DEVELOPMENT OF SMART HYDROPONIC SYSTEM WITH REMOTE MONITORING

BY

ADEWUMI OREOLUWA AYOMIDE

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SUPERVISED BY:

# CHAPTER ONE

**INTRODUCTION**

## BACKGROUND OF STUDY

Hydroponics is a method of growing plants without soil, using nutrient-rich water and a controlled environment to provide the optimal conditions for plant growth. With the rise of the Internet of Things (IoT), there is increasing interest in developing smart hydroponic systems that can be monitored and controlled remotely using IoT devices. Hydroponics is a method of growing plants without soil, using nutrient-rich water as the growing medium instead. The plants are grown in containers filled with an inert substance such as perlite, rockwool, or coconut coir, and are fed with a nutrient solution that provides the necessary nutrients for growth.

The history of hydroponics dates back thousands of years, with evidence of early civilizations using hydroponic techniques to grow crops. Some of the earliest known examples of hydroponic growing include the ancient Egyptians, who used floating rafts to grow crops on the Nile River, and the Aztecs, who used chinampas, or floating gardens, to grow crops in Lake Texcoco.

Hydroponic growing became more widely known in the 19th century, when scientists began to experiment with growing plants in nutrient-rich water. In the early 20th century, researchers in Europe and North America started developing more sophisticated hydroponic systems and techniques, including the nutrient film technique (NFT) and the aeroponic system.

In the 1960s and 1970s, hydroponic growing gained popularity as a way to grow crops in controlled environments, such as greenhouses and indoor growing facilities. During this time, the use of hydroponics for food production became more widespread, and hydroponic systems and techniques continued to evolve and improve.

Today, hydroponic growing is used for a wide range of purposes, including food production, ornamental plant production, and research into plant growth and nutrition. With the rise of IoT and other technologies, the future of hydroponic growing is likely to see even greater innovations and advancements in the years to come.Top of Form

Advantages of hydroponic growing include faster plant growth, greater yields, and reduced water usage compared to traditional soil-based agriculture. Hydroponic systems also offer greater control over growing conditions, such as temperature, humidity, and light, allowing for year-round growing and the cultivation of crops in areas where traditional agriculture is not possible.

There are several different types of hydroponic systems, including nutrient film technique (NFT), deep water culture (DWC), aeroponics, and ebb and flow systems. Each has its own advantages and disadvantages, and the choice of system will depend on the type of crops being grown, the scale of the operation, and the resources available.

Hydroponic growing is used for a variety of purposes, including food production, ornamental plant production, and research into plant growth and nutrition. It is also becoming increasingly popular as a means of urban agriculture, as it allows crops to be grown in small spaces with limited land and water resources.

The development of a smart hydroponic system with remote monitoring using IoT has the potential to revolutionize the way we grow plants, making hydroponic gardening more accessible and efficient. By using IoT devices and sensors, such a system can monitor and regulate key environmental parameters such as temperature, humidity, and nutrient levels, ensuring optimal growth conditions for plants.

Additionally, a smart hydroponic system with remote monitoring can be controlled from anywhere with an internet connection, allowing gardeners to monitor and adjust their systems from their smartphones or computers. This not only provides greater convenience and flexibility, but also enables real-time monitoring of the system's performance, making it easier to detect and resolve issues before they become serious problems.

Overall, the development of a smart hydroponic system with remote monitoring using IoT has the potential to bring hydroponic gardening to the forefront of sustainable agriculture and provide a more efficient, environmentally-friendly, and convenient way to grow crops.

## 1.2 MOTIVATION

The motivation for development of smart hydroponic system with remote monitoring is driven by the need to:

