significant difference between the conventional fish culture systems and the BFT systems is the use of constants such as alkalinity, pH, CO2, and temperature in the traditional fish culture methods. Low pH, high alkalinity and CO2 levels are necessary for the Bioflock approach. High stocking densities are critical in the Bio-flock method. Bio-floc has a 100% death rate and a 0% survival rate when exposed to acidic conditions like pH 3. pH 4 had a 36.7 per cent mortality rating in Bio-flock, whereas survival was 63.3 per cent at pH 4. When the pH was 5-9, Bio-morality flock's was 0%, but its survival was 100%. In a pH range of 9.5 to 10.5, there was a 3% Morality rate and a 97% survival rate. It's impossible to survive when the pH is more than 9.5 since the Morality rate goes to 100%.

[5] Nikesh Gondchawar , Prof. Dr. R. S. Kawitkar, “IoT based smart Agriculture, ” International Journal of advanced research in Computer and Communication Engineering, Vol.5”, Issue. 6th June 2016.

Fish do what they need to do to be healthy while submerged in water. Because fish rely on water for everything from breathing to eating to excreting waste to reproduction, knowing water's physical and chemical qualities are critical to Bio-Floc Technology success. Quality of water is a significant factor in the success or failure of an aquaculture operation. For aquatic species, pH values exceeding 9.5 or lower than 4.5 are unsuitable while employing Bio-Floc Technology, especially in the lab. A pH of less than five is lethal for young fish and aquatic insects because of their vulnerability to acidic environments. A fish's cells can be damaged if the pH is too high (9-14). This causes denaturation of the membranes. Aquatic life may beadversely affected by further changes in water chemistry.

[6] S.Kayalvizhi, Koushik Reddy G, Vivek Kumar P, VenkataPrasanth N, “Cyber Aqua Culture Monitoring System Using ArdunioAnd Raspberry Pi,” International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 4, Issue 5,Pg:2320-3765; May 2015.

It was shown that in Bio-Floc operations, temperatures of 28–30° are optimal for BioFloc; low temperatures of 20° C may impact microbiological development, harming the environment in Bio-Floc tanks. In freezing temperatures (4oC), favourable conditions (15-18oC), and higher temperatures, the de-flocculation of the flocculants is determined by temperature (30-35oC). The de-flocculation, on the other hand, is greater due to the massive volume of sludge formed. The surroundings normally regulate the temperature in open systems. However, this may be prevented with sufficient cost. The temperature must be kept constant in a closed system, though. We created a real-time IoT monitoring system for Bio-floc fish farming to maintain tabs on these two critical indications and know when to intervene. A labour-saving automated feeding system has been created for Bio-fish floc's farming operations. To help the environment, Biofloc tanks utilize automated water filtration technology.

[7] Daudi S. Simbeye and Shi Feng Yang, “Water Quality Monitoring and Control for Aquaculture Based on Wireless Sensor Networks,” JOURNAL OF NETWORKS, VOL. 9, NO. 4, APRIL 2014.

Zolkapli designed a PIC microcontroller application for an automated fish feeder system. Using mechanical and electrical technologies to regulate fish feeding behaviour, the gadget was created. A pellet store, a former stand, a DC motor, and a microcontroller are all included in this apparatus. Anuradha has developed an "IoTbased low-cost system for real-time monitoring of water quality." system. Turbidity, dissolved solvents, pH, and temperature may all be measured with this method. There are hardware and software components to the Smart Farm Monitoring System. Arduino's development environment for microcontrollers and other peripherals is called the Arduino IDE. The Arduino IDE shows sensor readings that have been plugged in with the help of the accompanying hardware. PIR, temperature, humidity, and soil moisture sensors are some of the more specialized types. Arduino UNO's ATmega328 microprocessor receives data from the sensors and sends it to the Arduino UNO. The gathered data may be seen on an Arduino display.

As the aquaculture industry grows, so does the popularity of Biofloc technology (BFT), a type of indoor fish farm. As an example, consider Biofloc Technology. In a big tank, aquatic creatures are being raised for food water quality by cleansing. They think it's a good idea to reuse water Water is scarce in this part of the tree. The fish have been developing in the tank for some time now without any water that stretches for miles and miles. As well as fish farming's most important characteristics. The arc is rapidly tightening. Traditionally, water samples are taken by arcing a stick under a microscope gathered and evaluated, and the results take time to get in. It's difficult to frequent monitoring of water quality indicators and water replacement based on impurity.

[8] Mr. Kiran Patil,Mr. Sachin Patil,Mr. Sachin Patil and Mr. Vikas Patil,“Monitoring of Turbidity,pH & Temperature of Water Based on GSM,”International Journal for Research in Emerging Science and Technology,Volume-2,Issue-3,March-2015.

Current trends in aquaculture point to IoT playing a significant role. Because of this, many variables can be monitored and adjusted as necessary. IoT-based fish-fanning devices are an excellent solution to the current problem. For the most part, modern agriculture and traditional farming were economically distinct. If anything, the Internet of Things (IoT) streamlines the use of various sensors and control devices on mobile platforms to automate communication. This research focuses on embedded system development. As long as you have a control system in place, you can monitor the fish production process in real-time. Real-time tracking is possible with the cloud because of the database-based system and web-based or mobile app control available at any time and anywhere. This helps to solve the problem of fish tlics without the fanner's bias. Everything will be fine from now on. We came up with a successful conclusion to the study.

[9] Bhatnagar, et al, "Water quality guidelines for the management of pond fish culture." International Journal of Environmental Sciences 3, no. 6 (2013).

Several years ago, scientists devised a proposal for a system to monitor and regulate aquaculture water quality. However, they only included a few sensors, such as pH temperature and water level, rather than a water-controlling actuator. They could have included more. African agricultural fish fanners now have low-cost IoT solutions because Zougmorc et al. use the Internet of Things (IoT). Water parameters cannot be controlled because there is no controller for them. Toiletries and the like, for example. It uses Zigbee technology and a temperature sensor to integrate the pH sensor and dissolved oxygen sensor. Management of water parameters is not, on the other hand. Using a variety of sensors and data visualization tools available on the web and in a mobile app, Raju developed a system that he demonstrated. On the other hand, they're devoid of actuators (3). Dzulqornain and colleagues have developed a dissolved oxygen-based oxygen monitoring device (Dzulqornain and colleagues, 2004). An aeration pump powered the pH and temperature sensors, and the findings were presented on a smartphone app and website via an ac adapter. The Arduino Mcga2560 board serves as the basis for their project. A DS1302 LED serves as the isochronous module for the Wivity RTC, and electronic devices like buzzers and LCDs are instances of this. A method was developed to continuously check the ponds' water quality to keep the water parameters for fish farming in good shape. The system constantly monitors these two variables. The heater is the only thing in this scenario that can be controlled. Unfortunately, they relied on a sloppy analysis instead of examining all important elements like pH, TDS, and an easy management system for these water factors. ESP 32 DcvKit, AWS cloud, and sensor network-based real-time monitoring system for fish pond management have been created by Teja and colleagues.

[10] Raju, K. Raghu Sita Rama, and G. Harish Kumar Varma. "Knowledge Based Real Time Monitoring System for Aquaculture Using IoT." In Advance Computing Conference (IACC), 2017 IEEE 7th International, pp. 318-321. IEEE, 2017.

This system's brain is a pH sensor. The DHT 11 protocol is used in an ultrasonic sensor that monitors sound pressure levels. Sensors could be monitored with this approach. Despite this, it was constrained by the TLIC. No water parameter control is utilized here via a tlic actuator. Fisheries use various water quality parameters, including the following: To get the most out of their efforts, people must keep these principles in mind and adhere to them. When it comes to fish farming, the water's temperature is a key factor. The survival rate of fish larvae differs depending on the temperature environment in which they are found. As a result, fish suffer greatly when there are abrupt changes in the temperature. Water temperature affects zooplankton in addition to algae growth. Temperature affects PH, salinity, and other water quality indicators directly and indirectly by influencing Oxygen levels.Since warm water has less dissolved oxygen, more carbon dioxide is generated due to the increase in temperature. Maintaining the water temperature between 24 and 30 degrees Celsius is ideal for keeping belter fish healthy. The die temperature influences every mechanism in this research. Temperature and pH (Potential of Hydrogen) affect fish behaviour; therefore, keep this in mind when working with fish. The water in the tank may be acidic (pH 7.0) or alkaline (pH > 7.0). This is possible. pH rates drop by 10 J, causing the ammonia ions ($NH_3$) to interact chemically with the water to produce ammonium and hydroxyl ions and carbon dioxide ($CO_2$). A rise in pH levels causes the formation of harmful ammonia ions ($NH_3$), which are toxic to aquatic life. Improved productivity and fish safety are achieved when the pH of the water is between 6.8 and 8.5. Using the TDS method, scientists can determine how much water has dissolved even the tiniest particles of solids. When calculating TDS, several variables are considered, including pH, ionic strength (or cation concentration), temperature, and dissolved oxygen concentrations. As water salinity increases, so do the TDS. TDS is harmful because it raises the salt in the water, which is caused by the compound. Greater salinity slows the emergence of young in some fish species and can have long-term consequences for their development. Thus, the TDS value has been changed to TDS = £1 2500 mg/L due to this change. Boyd CE. Water quality management for pond fish culture. Elsevier Scientific Publishing. GSM module is connected to Arduino to give messaging service to warn farmers every 10 seconds on climate conditions. He worked on Internet of Things (IoT) water parameter monitoring devices and was known as Krishna S Sarath during his time at MIT. Human-caused acts and natural disasters pollute waterways at an alarming rate, and water monitoring systems are becoming more vital to humankind's well-being as a whole. The potential for automating water-related operations is immense. Water quality, smart irrigation, and a cutting-edge water distribution network will all benefit from the arrival of big data analytics. Every one of these works wonderfully when given the most up-to-date and accurate information.

[11] Delincé, Guy. The ecology of the fish pond ecosystem: with special reference to Africa. Vol. 72. Springer Science & Business Media, 2013.