1. Address growing food demand: With the world's population expected to reach 9.7 billion by 2050, there is a pressing need for innovative solutions to help meet the increasing food demand. The development of a smart hydroponic system with remote monitoring has the potential to contribute to this effort.
2. Improve crop yield and efficiency: The implementation of remote monitoring capabilities in hydroponic systems can optimize crop growth by constantly monitoring and adjusting various parameters such as nutrient levels, pH, and temperature. This can result in improved crop yield and overall efficiency.
3. Reduce waste and minimize manual labor: By automating the monitoring and adjustment of hydroponic systems, manual errors and the associated waste can be reduced. Additionally, the remote monitoring feature provides convenience and reduces the time required for manual monitoring.
4. Enhance sustainability: Hydroponic systems have shown great promise in reducing water and pesticide usage compared to traditional soil-based agriculture. The development of a smart hydroponic system with remote monitoring can further enhance the sustainability of this method of agriculture.
5. Contribute to global efforts towards sustainable food production: The development of a smart hydroponic system with remote monitoring represents a crucial step towards sustainable and efficient agriculture. The impact of this project has the potential to positively impact not only the agriculture industry but also contribute to the global effort towards sustainable food production.
6. Facilitate research and innovation: The smart hydroponic system with remote monitoring provides a platform for further research and innovation in this field, leading to new advancements and solutions in sustainable agriculture.
7. Enhance accessibility and convenience: The remote monitoring feature of the smart hydroponic system provides farmers with the convenience of being able to monitor their crops from anywhere, at any time.

## 1.2 PROBLEM STATEMENT

The traditional methods of hydroponic farming face numerous challenges such as the need for constant monitoring and adjustments of environmental conditions, leading to increased labor costs and decreased efficiency. Additionally, manual monitoring of plant growth, nutrient levels, and water quality can lead to human error, which can affect plant health and yields. Furthermore, traditional hydroponic systems lack the ability to monitor and control remotely, which limits the ability to adjust conditions in real-time.

The development of smart hydroponic systems with remote monitoring using IoT can address these challenges by providing a more efficient, accurate, and reliable method of monitoring and controlling hydroponic systems. However, the implementation of such systems requires careful consideration of various factors such as sensor types, communication protocols, and the development of a suitable software application.

Therefore, the problem statement for this study is to develop a smart hydroponic system with remote monitoring using IoT that can provide real-time monitoring and control of environmental conditions, plant growth, and nutrient levels. The system must be able to remotely monitor and control the system via a web or mobile application. Additionally, the system must be cost-effective, easy to use, and capable of improving plant growth and yields while reducing the need for manual intervention.

## 1.2 AIM

The aim is to developing a smart hydroponic system with remote monitoring using IoT is to create a more efficient, convenient, and environmentally-friendly way to grow crops.

## 1.3 OBJECTIVES

Key objectives of this development include:

1. Optimize plant growth: By using IoT sensors and devices to monitor and regulate environmental parameters such as temperature, humidity, and nutrient levels, the aim is to create a hydroponic system that provides optimal growing conditions for plants.
2. Increased convenience: By allowing the hydroponic system to be monitored and controlled remotely using a smartphone or computer, the aim is to provide greater convenience and flexibility for hydroponic gardeners.
3. Real-time monitoring: By providing real-time monitoring of key parameters such as pH levels, nutrient levels, and plant growth, the aim is to make it easier to detect and resolve issues before they become serious problems.

Overall, the development of a smart hydroponic system with remote monitoring using IoT has the potential to bring hydroponic gardening to the forefront of sustainable agriculture and provide a more efficient, environmentally-friendly, and convenient way to grow crops.

## 1.4 SCOPE

The scope of the "Development of smart hydroponic system with remote monitoring" project encompasses the following aspects: one of the aspects is the Design and development of a smart hydroponic system that integrates remote monitoring capabilities. Another is the implementation of sensors and actuators to measure and control various parameters such as nutrient levels, pH, temperature, and humidity. Development of a user-friendly interface to monitor and control the hydroponic system remotely and Integration of the smart hydroponic system with a cloud-based platform to facilitate remote monitoring and data storage is also very essential just as the Testing and validation of the smart hydroponic system with various crops to assess its performance and efficiency.

The project is limited to the development of a single smart hydroponic system with remote monitoring capabilities. Further development, scaling, and commercialization of the system may be considered in future work.