Developing an automated water monitoring system is complicated by the requirement for a wide range of sensor characteristics and a robust communication architecture. These problems can be addressed with the help of the study being done now. Using industrial multi-parameter sensors like the EXO Sonde, it is possible to extract the sensor readings required from the environment. All of the data is transmitted to a server via layered architecture for further processing. In the event of a network failure, sensor data is stored in a file system on the sensor node. GSM is utilized to connect nodes and sensors, as previously stated. It is possible to observe the data on the server using an IoT-based method for monitoring entirely new water quality. Among other things, sensors can detect conductivity, turbidity, and temperature in water.

[12] S. S. Patil, "Internet-of-Things (IoT) Based Smart Agriculture", IJESC, vol. 105, 2020.

With the growing use of Internet of Things (IoT), linked gadgets have proven valuable in a variety of areas, including health and fitness, home automation, automotive, and logistics. There's little doubt that the Internet of Things (IoT), linked gadgets, and automation will have a significant impact on agriculture, as they have in other sectors. Agriculture has undergone numerous tectonic shifts in the previous few decades, becoming increasingly industrialized and reliant on technology. Farmers have taken control of the livestock and crop rearing process by using various smart agricultural technologies, making it more predictable and efficient. Web-based crop analysis enables identification of wild plants, water level, bug location and horticulture. IoT modernisation aids in the collection of information on climate, moisture, temperature and soil fruitfulness. There are two authors who contribute to this work: Muthnoori and Munaswamy (2019). Thanks to the Internet of Things, farmers can access their fields from anywhere and take action when necessary, even if they aren't present on the field themselves. Simplifies agricultural procedures by reducing labor requirements while also saving time. IoT implementation can lower crop production costs while increasing yields. As a result, a comprehensive review of IoT in agriculture was conducted. According to the findings, IoT-based agriculture will see continued research and development in the future.

[13] X. Yang, S. Zhang, J. Liu, Q. Gao, S. Dong and C. Zhou, "Deep learning for smart fish farming: applications, opportunities and challenges", Reviews in Aquaculture, vol. 13, no. 1, pp. 66-90, 2020.

Intelligent fish farming, the algorithm and the method's outcomes were used. The results revealed that deep learning was capable of automatically extracting characteristics. In the realm of agriculture, they contributed much. In aquaculture, however, the approach fell short because of the data's complexity. The Recirculating Aquaculture System (RAS) was used to raise "Ras Carpio" in an experiment conducted by S. Liu and colleagues. Compared to traditional pond aquaculture, RAS was a better option in 2011. To keep the fish happy, the water's parameters were constantly checked and, if necessary, recirculated to bring them back into balance. Two drainage systems were put in place to help with this. Water dissolved oxygen (DO), dissolved hydrogen ion (DHI), and temperature were all tracked using sensors from Watt. Compared to a traditional aquaculture setup, the method offered numerous advantages, but it also had significant drawbacks. That would necessitate extensive and expensive water exchange. Zulkarnaen put a cutting-edge Internet of Things (IoT) system based on the IFTTT design. Dissolved oxygen, water temperature, and hydrogen potential (pH) were all taken into account. Sensors monitored the water level, and an aerator system integrated with a microcontroller Node MCU v3 relay, power supply, and propeller was used to manage the system. After the sensor data has been uploaded, the client may see it from any location with an internet connection. The app was available on the web and Android devices. The system worked OK, but everything had to be done by hand. It was discovered that fish illnesses might be detected by monitoring changes in water quality, thanks to A. A. Nayan et al. To determine the quality of the water, they utilized a machine learning approach. These variables were used to quantify water quality and forecast the outcome of the boosting procedure. They included pH and DO in their calculations as well as BOD, COD, TSS, TDS, EC, and PO43-. However, the research was limited to significant water sources like rivers and offered no solutions for smaller water bodies like ponds. Progress in water quality parameters and how IoT may solve the problem are the main topics of a few studies in this literature review. Due to IoT's new ground-level use for agriculturists, a significant amount of study has been done to solve this type of issue. Many publications concentrate on a few types of sensors, such as pH, DO, Turbidity and so on, and a solution to the problems they provide. However, optimal fish production is highly dependent on a wide range of water properties, including chemical, physical, and biological ones in particular. To maintain a pond effectively, you need to understand water quality. Several variables affect water quality, such as dissolved oxygen (DO), temperature, turbidity, transparency, watercolor, pH value, carbon dioxide, alkalinity and hardness, conductivity and salinity, as well as TDS and unionized ammonia. After extensive research, we've concluded that not all characteristics are necessary to track. When one parameter is out of balance, it affects the balance of others.

[14] S. Liu et al., "Prediction of dissolved oxygen content in river crab culture based on least squares support vector regression optimized by improved particle swarm optimization", Computers and Electronics in Agriculture, vol. 95", pp. 82-91, 2013.

The temperature is the first operational parameter, while the pH is the second. The rationale for this will become clear in a moment. Temperature plays a major role in both chemical and biological processes. The speed of biological and chemical reactions both doubles for every 10 degrees Celsius increase in temperature. A chemical treatment's efficacy is greatly affected by ambient temperature. Fish can't handle extreme temperature changes very well. Even a temperature shift of 5 °C can be fatal to fish. pH, dissolved oxygen, conductivity, salinity, and other chemical characteristics are all influenced by temperature. Before continuing with the examination, make sure the temperature is within the acceptable range. The optimal operating temperature is between 21 and 33 degrees Celsius, which is easily maintained. Therefore, we prioritize temperature as a key operational factor.

[15] U. Ahmed, R. Mumtaz, H. Anwar, A. Shah, R. Irfan, and J. García Nieto, "Efficient Water Quality Prediction Using Supervised Machine Learning", Water, vol. 11, no. 11, p. 2210, 2019.

Water is essential to all kinds of life and must be preserved at all costs. But contamination from living things is a persistent danger to water supplies. Water is a powerful medium for conveying information over great distances. The high pace of growth is having a devastating effect on water quality. Lack of access to safe drinking water is a major factor in the proliferation of disease. The numbers show that in developing countries, water-borne diseases are responsible for the deaths of 5 million people and the illness of 2.5 billion. Intestinal parasites like giardiasis and parasitic infections like cryptosporidium are common in Pakistan, along with the usual suspects like diarrhea, typhoid, and gastroenteritis. Also common is typhoid. Pakistan's GDP loses between 0.6% and 1.4% per year due to water-related ailments. This is especially problematic in economically weak nations like Pakistan. Current methods for estimating water quality rely on costly and time-consuming laboratory and statistical analyses, which necessitate the collection of samples, their transport to laboratories, and a considerable amount of time and calculation, which is inefficient given that water is a highly infectious medium and time is of the essence if water is polluted with disease-inducing waste. The catastrophic effects of water contamination demand a quicker and cheaper remedy. The major purpose of this research is to design and evaluate a novel method for predicting water quality using supervised machine learning. Seventy percent of Earth is covered by water, making it an essential component of any sustainable ecosystem. Water quality has worsened alarmingly as a result of increased urbanization and industrialization, leading to a wide variety of debilitating illnesses. Since determining water quality has always involved expensive and time-consuming laboratory and statistical analysis, the idea of real-time monitoring has been largely theoretical up until recently. The disastrous repercussions of polluted water sources necessitate a quicker and cheaper alternative remedy. Because of this, this research looks into various supervised machine learning techniques for estimating both the water quality index (WQI), a single index for characterizing water quality in general, and the water quality class (WQC), a separate class formed on the basis of the WQI. The new method takes in temperature, turbidity, pH, and total dissolved solids as input variables. The error for polynomial regression is 1.9642, while the error for gradient boosting is just 0.01. The most effective approach for classifying the WQC is the (3, 7) multilayer perceptron (MLP). To test if the proposed method is suitable for application in real-time water quality detection systems, it just requires a few parameters to achieve adequate accuracy.

[16] A. A. Nayan, et al, "River Water Quality Analysis and Prediction Using GBM," 2020 2nd International Conference on Advanced Information and Communication Technology (ICAICT), Dhaka, Bangladesh, 2020, pp. 219-224.

Extraordinary environmental stages, such as soil moisture content, animal movement, temperature, and water level, are tracked by a system with far-flung sensors. An Arduino UNO board is used for GSM security. The farmer receives updates on the field via text message on his mobile device. This apparatus handles issues related to sensor node failure and power conservation. For practical agricultural monitoring, a machine built specifically for the IoT era has been proposed. The machine takes in data, processes it, and then sends, receives, and transmits it. Researchers are conducting tests to enhance the efficiency of the equipment in the area and reduce production and farming costs as they work to develop an intelligent agricultural device. Simply said, the setup allows for remote monitoring and control of environmental parameters, and it replaces expensive human labour with cheaper, more efficient Wi-Fi-based stressed generation. It is suggested that a thermal imaging system be used to monitor crop development. In this case, a method called irrigation temperature distribution size (ITDM) was used. Better irrigation can be performed in real time thanks to the captured values that make up the acquired data.

[17] A. A. Nayan, et al,"Early Detection of Fish Diseases by Analyzing Water Quality Using Machine Learning Algorithm", Walailak Journal of Science and Technology, vol. 18, Article 11740 (12 pages), 2021.

This aids farmers in avoiding economic and reputational damage to the agricultural sector caused by disease outbreaks. Aquaculture operations greatly benefit from prompt disease diagnosis and isolation. Fish mortality has been linked to biochemical changes in water chemistry, including shifts in pH, DO, BOD, COD, TSS, TDS, EC, PO43-N, and NH3-N. Fish illnesses are typically caused by viruses and bacteria. Photosynthesis, respiration, and decomposition are three more natural processes that lower water quality and so harm fish. This paper adopts a state-of-the-art machine learning algorithm to detect and predict the degradation of water quality in a timely and accurate manner, which can help in the prevention of potential fish diseases, as machine learning techniques have recently shown success in complex relational data analyses. The experimental results show that the algorithm and real datasets can accurately diagnose fish diseases that are specific to each type of water.

[18] S. Saha, R. Hasan and S. Kabir, "IoT Based Smart Farm Monitoring System", International Journal of Recent Technology and Engineering, vol. 8, no. 4, pp. 54905494, 2019.

With the global shift towards new technologies and applications, boosting agricultural productivity has become increasingly important. Multiple investigations into agriculture are currently under way. Commonly used in projects, wireless sensor networks transfer data collected by a variety of sensors located at different nodes. Researchers may be able to better understand many aspects of the environment with the help of the collected data. Only by keeping an eye on environmental issues will we be able to increase agricultural yields. The decline in productivity is more strongly affected by other factors. Therefore, agricultural automation is necessary to solve these problems. Therefore, an integrated system that takes into account all of the factors that affect productivity at every level is required to deal with all of these problems. There are a number of obstacles that prevent full automation in the agricultural sector. This means that despite being put to good use in scientific study, farmers are still going without essential support. The purpose of this article is to talk about the expansion of IoT-based intelligent agriculture and its dissemination among farmers.

[19] Krishna S1, Sarath TV2 and M S Kumaraswamy 3, Vishnu Nair “IoT based Water Parameter Monitoring System”.

The increasing contamination of water bodies due to both human activities and natural calamities highlights the growing need of water monitoring systems in modern civilization. The potential for automating water-related operations is immense. With the advent of big data analytics, numerous industries can now benefit from improved water quality, irrigation, and distribution. When fed complete and current information, these systems never fail to impress. It is challenging to create an automated application in the water monitoring space due to the large number of sensors and the need for a reliable communication infrastructure. This article proposes a method for resolving these problems. An industrial multi-parameter sensor node, such as the EXO Sonde, can be deployed into the environment to collect the required sensor readings. Through a complex nested architecture, sensitive data is processed and transmitted to a server. When the network goes down, the information gathered by a sensor node will be saved in a file system. In order for nodes and sensors to communicate with one another, GSM is employed. Information is stored on the server and presented via a web user interface (UX).

[20] Jayti Bhatt, Jignesh Patoliya, IoT based water quality monitoring system", IRFIC,21feb, 2016

Keeping the water in the fish farm tank at a constant, healthy temperature is a major challenge in the fish farming industry. An automated system based on the Internet of Things (IoT) that monitors the fish tanks in real time while making efficient use of available resources is very desirable. Money could be saved by just using optimization tactics when operating farm machinery and water pumps. Our intent is to equip the reader with a generalized set of tools necessary to create intelligent fish farms. We have developed an energy-efficient method of keeping the water level in the fish tank at the specified level by selecting the optimum pumping flow rate and tank filling level. The proposed optimization technique aims to strike a balance between pumping duration and flow rate by determining an optimal water level. The Kalman filter technique can be used to correct inaccurate sensor readings. Data from simulations show that the optimization technique greatly reduces energy consumption compared to the other strategies, which involve pumping at maximum and minimum flow rates, respectively. The proposed procedure can aid in the collection of data on farms for future study and better decision making, leading to more efficient use of resources and higher profits.

[21] Nikhil Kedia, 'Water Quality Monitoring for Rural Areas- A Sensor Cloud Based Economical Project", in 1st International Conference on Next Generation Computing Technologies (NGCT- 2015) Dehradun, India, 4-5 September 2015. 978-1-4673-68094/15/$31.00 ©2015 IEEE.

Embedded systems are built using water quality sensors like Ion Selective Probes and Optical Sensors for data processing. Then, in Section III, we'll take a look at the structure of a Wireless Sensor Network (WSN) and how it works with other components to spread data. In addition, we'll discuss the role of the government in this procedure. When all the parts are in place, we move on to Section V, where the Sensor Cloud Framework takes centre stage. In this section, we explore how it may be utilised to solve security concerns in a considerably more effective manner than before. Financial analysis is performed to see if the concept can be realized. Finally, we'll discuss the ongoing efforts we'll do to enhance the current setup. Therefore, research into the creation of online, real-time water monitoring systems is crucial. In this category, you'll find carbon sensors alongside ion electrode sensors, ion sensitive probes, and ions sensitive sensors. In ion-sensitive probes, this measurement principle is put to use. The probe needs to have a measuring electrode and a reference electrode. The peculiar membrane of the measuring electrode allows it to form reversible bonds with certain ions. Since the number of ions attracted to the measuring electrode differs from medium to medium, the potential difference between the measuring electrode and the reference electrode, which maintains a constant potential relative to the medium, also shifts.

[22] Noor, M.Z.H., Hussian, A.K., Saaid, M.F., Ali, M.S.A.M., and Zolkapli, M., July. "The design and development of automatic fish feeder system using PIC microcontroller", In Control and System Graduate Research Colloquium (ICSGRC), 2012 IEEE (pp. 343- 347). IEEE.

Automatic fish feeders are machines that disperse food pellets at regular intervals, eliminating the need for human intervention. It validated the system's daily repeatability and accuracy, which bodes well for fish farms' long-term productivity and efficiency. Two primary ideas—fixed and mobile—formed the basis of the automated fish feeder's design. Therefore, fish were not overfed because the device provided food at the appropriate times and in the amounts set by the user. Even in modern times, handfeeding is still widely used by fish farmers. The traditional manual feeding technique necessitated the employment of extra people by the fish farm owner for purposes such as cleaning the feeder, replacing the pellet, and performing repairs or maintenance. Compared to the automated fish feeding system, all of these methods were extremely time- and energy-consuming. The benefits of the automated fish feeding system increased as the farm grew larger. Users of manual feeding systems will have a harder time regulating the feeding strategy over a larger area. The research aims to optimize the current pellet dispensing technology and cut down on labor costs. Subsequently, it was proposed that this research be used to develop a PIC microcontroller-based automated fish feeder system. The newly developed device combines mechanical and electrical components to regulate feeding habits in fish. The system consists of a pellet storage bin, a DC motor, and a former stand. A DC motor located in the pellet storage room moves the pellets. Once the control system is in place, the fish can be fed whenever the user or the system decides is best. This device could be used to evenly distribute pellets around a body of water by timing the rotation of a motor attached to a sphere-forming device. Pellets were dropped into the marking section of the pond at varying rates of speed. The additional operator could adjust the motor's speed via a keypad included into the controller.

[23] Anuradha T, Bhakti, Chaitra R, pooja D. 2010. “IoT based low-cost system for monitoring of water quality in Real-Time”.

Scientists and academics are trying to combat the growing problem of water contamination by closely monitoring and maintaining water supplies. The examination of water quality is the focus of this research. This research seeks to assess the water quality in real time to keep people safe from contamination. The water needs to be tested to see if it's fit for human consumption and plant growth. There is a wide range in price and functionality across the many water.The following are examples of water quality meters: Dr.Meter TDS-3C Water Quality, Sunny Water Tester, Water Quality Meter by generic, PlayX-STORE, APEC Water Systems Digital Meter, and Started Filter Tester. Although inexpensive and simple to operate, current technologies fall short of the speed and accuracy required for quality assurance testing. Furthermore, none of these water testers measures both turbidity and pH. The pH of the solution is all that is measured by other water quality monitors. If a device meets every requirement, it will be prohibitively expensive. Since all three metrics are not commercially available currently, this research includes them all to analyse water quality cheaply. The pH, turbidity, total dissolved solids, and temperature of the water will be measured to establish its suitability for regular consumption.

[24] N. Shamsuddin, Z. Masri, Environments · January 2021, “Water Quality Monitoring with Arduino Based Sensors”.

It would be foolish to discount the importance of water to human survival. The versatility of its uses ensures that it is consistently in demand. Lakes, rivers, and oceans are the primary sources of freshwater around the globe. Traditional labs are currently relied upon for the bulk of water quality monitoring, a process that is time-consuming and error prone. This article seeks to answer the question of whether it is possible to implement a sensor system based on the Arduino platform for the purpose of monitoring water quality. The prototype, equipped with a microprocessor and sensors, was put through a battery of daily and weekly on-site tests. The system is inaccurate and requires human intervention. The technology offers a stable foundation for similar expansion projects in the future, making it more IoT friendly.

# CHAPTER 3
# HARDWARE COMPONENTS

## 3.1 INTRODUCTION

An undertaking can't be completed successfully without its components. The procedure of choosing the right components is very critical and difficult. In this part, we'll talk about the materials that will go into our project's construction. In this section, we'll try to describe the hardware, including its function, design, block diagrams, and so on.

## 3.2 LIST OF COMPONENTS

The components that are used in this project are given below.

1. Arduino Nano
2. LM2596 Module
3. NodeMCU
4. Switch Mode Power Supply
5. 16*2 Display
6. I2C Module
7. Analog pH Sensor/ Meter Kit for Arduino
8. Relay
9. DHT11
10. Wires

## 3.3 ARDUINO Nano

A microcontroller board, the Arduino Nano uses an ATMega328p-based microprocessor. It has a crystal oscillator running at 16 MHz, 12 digital I/O pins (6 of which are PWM outputs), 8 analog I/O pins, 4 UARTs (hardware serial ports), a reset button, a USB connection, a power connector, an ICSP header, and a power connector. Additionally, it has a power connector. It has more or less the same functionality of the Arduino Uno, but in a smaller form factor. The Arduino Nano is a great choice for projects that require a small, affordable, and versatile microcontroller board.

### 3.3.1 Elements of Arduino Board

Elements of Arduino Board can be done into two categories.

1. Hardware
2. Software

### 3.3.2 Hardware

The Arduino Development Board is constructed of a number of different parts, all of which are necessary for the board to carry out its intended purpose. The following are some of the fundamental elements that are necessary for its operation:

- **Microcontroller** This part of the development board serves as a minicomputer and is able to both receive and send information as well as orders to the many peripheral devices that are connected to it. It is the board's "heart." Every board utilizes a different microprocessor, each of which has its own unique set of specifications.
- **External Power Supply** the Arduino development board can operate with a stable voltage in the range of 9 to 12 volts, which is provided by this power supply.
- **USB Plug** This jack is an essential port on the circuit board that we have here. It is used to upload (burn) a program onto the microcontroller by connecting it to a computer using a USB connection. In addition to this, it has a regulated power source of 5V that may be used to power the Arduino board in the event that the External Power Supply is not available.
- **Internal Programmer** The built-in USB port on the microcontroller allows the created software code to be sent to the device without the requirement for an external programmer.
- **Reset Button** A reset of the Arduino microcontroller may be triggered by pressing this button on the board.
- **Analog Pins** It has a few analog input pins labeled A0 through A7 (typical). Analog signals may be sent to and received from these jacks. Additionally, the number of analog pins might differ across different circuit boards.
- **Digital I/O Pins** Multiple digital input pins (2-16) are also provided (typical). All digital data should be sent and received using these terminals. Different boards may have a different number of digital pins.
- **Power & Ground Pins** There are pins on the development board that provide 3.3 volts, 5 volts, and ground to the device.