## 1.5 SIGNIFICANCE **OF THE WORK**

The development of a smart hydroponic system with remote monitoring using IoT has significant implications for the future of hydroponic farming. Here are some of the key significances of this technology:

1. Increased Efficiency: Smart hydroponic systems with remote monitoring can significantly improve efficiency by reducing the need for manual monitoring and adjustment. With real-time monitoring and control, farmers can make more informed decisions about plant growth, nutrient levels, and water quality, leading to better yields and more efficient use of resources.
2. Cost Savings: By reducing labor costs and improving yields, smart hydroponic systems with remote monitoring can lead to significant cost savings for farmers. Additionally, the ability to monitor and control the system remotely can reduce the need for onsite personnel and travel expenses.
3. Precision Agriculture: The use of IoT in hydroponic farming allows for precise and targeted application of inputs, such as nutrients, light, and water. This level of precision can improve plant growth and yields while reducing waste, which is critical for sustainable agriculture.
4. Remote Monitoring: With remote monitoring capabilities, farmers can monitor their hydroponic systems from anywhere at any time, providing flexibility and convenience. This is particularly important for small farmers who may not have the resources to monitor their systems onsite continuously.
5. Data Analysis: Smart hydroponic systems with remote monitoring generate large amounts of data that can be analyzed to identify patterns, optimize inputs, and improve overall system performance. This data can also be used for research and development purposes.

In conclusion, the development of a smart hydroponic system with remote monitoring using IoT has significant implications for the future of hydroponic farming. This technology can increase efficiency, reduce costs, enable precision agriculture, provide remote monitoring capabilities, and generate valuable data for analysis and research.

# CHAPTER TWO

**LITERATURE REVIEW**

## 2.1 HISTORY OF WORK

The development of a smart hydroponic system with remote monitoring using IoT has gained significant attention in recent years due to its potential to revolutionize hydroponic farming. In this literature review, we will explore various studies and applications of IoT in hydroponics.

One study found that the use of IoT in hydroponics can improve plant growth by providing precise environmental conditions such as light, temperature, and nutrient levels. The study also found that IoT-based hydroponic systems can reduce labor costs, increase yields, and improve water use efficiency. The use of remote monitoring in the study allowed farmers to monitor the hydroponic system's condition from a remote location and to make timely adjustments as needed.

Another study found that IoT-based hydroponic systems can help farmers to make informed decisions about nutrient management and water use. The study found that real-time monitoring of nutrient levels and water use allowed farmers to optimize their inputs and reduce waste. The study also found that IoT-based hydroponic systems provide farmers with the flexibility to monitor and control the system remotely, which is important for small-scale farmers.

The use of IoT in hydroponics can also provide valuable data for research and development. A study found that the use of IoT in hydroponics can help to identify new plant growth patterns, leading to new insights into plant biology and the development of new hydroponic techniques. The study also found that IoT-based hydroponic systems can provide data on energy consumption, which can be used to optimize energy use and reduce costs.

In conclusion, the use of IoT in hydroponics has the potential to revolutionize the way hydroponic farming is conducted, leading to improved plant growth, increased yields, and more efficient use of resources. The use of remote monitoring and control in IoT-based hydroponic systems can reduce labor costs, increase efficiency, and improve overall system performance. The generation of valuable data through IoT-based hydroponic systems can be used for research and development purposes, which can lead to the development of new hydroponic techniques and improved system performance.

Hydroponics is the process of growing plants in the absence of soil with the help of added nutrients. The roots of the plants are directly exposed to the mineral nutrient solution in the water solvent. This ensures the healthy growth of the plant. Apart from the nutrient solution, regulating the artificial atmospheric conditions is also an important contributing factor in ensuring the growth of the plant, which is generally 25-30% faster with higher yield. Due to constraints of farming areas, farmers hugely depend on intensive farming with added amounts of fertilizers, degrading the quality of soil. Its dependency on the natural elements leaves him in a very vulnerable state to decide the quantity, quality and the type of plant to harvest. With close monitoring and the ability to modify and control the specifics of the environment in which the plant is supposed to grow, the producers can effortlessly meet the requirements of the market. Apart from the mass production, this system will also help and prove beneficial to small scale cultivators, urban producers and individuals who want to grow vegetables in their backyard

## 2.2 RELATED WORKS

### 2.2.1 IOT BASED AUTOMATED HYDROPONIC CULTIVATION SYSTEM

This work based on IOT Based Automated Hydroponic Cultivation System to produce high yield and high-grade crops which are essential in modern day agriculture. The architecture of this hydroponic system which is fully automatic that can be integrated into the agricultural curriculum while introducing business skills.

The automatic monitoring and control of the environmental events such as light intensity, pH, electrical conductivity, water temperature, and relative humidity is carried out by lodging sensors and actuators onto the system. Sensors and actuators are used in order to automate the hydroponic system, these sensor values are sent to the cloud database from which the user is updated with the real time information about crops condition. The user can also adjust the configuration of the sensors and actuators from the developed mobile application. The maintenance and automated monitoring are done by the intervention of the IoT that are used to transfer and retrieve data to the internet (mass storage) and a mobile app is used to communicate the current status of the hydroponic system to the user through the use of internet to their mobile phones. The IoT plays a major role in the automation process. Automating this hydroponic system is the most crucial part, this can be easily achieved by integrating the hydroponic system with the IoT. Cloud database acts as the hub for the whole automation process, this database contains all the information on the hydroponic system that is it has the information on the data that has been retrieved from the crops and the water tank. Thus, this hydroponic system can be adopted in any environmental conditions and it is a fully automated setup that can be operated through a web application. (Sudharsan et al., 2019)

### 2.2.2 SMART HYDROPONIC FARMING WITH IOT-BASED CLIMATE AND NUTRIENT MANIPULATION SYSTEM

This work significance explains the current state of food security and the need for agricultural innovations to address the issue. It also mentions the various types of urban agriculture that have been applied in various places, such as Barcelona, KwaZulu-Natal, Gauteng Province, Eastern Cape (EC) and Western Cape in South Africa. The introduction also mentions the various types of urban agriculture, such as small commercial agriculture, community-supported agriculture, community gardens, roof or greenhouse gardens, hydroponic and aquaponic agriculture, and indoor agriculture. Hydroponics is a type of urban agriculture that involves growing plants in a nutrient-rich solution, instead of soil. Aquaponics is a type of urban agriculture that combines hydroponics with aquaculture, which is the farming of aquatic animals. Both hydroponics and aquaponics have many benefits, both commercially and environmentally. However, there are many parameters that must be considered in order to successfully practice these methods, which can make it a challenge. The project proposes an automatic computer-controlled climate and nutrient manipulation system that will be based on monitoring carried out by a number of sensors. These sensors will be processed by computers in an Internet of Things (IoT) based system.

The project is discussing a method of manipulation that relates to the atmosphere, including aeration, room temperature, and light intensity. This study considers manipulating these parameters based on the latest experiments, which have shown that these parameters have an impact on plant growth. For example, the total biomass of cultivars increased under LED lighting, while the root ratio: shoots were more visible under NS1 light compared to fluorescent lighting. Additionally, another study found that aeration of roots and room temperature were two of the most important and crucial factors in hydroponic practice. Aeration is the process of introducing air into a liquid or other substance, such as soil. Room temperature is the temperature of the air in a room, usually measured in degrees Celsius or Fahrenheit. Light intensity is the amount of light that is present in a given area, usually measured in lumens. LED lighting is a type of lighting that uses light-emitting diodes, which are small electronic components that convert electricity into light. NS1 light is a type of light that is used in hydroponic systems, and is a type of fluorescent lighting. Fluorescent lighting is a type of lighting that uses a gas-discharge lamp that produces light by passing electricity through a gas. The root ratio: shoots is a measure of the ratio of the root mass to the shoot mass of a plant. This ratio is important in hydroponic systems, as it can be used to measure the health of the plant and its growth.(Perwiratama et al., 2019)

### 2.2.3 AUTOMATED HYDROPONICS WITH REMOTE MONITORING AND CONTROL USING IOT

This works aims to collectively use the greenhouse principle and principle of nutrition film in Hydroponics to maximize the growth of plants with the help of an IOT based system for monitoring and control.

The purpose of this system is to monitor and try to control parameters with the help of actuators present in the system Aside from that, one of the primary goals is remote monitoring and control.

The entire system can be divided into two subsystems (Hardware and the Software). The hardware assembly is responsible for the processes and control over the system. This includes circuitry that incorporates sensors, such as temperature and humidity sensors, pH sensors, and conductivity plate sensors, among others, is included in this. These sensors will all be used to assess the water quality and the environment in which the plants are housed. The circuitry includes actuators like the water pump, air pump, and Peltier cooling system in addition to sensors. All sensors and actuators are connected to the microcontroller.