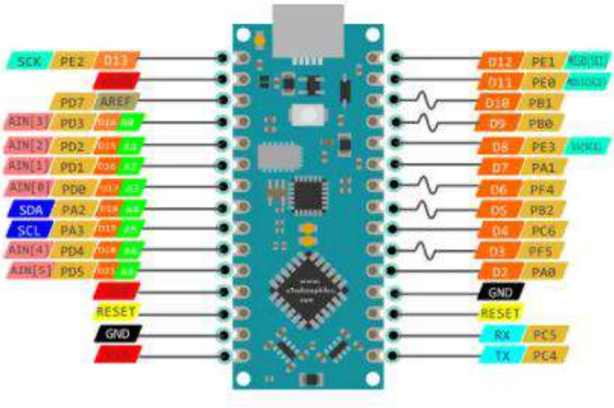


**Figure 3.1** A Labeled Diagram of Arduino Nano

### 3.3.3 Software

Arduino software is referred to as a "sketch" during development. These sketches for an Arduino are made using the Arduino IDE. The following features are included into this IDE:

- **Text editor** Here, a streamlined version of C++ might be used to write the simpler code.
- **Message Area** When attempting to save or export code, it checks for and reports any problems it finds.
- **Text** The console displays text data generated by the Arduino environment, such as messages of completion, error messages, and other information.
- **Console Toolbar** Among the options available from this toolbar are Serial Monitor, Open, Save, and Open/Upload/Verify. In the window's lower right corner, you'll see the Development Board and Serial Port.

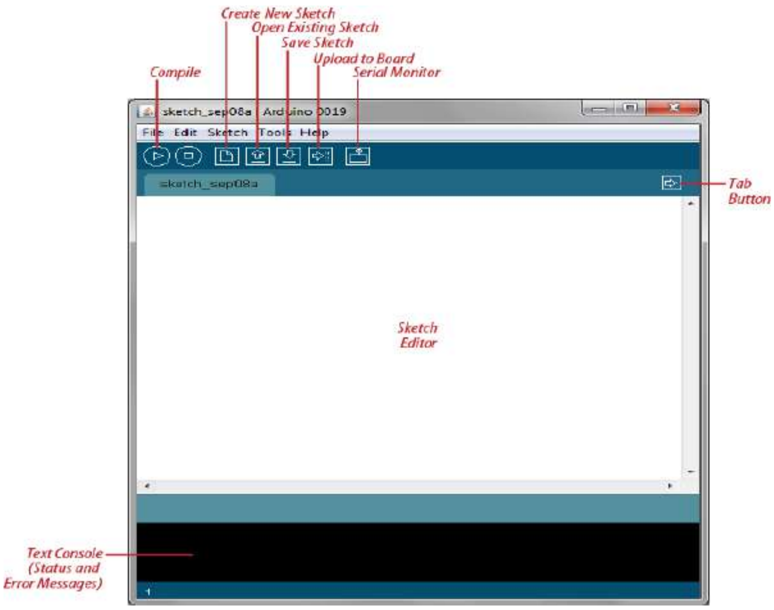



**Figure 3.2** A Labeled Diagram of Arduino IDE

### 3.3.4 Features of Arduino IDE

- The project file or project drawings are saved with the file extension.ino.
- This IDE supports features like cut, copy, and paste.
- The most fundamental component, or skeleton, of any Arduino code will contain two functions.
- By hitting the Ctrl + F keys on the keyboard, you may also find a certain word and replace it with another.

### 3.3.5 Arduino Programming Basics

Using the Arduino software development kit (IDE), we will now discuss how to write an Arduino sketch. Two elements are constant in any drawing

i. void setup ()

ii. void loop ()

### 3.3.6 void setup ()

This is the very first thing that is executed when an Arduino is turned up. During the lifetime of the program, this function receives a single invocation.

Every input and output pin in our project is initialized in the setup method. Here's how it ought to appear as an illustration

```
void setup()
  {
    pinMode(pin, INPUT);
    pinMode(pin, OUTPUT);
  }
```

The pin in this case represents the pin's identifying number. Indicates whether the pin is an input or output.

```
void setup()
  {
     Serial.begin(9600);
  }
```

In addition, the Serial Monitor's setup is included here. Data transfered serially to a peripheral device may be seen with the help of a serial monitor. All variables used in a program must be declared on a line above the "void setup()" procedure.

### 3.3.7 void loop()

Here we have the Sketch's second most important feature. Contrary to the code written in the setup function, this code is meant to be executed repeatedly. A void loop may look like this:

```
void loop()
  {
     digitalWrite(pin, HIGH);
  }
```

To set the logic high or low on a digital pin, a program needs a Write function. If pin Mode() was used to set the pin as an output, the pin's voltage will be set to the proper value: It's HIGH at 5V (or 3.3V for 3.3V boards) and LOW at 0V (ground).

Similarly, if the drawing has to be delayed, there's another function that slows down the program:

```
delay(1000);   //delay for a second
```

## 3.4 LM2596 MODULE

A buck converter (also known as a step-down converter) is a DC-to-DC power converter that reduces input voltage while maintaining output voltage at a constant level (load).

The LM2596 is a step-down (buck) switching regulator that can drive a 3-A load while maintaining excellent line and load control in a DC power supply. There is an adjustable output option, and fixed 3.3 V, 5 V, and 12 V versions. The 60kHz switching frequency of the LM2596 series allows for smaller filter components than are achievable with lower frequency switching regulators.

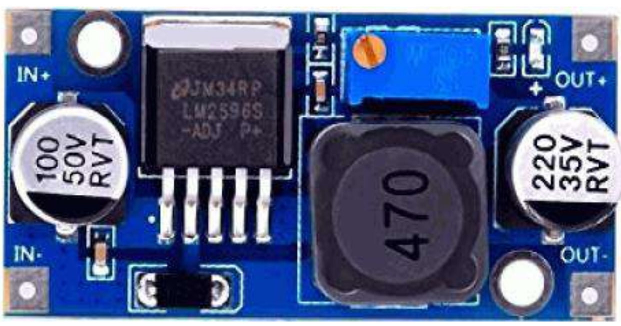



**Figure 3.*3*** LM2596 Module

### 3.4.1 LM2596 Module Features

1. Input voltage:3-40V
2. Output voltage:1.5-35V(Adjustable)
3. Output current: Rated current is 2A, maximum 3A(Additional heat sink is required)
4. Module Properties: non-isolated constant voltage module
5. Rectification: non-synchronous rectification
6. Short circuit protection: current limiting, since the recovery

### 3.4.2 LM2596 IC Pin Diagram

Below figure represents the pin diagram of LM2596 Module IC:


**Figure 3.4** LM2596 IC Pin Diagram

### 3.1 Table of Pin Description of LM2596 Module IC

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | V-IN | Input voltage that has to be regulated |
| 2 | V-OUT | Stepped down Regulated output voltage |
| 3 | Ground | Connected to system ground |
| 4 | Feedback | Sets the output voltage using divider network using output voltage feedback |
| 5 | ON/OFF | Enable pin, should be grounded for normal operation. |

### 3.4.3 Working Principle of LM2596 IC Module

1. DC 3.2V40V input voltage range (the input voltage must be more than 1.5V higher than the voltage to be output.)
2. Output Voltage Range: DC 1.25V35V continuous adjustable voltage with excellent efficiency (up to 92%); output current up to 3A. Obtain a power supply (3-40v), ensure that the power indicator light is on, and that the module is operational.
3. Turn the blue potentiometer knob to your liking (generally clockwise rotation makes boost and turning counter-clockwise makes step-down). Using a multi meter, measure the output voltage to acquire the desired voltage.

## 3.5 NodeMCU

NodeMCU is free software that includes schematics for a variety of prototype boards. Combining the terms "node" with "MCU" results in the phrase "NodeMCU" (micro-controller unit). NodeMCU is short for "NodeMCU Firmware," not the development kits that come with it.The firmware is written in Lua, a computer language. The eLua project is the basis for the firmware, which is created using the Espressif Non-OS SDK for ESP8266. It relies heavily on free, public domain software like SPIFFS and lua-cjson. Due to constraints, users must choose the firmware and components most relevant to their project. The ESP32, which is 32 bits, is also supported. Dual in-line package (DIP) circuit boards are often used for prototyping because they combine a USB controller with a smaller surface-mounted board holding the microcontroller unit (MCU) and antenna. Thanks to the DIP format, prototyping may be done quickly and easily using breadboards. The ESP-12 module of the ESP8266, a Wi-Fi system-on-a-chip (SoC) that also includes a Tensilica Xtensa LX106 core for Internet of Things (IoT) applications, served as the original inspiration for the design.

**Figure 3.*5*** NodeMCU ESP8266

### 3.5.1 NodeMCU ESP8266 Pin Diagram

Below figure represents the pin diagram of NodeMCU

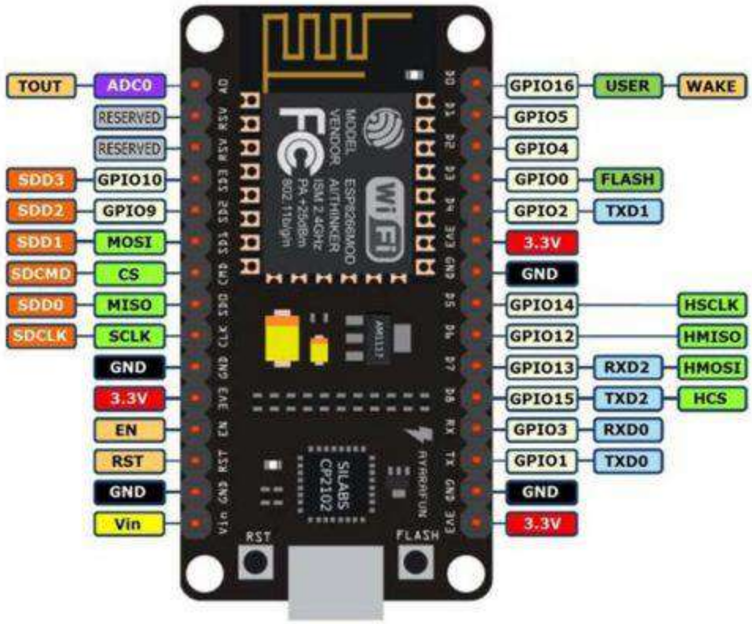



**Figure 3.6** NodeMCU Pin Diagram

### 3.5.2 NodeMCU ESP8266 Specifications & Features

- 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 (ADC): 1
- UARTs: 1
- SPIs: 1
- I2Cs: 1
- Flash Memory: 4 MB
- SRAM: 64 KB
- Clock Speed: 80 MHz
- USB-TTL based on CP2102 is included onboard, Enabling Plug n Play
- PCB Antenna

## 3.6 SWITCH-MODE POWER SUPPLY

For efficient electrical power conversion, electronic devices often use what is known as a switched-mode power supply (SMPS), switching regulator, switched power supply, or switcher.

**Figure 3.7** An adjustable switched-mode power supply for laboratory use

### 3.6.1 Theory of operation of Switch-Mode Power Supply

- Input Rectifier Stage
- Inverter Stage
- Voltage Converter & Output Rectifier
- Regulation

### 3.6.2 Input Rectifier Stage

The initial step in the operation of a switched-mode power supply (SMPS) is ac-dc conversion, if necessary. The term for this is "correction." When using a DC input SMPS, this is not necessary. Some power supply allow the rectifier circuit to be used as a voltage doubler by installing a switch with manual or automated operation. As a result, it may run on standard 16- or 230-volt electrical outlets. A massive filter capacitor receives the rectifier's unregulated direct current voltage. This rectifier circuit uses AC voltage peaks to pull power from the grid for short periods of time. These short, intense bursts of energy have a low power factor because of their high frequency. Power factor is corrected in many modern SMPSs by use of a dedicated power factor correction (PFC) circuit, which transforms the input current into a sinusoidal function of the incoming alternating current (AC). Most active PFC power supplies are "auto-ranging," meaning that they can accept input voltages anywhere from 100 VAC to 250 VAC without requiring manual adjustment. An SMPS designed for AC input may often be powered by a DC source, since the DC would pass through the rectifier unaltered. The required DC voltage is 163 VDC (16 * 2) if the power source is rated for 16 VAC but lacks a voltage selection switch. However, because only half of the rectifier's diodes are being used for the entire load, this kind of application might be harmful to the rectifier stage. This might lead to overheating and the early failure of these parts.

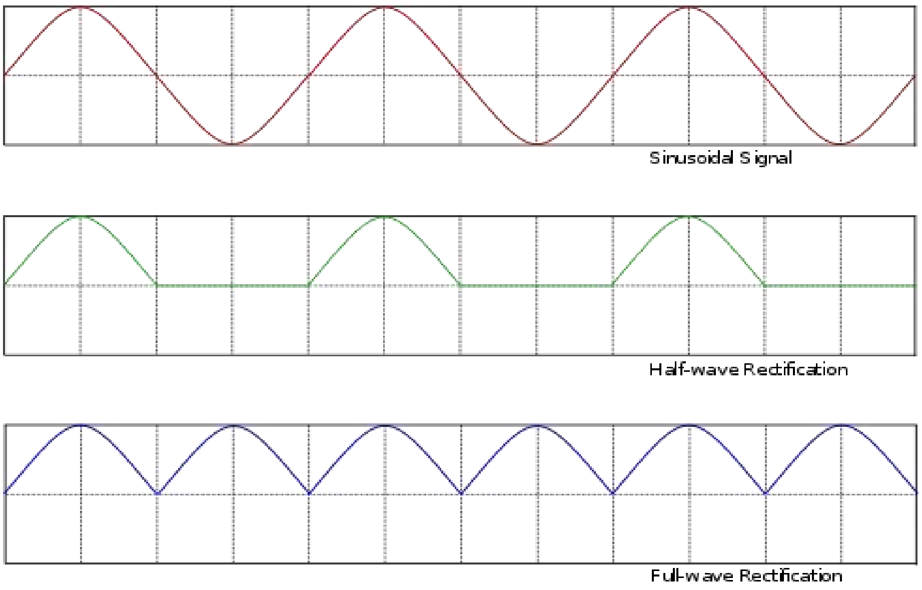



**Figure 3.8** AC, Half-wave and Full-wave rectified signals

### 3.6.3 Inverter Stage

The inverter stage takes DC from the input or the rectifier stage and converts it to AC using a power oscillator with a small output transformer with few windings, often operating at frequencies in the tens or hundreds of kilohertz range. The frequency is often over 20 kHz, making it inaudible to humans. A MOSFET amplifier with many stages (high gain) is used to effect the switch. High current may be handled by MOSFET transistors despite their low on-resistance.

### 3.6.4 Voltage Converter & Output Rectifier

High-frequency transformers employ reversed alternating current to power their primary windings when separating the output from the input, as is frequent in mains power supply. This adjusts the secondary winding voltage such that it produces the desired output. In the block diagram, this function is carried out by the output transformer. In order to get a direct current from a transformer, the alternating current must be rectified. For output voltages higher than around 10 volts, regular silicon diodes are often used. Due to their low forward voltage drop and fast recovery times, Schottky diodes are often used as rectifier components at lower voltages, allowing for low-loss operation at higher frequencies. For even lower output voltages, MOSFETs may be used as synchronous rectifiers due to their reduced voltage drops between their conducting states compared to Schottky diodes. The output of a rectifier may be filtered using inductors and capacitors to reduce ripple. Components need lower capacitance and inductance to accommodate higher switching frequencies.

### 3.6.5 Regulation

The voltage at the circuit's output is measured and compared to some standard. Depending on the specifics of the design and the necessary level of safety, the controller may have an isolation mechanism that physically separates it from the DC output. The output voltage of electronics like computers, TVs, and VCRs is carefully regulated by these opto-couplers, which are utilized in switching supplies. There is no feedback in an open-loop regulator. Rather, they only assume that the output is correct so long as a steady voltage is applied to the input of the transformer or inductor. To account for the impedance of the transformer or coil, regulated designs use compensation circuitry. Even more so than with dipole designs, magnetic hysteresis in the core is taken into consideration by monopolar ones. Since the feedback circuit must be powered in order to generate energy, a non-switching power source is supplied for standby.

### 3.6.6 Block Diagram of a Switch-Mode Power Supply

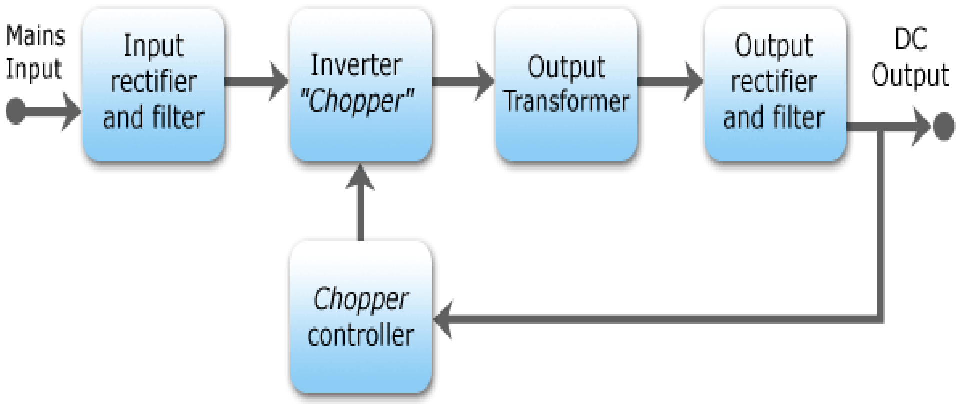



**Figure 3.9** Block diagram of a mains operated AC/DC SMPS with output voltage regulation

## 3.7 I2C (Inter-Integrated Circuit)

Inter-Integrated Circuit (I2C) is a serial communication protocol that enables communication between integrated circuits, sensors, and other devices. It is a popular protocol in embedded systems and is used in a variety of applications such as sensors, displays, and communication modules.

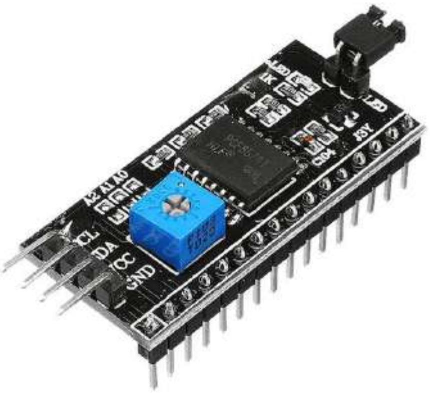


**Figure 3.10** I2C Serial Interface Adapter Module

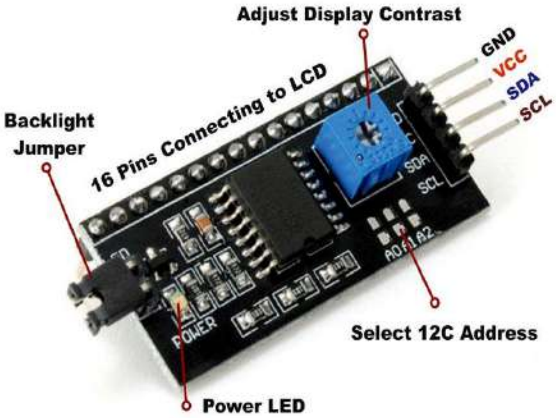



**Figure 3.*11*** I2C Serial Interface Adapter Module Pinout

Here are some details about the I2C protocol:

1. Communication: I2C is a synchronous serial communication protocol, which means that data is transferred bit by bit in a specific sequence. It uses two bidirectional lines, SDA (serial data) and SCL (serial clock), to transfer data between devices.
2. Master-Slave Architecture: I2C uses a master-slave architecture, where the master device initiates communication, and the slave devices respond. The master device generates the clock signal and controls the data transfer, while the slave devices respond to the master's commands.
3. Addressing: Each device connected to the I2C bus has a unique address that identifies it on the bus. The master device initiates communication by sending a start

condition and then sending the address of the slave device it wants to communicate with.