This entire project aims to automate the hydroponics system while also allowing for remote monitoring and management of the system via IoT. The system's hardware, sensors, actuators, and software all work together to reduce the complexity of the whole manufacturing process. This technique not only breaks down traditional agricultural methods and enhances the entire process, but it also makes it self-sufficient enough to produce anything at any time of year. The software is embedded into the hardware of the real system and displays the various parameters such as temperature, humidity, pH levels, and so on, on the application that can be downloaded on the smart (Dudwadkar et al., 2020)

## 2.3 COMPONENTS

### 2.3.1 NUTRIENT SOLUTIONS

Nutrient solutions are available in stores. However, expert chemists have produced several free open source tools that allow you to construct your own.

They are as follows:

1. HydroBuddy
2. HydroCal.

The controller system will measure the following environmental/nutrient solution characteristics that are critical for hydroponically growing plants. These are covered in the following sections.

### 2.3.2 PH LEVEL

The control of pH is critical not just in hydroponics but also in soil. When the pH changes, plants lose their capacity to absorb certain nutrients. Different plants have different ideal pH levels; nonetheless, most plants prefer a slightly acidic growth environment. A pH range of 5.5 to 7 is good. Changing the pH level too quickly is not a good idea because it can overstress the plant. Simply ensure that the pH level is within the range listed above. The controller has the advantage of constantly reporting the pH level of the water (every five seconds). The user can set limits on the pH levels and so there will be a visual cue on the main screen if the pH level fluctuates outside of the predefined levels. Without the controller the user would need to use an external device, which may be carried out only a few times a day. By which time the pH could be too out of range causing damage to the plants.

### 2.3.3 ELECTRICAL CONDUCTIVITY: EC LEVEL

After pH level, the second most important element to measure in the water solution is the EC level. EC is a measure of the concentration of nutrients in the solution. However, as each nutrient has a different salt content, you could have a high concentration of one nutrient and a lack of another. According to Fernandez

*“Of paramount importance are the ions that determine pH which have conductivities hundreds of times larger than other ions”.*

Therefore, EC should always be measured at a constant pH. The controller allows the user to know the pH when measuring the EC and so this requirement will always be met. The reason why the EC level is so important is outlined here:

“The electrical conductivity can tell you if your solution has lost nutrients or water due to evaporation, if measurements are done at the exact same pH value. The EC should be measured when the solution is prepared and three times each day after then. If your solution’s EC becomes too high, you can add water to lower it to the original value. If EC becomes too low (70% of original value), you should not add nutrients. This means that your solution has been substantially changed in composition by the plant and it needs to be disposed off and a fresh one needs to be prepared.”

Just like the pH level the EC is constantly being reported back to the user (every five seconds), with the ability for them to set alarms at predefined levels. A visual cue will be given if the EC level falls out of some predefined range. Again, without the controller, the user would need some external device to do this and ensure it is carried out a few times a day. (Fernandez, 2009)

### 2.3.4 WATER TEMPERATURE

In order for the nutrients to be properly absorbed by the plants the temperature of the water should be in the range of 18-26°C. If the water temperature is too low, then a water heater can be used to warm it back up again. The controller reports the water temperature in real time back to the user on the main screen. The user has the ability to set the lower and upper limits of the water temperature. The user, if they are using a water heater, can set it so that if the temperature falls too low, then the water heater will switch on. It switches off if the water becomes too warm, ensuring that the temperature remains constant. This feature is more useful if the user is using the controller outside, like in a greenhouse.

### 2.3.5 AIR TEMPERATURE

The controller reports the air temperature in real time back to the user on the main screen. Like the other main screen reports, if the value falls outside of a user specified range, a red light will show on the screen. If the temperature is within the range, it will be green. The controller has currently no way of controlling the air temperature. A possible extension of the project would be that a fan could be controlled if the air temperature is too high.

### 2.3.6 LIGHT LEVEL

Not just a hydroponics problem, but light level is a general problem of growers. If light levels are too low, the controller can be used to turn on a grow light. As the system will control external remote plugs, it means that the user has flexibility in the devices they choose. As shown above, the main advantages of the controller are that it allows the most important aspects of growing to be automated and alerts the user immediately if some element is out of a preset range.

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