4. Data Transfer: Data is transferred between devices in packets, with each packet containing an address and data bytes. The master device sends a packet to the slave device and waits for an acknowledgement signal (ACK) from the slave device before sending the next packet.
5. Speed: I2C supports multiple data rates, with the most common being 100 Kbps (standard mode) and 400 Kbps (fast mode). Some devices also support higher speeds such as 1 Mbps (fast mode plus) and 3.4 Mbps (high-speed mode).
6. Pull-up Resistors: I2C uses pull-up resistors to keep the SDA and SCL lines high when no data transfer is taking place. The value of the pull-up resistor depends on the bus capacitance and the desired speed of communication.
7. Applications: I2C is widely used in embedded systems for various applications such as sensors, displays, and communication modules. It is also used in many consumer electronics devices such as smartphones and tablets.

Overall, the I2C protocol is a popular and reliable serial communication protocol that enables communication between integrated circuits and other devices. Its simple master-slave architecture, addressing scheme, and support for multiple data rates make it a versatile and widely used protocol in the field of embedded systems.

## 3.8 Analog pH Sensor / Meter Kit for Arduino

An analog pH sensor/meter kit for Arduino is a device that can measure the pH value of a solution and output it as an analog voltage signal that can be read by an Arduino microcontroller. The kit usually includes a pH sensor probe, an amplifier circuit board, and connecting wires.

**Figure 3.12** Analog pH sensor / Meter Kit For Arduino

### 3.8.1 Application of Analog pH Sensor / Meter Kit for Arduino:

- Water quality testing
- Aquaculture
- Power indicator LED
- pH Sensor with BNC Connector
- Gain Adjustment Potentiometer

### 3.8.2 Working Principle of an Analog pH sensor/meter kit for Arduino:

1. The working principle of an analog pH sensor/meter kit for Arduino is based on the measurement of the hydrogen ion concentration (pH) of a solution. The pH sensor probe consists of a glass electrode and a reference electrode, which are immersed in the solution being tested.
2. The glass electrode is made of a special glass membrane that is sensitive to changes in the hydrogen ion concentration of the solution. When the electrode is exposed to the solution, hydrogen ions from the solution diffuse into the glass membrane and interact with the ions in the membrane. This generates a small voltage potential between the glass electrode and the reference electrode.
3. The reference electrode is usually made of a silver-silver chloride (Ag/AgCl) electrode, which provides a stable reference potential against which the voltage potential of the glass electrode can be measured.
4. The voltage potential generated by the glass electrode and reference electrode is very small, typically on the order of millivolts. The amplifier circuit board included in the kit is used to amplify this small voltage signal to a larger voltage signal that can be read by an Arduino microcontroller.
5. Operational amplifier (op-amp) circuits on amplifier circuit boards amplify pH sensor probe voltage signals. A potentiometer on the circuit board sets the gain of the non-inverting amplifier, whose output voltage is proportionate to input voltage.
6. When the pH sensor/meter kit is connected to an Arduino microcontroller, the analog voltage signal output by the kit can be read by the microcontroller and converted to a pH value using a formula or lookup table. The exact formula or lookup table will depend on the specific kit you are using, so be sure to follow the manufacturer's instructions carefully.

## 3.9 DHT11-Temparure and Humidity Sensor

The DHT11 is a popular temperature and humidity sensor that is used in a wide range of projects. It has a simple 3-pin interface and is easy to use with microcontrollers and other embedded systems.

The DHT11 is a commonly used Temperature and humidity sensor that comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data.

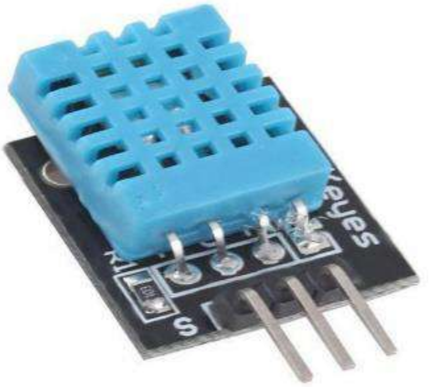


**Figure 3.13** DHT11-Temparure and Humidity Sensor

## 3.2 Table of DHT11 Pinout Configuration

| Number | Pin Name | Description |
|---|---|---|
| 1 | Vcc | Power supply 3.5V to 5.5V |
| 2 | Data | Outputs both Temperature and Humidity through serial Data |
| 3 | Ground | Connected to the ground of the circuit |

## 3.10 Relay

A relay is a low-voltage electrical switch that can be switched on or off, allowing current to flow through or not, and maybe controlled by Arduino pins running at 5V. As we'll see later, controlling a relay module with the Arduino is as easy as monitoring any other output. Dual-channel relay module (those blue cubes). One, four, and eight channel versions are all readily available. To utilize this module with an Arduino, connect it to a 5V supply. Most other relay modules are powered by 3.3V microcontrollers like the ESP32 and ESP8266.

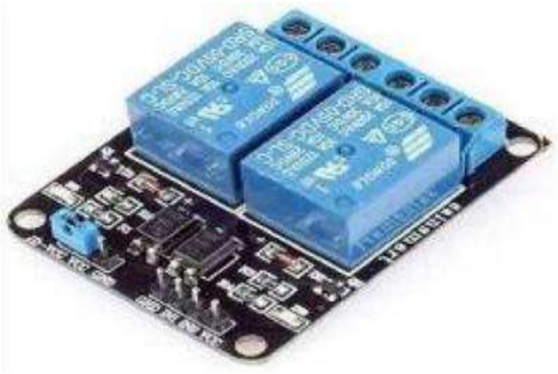


**Figure 3.14** Relay

Here are some of the advantages of using relays:

- Relays can be used to control high power or high voltage circuits with a low power circuit.
- Relays can provide galvanic isolation between the controlling and controlled circuits.
- Relays are relatively inexpensive and easy to use.
- Relays are available in a wide variety of sizes and types to meet a variety of needs.

A relay consists of two main parts: an electromagnet and a mechanical switch. The electromagnet is a coil of wire that is wrapped around a ferromagnetic core. When current is applied to the coil, it creates a magnetic field. The magnetic field attracts a movable metal armature, which is connected to the mechanical switch. When the armature is attracted, it closes the mechanical switch. This completes the circuit of the load that is being controlled by the relay. When the current is removed from the coil, the magnetic field collapses and the armature is released. This opens the mechanical switch and breaks the circuit of the load. Controlling a wide variety of loads, such as motors, lights, and other electrical devices, can be accomplished through the use of relays. In many applications, it is required to regulate a high-power or high-voltage circuit with a low-power circuit, and these are frequently utilized to accomplish this task. In order to achieve galvanic isolation between the controlling circuit and the circuit being controlled, relays can also be used.

# CHAPTER 4
# DESIGN METHODOLOGY

## 1. INTRODUCTION

The methodology section of this project report outlines the design approach taken to develop the IoT-based smart water management, water pH, and soil moisture monitoring and controlling system for indoor agriculture. It presents the key steps involved in the project's design process and provides visual representations in the form of a block diagram, flowchart, and circuit diagram.

## 2. BLOCK DIAGRAM

We have completed the block diagram for the project, utilizing the ATMega328p Nano microcontroller board from Arduino. The Arduino Nano 328p features a 16 MHz crystal oscillator, USB port, power connector, ICSP header, reset button, and 12 digital I/O pins (including 6 PWM outputs). The following figure (Fig 4.1) illustrates the block diagram of the entire project. In this design, we have employed the ATMega328p microprocessor for processing tasks. The code can be stored in the flash memory of the ATMega328p, which has a capacity of 256 KB (with 8 KB allocated for the bootloader). Additionally, the microcontroller has 8 KB of SRAM for data storage and 4 KB of EEPROM, accessible via the EEPROM library, for reading and writing. The block diagram (Fig 4.1) depicts three main components of the Arduino system: input, Arduino Nano, and output. These sections outline the flow of data and functionality within the project's architecture.


**Figure 4.15** Block Diagram of This Project

The Arduino Nano receives data from the ESP8266, pH sensor, DHT11, and soil moisture sensor. We are providing power to the Arduino Nano through the power supply block. Here, the Arduino Nano serves as the central hub for all the electrical components and sensors. Here, the input voltage range for Arduino Nano is between 7v and 12v.

## 3. FLOW CHART

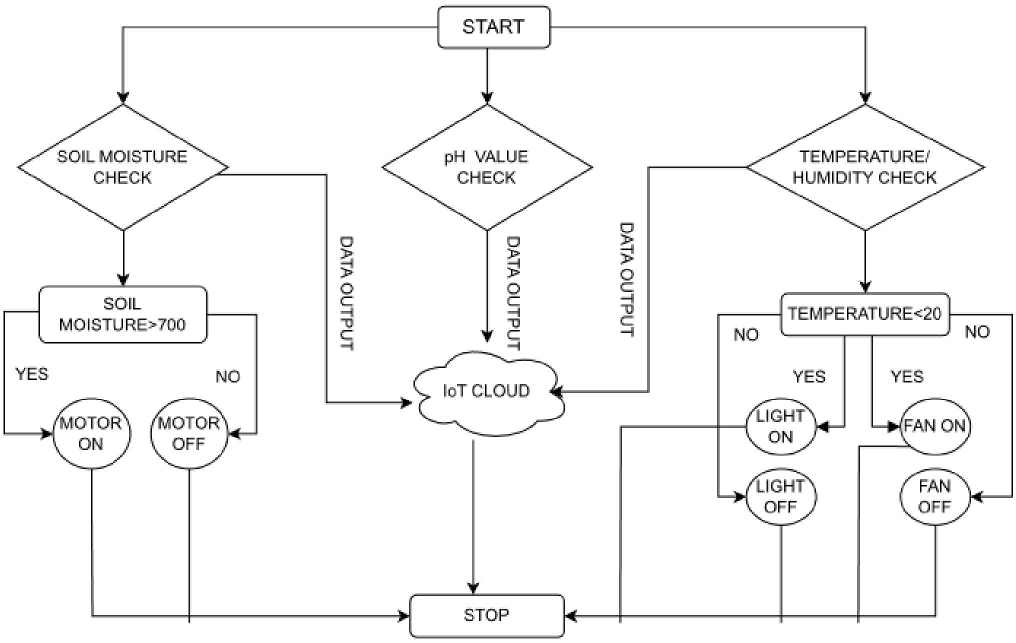



**Figure 4.16** Flow chart of this project

The process of making a system is the initial step in making the system itself. It's easy to see how everything works thanks to the flowchart. Thus, we have developed a process flow diagram. Developed project flow is shown in Fig 4.2.

The operation of the flow chart is discussed below.

- Initiating the program's algorithm is the first step.
- Following this, a software simulation will check soil moisture, pH value of water and temperature/humidity.
- After that, all the data will be uploaded through NodeMCU in cloud server.
- Next, if the soil moisture is equal to or more than 700, then the algorithm will understand that there is moisture in the soil, so the motor will be off. And if it drops below 700 then the motor will turn on and start watering the ground.
- In the meantime, it will measure the temperature. In that case, if the temperature is below 20 degrees, the bulb will turn on and the fan will be off. Similarly, if the

temperature is above 40 degrees, the fan will turn on and the bulb will turn off. Between 21 and 39 degrees, there will be offs.

## 4. CIRCUIT DIAGRAM

For this project, the circuit diagram was made with the Proteus Software. The circuit schematic and its pin-to-pin connection are detailed below:

### 1. Circuit Diagram of the Project

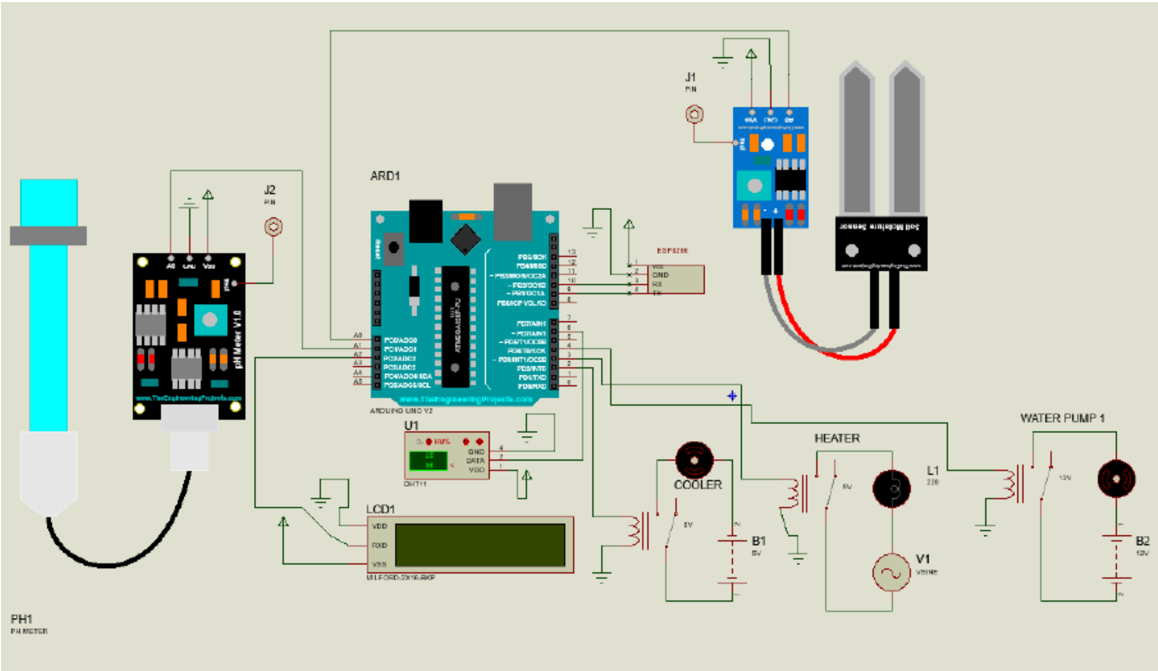



**Figure 4.17** Circuit Diagram of the Proposed Model

### 2. Pin Connection of the Project

This system's ATMega328p, or microcontroller, is linked to all of its parts. The NodeMCU's pins D2 and D3 are wired to the ATMega328p's pins 23 and 23. The 16*2 display module has a total of 16 pins for use in a wide variety of situations. The number of pins on the display is 4, but we only needed 4 since we were using I2C. Both the VCC and Ground pins are wired to the 5V power supply and ground. The microcontroller's pin number SCL is linked to SCL, whereas pin number SDA is connected to SDA. In this context, the SDA and SCL pins are referred to as the I2C pins and are utilized for serial communication.

The ATMega328p's pin A0, the soil moisture sensor, and the soil moisture sensor output all deliver power and ground to the device, respectively.

Infrared (IR) sensor modules were utilized twice for this experiment. To secure it, we need to employ the infrared (IR) gate, so we have one of those, too. Specifically, the 5v and

Ground connections are wired to the IR Gate module's VCC and Ground pins. The signal or output pin from the IR Gate is wired to the microcontroller's pin 46. Again, the VCC and Ground connections are the same, and the signal pin of the IR sensor is linked to the microcontroller's pin 47.

For the gate, we utilized a servo motor with its signal pin attached to ATMega328p pin 2.

There are 8 pins on the RFID module, but we only need 7. SDA, SCK, MOSI, MISO, RS, VCC, and Ground are their respective pins. Connected to the 3.3V power supply and ground, as well as pins 48, 52, 51, 50, and 49 on the microcontroller. We used a 3.3V power supply since that is what the RFID Module required.

We used a 7-pin 4x3 keypad, with the first three column pins connected to pins 32, 34, and 36 of the microcontrollers and the last four row pins connected to pins 38, 40, 42, and 44 of the ATMega328p.

# CHAPTER 5

# IMPLEMENTATION AND RESULT

## 1. INTRODUCTION

The goal of this initiative is to compile suggestions for an automated hydroponic plant. The code for this project was written in Arduino. We have developed an enhanced debt management system in addition to an automatic water management system using NodeMCU.

## 2. IMPLEMENTATION

All the system's hardware fits onto a single board made of wood. The Arduino is linked to several sensors like pH sensor, soil moisture sensor, temperature sensor, relay etc. Connectors are used to link each component to the Arduino board. We also use connectors for a variety of connections.

### 5.2.1 COMPLETE OVERVIEW

Our whole project was mapped out using Proteus software, and all of the interconnections between components were drawn out as a circuit diagram. We used an infrared pH sensor, soil moisture sensor, temperature sensor, relay, buck converter, smps power supply, display i2c and some wires in this project. A schematic representation of the whole system is shown in Fig 5.1.

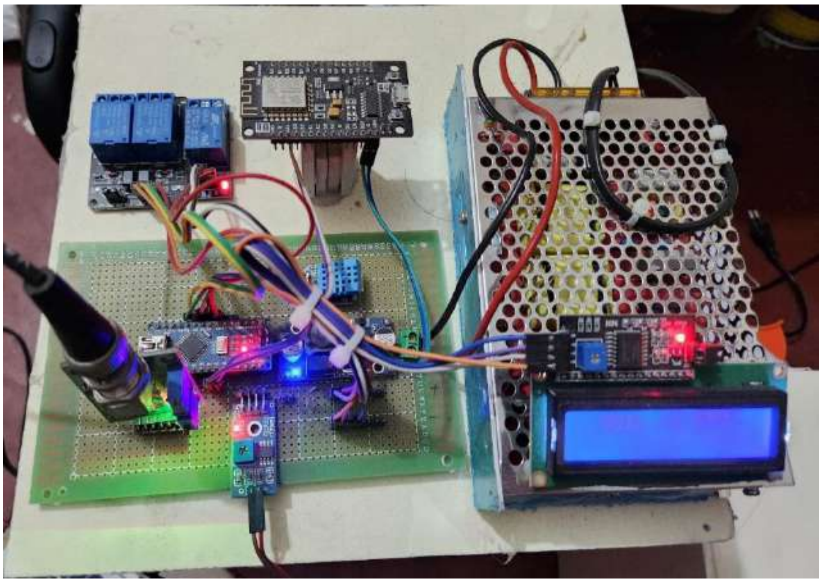


**Fig 5.1** Total overview of the system

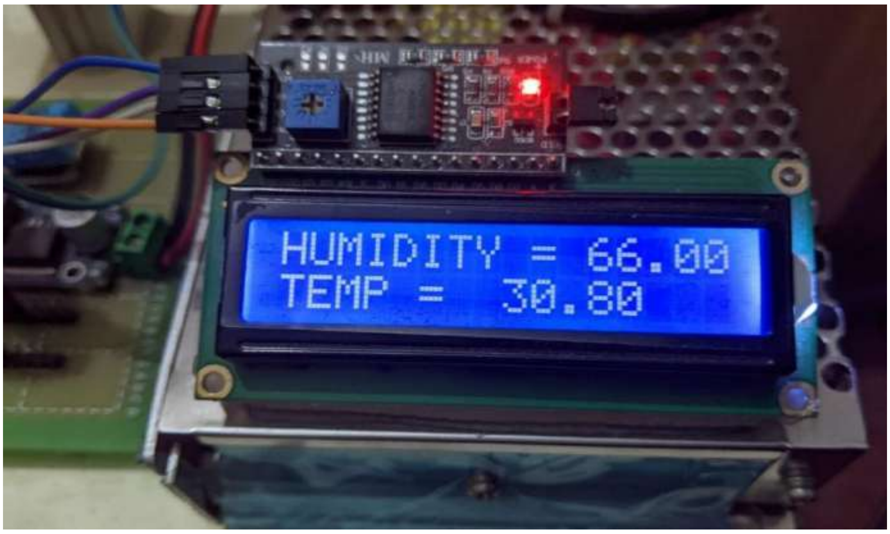
## 5.3 PERFORMANCE OF THE SYSTEM

First, we must download the software from PC-Arduino via a programming cable. The software will then be started by providing electricity. When soil moisture sensor detects low moisture level than pump motor will be turn on. The hitting elements and cooling elements will turn on when the temperature level is less than 20 or greater than 40. PH sensor continuously measures water pH level and sends the data in thinkspeak.

## 5.4 DEMONSTRATION AND RESULT OF THE PROJEC


(i) Smart Hydroponic Plants


(ii) pH Value




(iii) Humidity & Temperature


(iv) Soil Moisture


(v) Soil is Dry


(vi) Soil is Moisture

## 3. TOTAL COST OF THE PROJECT

Due to its typical use in industrial settings, our project is rather costly. This endeavor will set you back 3540 takas. We may reduce expenses by getting rid of or selling off some of the less essential equipment. The project's output, though, will suffer as a result. The overall budget for this project is shown in Table 5.1.

## 5.1 Table of Cost Analysis

| Component Name | Quantity | Price (BDT) |
|---|---|---|
| Arduino Nano | 1 | 300/- |
| LM2596 Module | 1 | 50/- |
| NodeMCU | 1 | 300/- |
| pH Sensor | 1 | 1500/- |
| Switch Mode Power Supply | 1 | 300/- |
| Motor | 2 | 300/- |
| 16*2 Display | 1 | 200/- |
| I2C Module | 1 | 100/- |
| Relay | 3 | 100/- |
| DHT | 1 | 120/- |
| Soil Moisture Sensor | 1 | 220/- |
| Wires | 1 | 50/- |
| **Total** | | **3540/-** |

## 4. COST COMPARISON

Our research shows that this project, with a projected budget of BDT3540, is "IoT based smart Water management, Water PH and Soil moisture monitoring and controlling system for indoor agriculture," and that it costs less than similar projects that have been published in reputable journals and publications. The fundamental idea here is to use pH sensor and real-time data input to automate the water management system. The anticipated cost of "IoT Based Monitoring and Smart Feeding System for Biofloc Fish Farming " is BDT8,740. Both are in the fish farming system. According to the findings of the study entitled " An IoT based system for remote monitoring of soil characteristics," the total cost of this project is around BDT 10,000. PH level monitoring and automated load control throughout relay module.

The initiatives we found most relevant to our own included things like sensors for security and safety, soil moisture management, and real-time data input. However, these elements often coexist in construction projects. The development costs for a project with these features will be high and will likely not be less than BDT 20,000-25,000.

We built a fully functional automated water management system as part of this project. Our project is expected to cost BDT 3540 and includes safeguards, real-time data input, and an innovative pH and soil moisture data monitoring and control among other things. Now we can confidently claim that our project is more affordable than the alternatives.

# CHAPTER 6
# CONCLUSION

## 6.1 INTRODUCTION

This is the project report's last chapter. In this chapter, we will talk about the project's completion. We will also talk about the project's limits, potential developments, applications, and benefits.

## 6.2 CONCLUSION

In conclusion, our IoT-based smart water management and monitoring system for indoor agriculture offers a cost-effective and efficient solution for optimizing plant growth. By closely monitoring water pH and soil moisture levels, the system ensures that plants receive the necessary nutrients and hydration for healthy development.

With our system, farmers and gardening enthusiasts can harness the power of technology to achieve better crop productivity while minimizing water waste and resource usage. The ability to remotely monitor and control the system adds convenience and flexibility, allowing users to manage their indoor agriculture setup with ease.

As we conclude this project, we are excited about the potential impact it can have on the future of farming. By combining innovation and sustainability, we hope to inspire others to explore smart farming solutions and contribute to a greener and more efficient agricultural ecosystem.

In this journey, we have witnessed the power of technology to transform traditional farming practices and pave the way for a more sustainable and productive future. We look forward to the continued growth of IoT-based solutions in agriculture and the positive impact they can have on food production and environmental conservation.

## 6.3 APPLICATIONS

Our project has real life applications which are given below.

- **Indoor Farms:** Precise control over water pH and soil moisture for optimal crop growth.
- **Urban Gardening**: Convenient indoor gardening with IoT-enabled monitoring and control.
- **Research and Education:** Platform for studying and analyzing water management's impact on plant growth.
- **Commercial Greenhouses**: Enhanced productivity and resource management

through continuous monitoring.
- **Community Gardens:** Collaborative management of shared plots for thriving communal gardens.

## 6.4 ADVANTAGES

Our project has some advantages which are given below.

- **Increased Crop Yield**: Optimal water and nutrient management leads to higher crop productivity.
- **Resource Efficiency:** Minimized water and resource usage for sustainable agriculture.
- **Remote Monitoring:** Convenient access and control of the system from anywhere via IoT technology.
- **Cost Savings:** Potential financial benefits through reduced water and resource consumption.

## 6.5 LIMITATION

Everything in this world is limited by certain things. In this way, there are a number of rules about this project, which are explained below.

- It can't be used in the business world because it's simple work. In the business world, more advanced modules are used for the parts that are used.

## 6.6 FUTURE IMPROVEMENT

Some changes can be made to this project in the future, which are discussed below:

**Integration of Advanced Sensors:** The system can benefit from the integration of more advanced sensors capable of providing additional data points, such as nutrient levels, light intensity, and atmospheric conditions. This would enable more comprehensive monitoring and control of the indoor growing environment.

**Machine Learning and Artificial Intelligence**: Incorporating machine learning algorithms and artificial intelligence techniques can enhance the system's capabilities. By analyzing the collected data, the system can learn and adapt to optimize water and nutrient management strategies based on specific crop requirements.

**Automation and Robotics:** Introducing automation and robotics into the system can further streamline and enhance the efficiency of agricultural operations. Automated nutrient delivery systems, robotic harvesters, and autonomous monitoring devices can reduce labor requirements and improve overall productivity.

**Data Analytics and Visualization:** Implementing advanced data analytics techniques and visualization tools can provide deeper insights into crop performance, resource utilization, and yield prediction. This would enable farmers to make data-driven decisions and optimize their farming practices.

**Integration with Climate Control Systems:** Integrating the smart water management system with climate control systems, such as temperature and humidity control, can create a comprehensive and integrated solution for indoor agriculture. This would allow for more precise control over the entire growing environment, further optimizing plant growth and resource utilization.

**Expansion to Vertical Farming Systems:** The system can be adapted and enhanced to support vertical farming systems, which maximize space utilization and crop production. By incorporating features such as vertical stacking, automated irrigation, and optimized lighting systems, the system can effectively cater to the unique requirements of vertical farming.

**Mobile Application Development:** Developing a user-friendly mobile application can provide farmers and growers with convenient access to real-time data, monitoring, and control of the system from their smartphones or tablets. This would enhance the system's accessibility and ease of use.

By exploring and implementing these future improvements, the IoT-based smart water management system for indoor agriculture can continue to evolve and contribute to sustainable and efficient food production in the coming years

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# APPENDIX

```
#include <WiFi.h>
#include <Wire.h>
#include "DHT.h"
#include <LiquidCrystal_I2C.h>
WiFi serial(2,3);
#define soil A7
float calibration_value = 21.34 + 5.0;
int phval = 0;
unsigned long int avgval;
int buffer_arr[10],temp;

float ph_act;
int fan = 8;
int light = 7;
int motor= 4;
#define DHTPIN 12
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);

LiquidCrystal_I2C lcd(0x27, 16, 2);
void setup()
{
 Wire.begin();
 dht.begin();
 Serial.begin(9600);
 lcd.begin();
  lcd.backlight();
 pinMode(soil,INPUT);
 pinMode(fan,OUTPUT);
 pinMode(light,OUTPUT);
 pinMode(motor,OUTPUT);
```

```
WiFi.begin();

 lcd.setCursor(0,0);
  lcd.print("SMART HYDROPONIC");
  lcd.setCursor(5,1);
  lcd.print("PLANTS");
  delay(3000);
  lcd.clear();

   lcd.setCursor(0,0);
  lcd.print("RAYHAN - T183016");
  lcd.setCursor(0,1);
  lcd.print("ASIFUL - T183022");
  delay(3000);
  lcd.clear();
}
void loop() {
    float h = dht.readHumidity();
    float t = dht.readTemperature();
    int soil_output = analogRead(soil);
 // timer.run(); // Initiates SimpleTimer
 for(int i=0;i<10;i++)
 {
 buffer_arr[i]=analogRead(A3);
 delay(30);
 }
 for(int i=0;i<9;i++)
 {
 for(int j=i+1;j<10;j++)
 {
 if(buffer_arr[i]>buffer_arr[j])
 {
```

```
 temp=buffer_arr[i];
 buffer_arr[i]=buffer_arr[j];
 buffer_arr[j]=temp;
 }
 }
 }
 avgval=0;
 for(int i=2;i<8;i++)
 avgval+=buffer_arr[i];
 float volt=(float)avgval*5.0/1024/6;
  ph_act = -5.70 * volt + calibration_value;

// lcd.setCursor(4,0);
// lcd.print("pH VALUE");
// lcd.setCursor(6,1);
// lcd.print(ph_act);
// delay(1000);

 if(ph_act<=7 && ph_act>=5){
   lcd.clear();
  lcd.setCursor(0,0);
 lcd.print("pH VALUE NORMAL");
 serial.print(1);
 delay(1000);
  }
  else if(ph_act>=7 && ph_act<=9){
     lcd.clear();
 lcd.setCursor(0,0);
 lcd.print("BASE DETECTED");
 serial.print(2);
 delay(1000);
    }
else{
```

```
  lcd.clear();
   lcd.setCursor(0,0);
lcd.print("ACID DETECTED");
serial.print(3);
delay(1000);
 }
lcd.setCursor(0,0);
lcd.print("HUMIDITY =");
lcd.setCursor(11,0);
lcd.print(h);

lcd.setCursor(0,1);
lcd.print("TEMP = ");
lcd.setCursor(8,1);
lcd.print(t);
delay(1000);
lcd.clear();

if(t>=40){
 lcd.clear();
 lcd.setCursor(0,0);
 lcd.print("HIGH TEMPERATURE");
 serial.print(5);
 lcd.setCursor(4,1);
 lcd.print("FAN ON");
 digitalWrite(fan,LOW);
 }
 else if(t<=20){
 lcd.clear();
 lcd.setCursor(0,0);
 lcd.print("LOW TEMPERATURE");
 serial.print(6);
 lcd.setCursor(3,1);
```

```
  lcd.print("HEATER ON");
  digitalWrite(fan,LOW);
    }
    else{
        digitalWrite(light,HIGH);
        digitalWrite(fan,HIGH);
      }
  lcd.setCursor(2,0);
 lcd.print("SOIL MOISTURE");
 lcd.setCursor(6,1);
 lcd.print(soil_output);
  delay(1000);
  lcd.clear();

    if(soil_output>=700){
      digitalWrite(motor,HIGH);
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("SOIL IS DRY");
  delay(2000);
  serial.print(7);
    }
    else{
      digitalWrite(motor,LOW);
      }
      lcd.clear();
}
```