DESIGN AND DEVELOPMENT OF AN AUTOMATED INDOOR HORTICULTURE SYSTEM

By

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A Final Year Design Project (FYDP) submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of Bachelor of science in Electrical and Electronic Engineering

Department of Electrical and Electronic Engineering
Brac University
January 2024

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January 2024

Declaration

It is hereby declared that

1. The Final Year Design Project (FYDP) submitted is my/our own original work while completing degree at Brac University.
2. The Final Year Design Project (FYDP) does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Approval

The Final Year Design Project (FYDP) titled “Design and Development of an Automated Indoor horticulture System” submitted by

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of Fall, 2023 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of B.Sc. in Electrical and Electronic Engineering on 14-12-2023.

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Ethics Statement

Our final year design project report contains 8% similarity.

Abstract/ Executive Summary

The swift process of urbanization and the escalating population in Bangladesh have caused a substantial decrease in agricultural area, leading to a loss in food production and a heightened reliance on imports. This study presents a remedy to tackle these difficulties by developing and executing a mechanized indoor horticulture system. The technique employs hydroponics, nutrient-enriched water, and cutting-edge technologies, such as LED lighting, to effectively cultivate crops without soil. The study examines the system's technical specifications, functional requirements, and non-functional concerns, with a particular focus on its possible socio-cultural and environmental advantages. In addition, the research investigates areas of insufficient knowledge in the specific context of developing nations such as Bangladesh. It examines the long-term financial viability, ecological consequences, potential for expansion, and societal reception of vertical hydroponic systems. The research highlights the significance of regulatory frameworks in guaranteeing food safety and quality in this developing industry. To summarize, the suggested automated indoor horticulture system offers a hopeful resolution to the urgent problems in Bangladesh's agriculture industry, providing a way towards sustainability, economic stability, and technological progress.

Keywords: Horticulture; LED; Automated; Urbanization

Dedication

We want to dedicate to our parents for their endless support that assist us to complete our graduation.

Acknowledgment

We would especially want to express our gratitude to Professor Dr. Md. Mosaddequr Rahman, our ATC Chair, whose skill and diligence were invaluable to the accomplishment of our project.

In addition, we would like to thank to our supervisor Mohaimenul Islam for his unwavering leadership over the whole project. His knowledge and support were invaluable in helping establish our strategy and improve the results. We sincerely appreciate the mentorship he gave us; his advice and assistance were priceless.

We also want to express our sincere gratitude to the hardworking individuals in our group. The success of the project has been largely attributed to the individual contributions and teamwork of each member. This project has been a remarkable team effort because of the dedication, effort, and passion shown by all of our team members.

We acknowledge that our ATC Chair Professor Dr. Md. Mosaddequr Rahman and our supervisor Mohaimenul Islam provided us with inspiration and motivation, and we believe their assistance was essential for the success of our Final Year Design Project (FYDP).

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1.1 Introduction

The swift process of urbanization and the increase in population in Bangladesh have resulted in a worrisome decrease in agricultural land, jeopardizing the country's ability to ensure food security and causing a loss in the agriculture sector's contribution to the GDP. With the population predicted to reach roughly 5 billion by 2030, the pressure on available land for agriculture becomes even more evident. This urbanization-induced loss of agricultural land has forced new methods to ensure sustainable food production. In answer to this significant challenge, our proposed project provides an automated indoor horticulture system, leveraging new technology to cultivate crops without traditional soil. This technology solves the issues posed by depleting cropland by giving a space-efficient and vertically expandable alternative. Furthermore, the combination of nutrient water and LED illumination boosts efficiency, giving a sustainable approach to boosting food output. As a result, we set the ground for exploring our initiative, which intends to contribute to food security, economic stability, and self-reliance in Bangladesh.

1.1.1 Problem Statement

Bangladesh is a densely populated country and due to population growth urbanization is increasing rapidly. One study said that the urban population at those days 3.2 billion will rise to nearly 5 billion by 2030 (Islam et al., 2013).

Population growth is triggering a rise in urbanization. People are building houses on agricultural land. As a result, the amount of agricultural land is decreasing day by day. In 1976, it was estimated that 9,761,450 hectares were under agricultural land. In 2000, it was 9,439,541 ha and in 2010, it was 8,751,937 ha, or 67.38, 64.96, and 60.04% of Bangladesh's total land area. This shows that cropland reduced with time, and it was estimated more than five times over the time frame from 2000 to 2010 compared to the period from 1976 to 2000.
Rapid loss of agricultural land has reduced food production. As a result, food has to be imported to meet the food demand, leading to an increase in food prices. One of Bangladesh's most important economic foundations is the agriculture industry. Its contribution to GDP was over 60% just after liberation in 1971. We all know that it is the most significant sector in Bangladesh in terms of how it affects people's lives, provides jobs, and raises the GDP. Nonetheless, its contribution to GDP has decreased over the past ten years, from 17% in 2010 to 12.6% in 2020 (The Daily Star, Mar 1, 2023)

1.1.2 Background Study

With a population of over 170 million, Bangladesh is one of the most densely populated nations in the world. The backbone of the nation's economy is agriculture which generates roughly 14% of GDP shown in Figure 2, employs 47% of the labor force, and feeds the whole population. However, Bangladesh lost over 1 million acres of productive arable land between 1983 and 1996 (BBS, 1999). In terms of acres, that equals about 80,000 acres of agricultural land being removed from crop production annually [1]. Agriculture land occupies 9.5 million ha in Bangladesh, according to official data from the Soil Resources Development Institute (Land and Soil Statistical Appraisal Book of Bangladesh, SRDI, 2010). In contrast, the Krishi (agriculture) Diary published in 2011 by the Bangladesh Bureau of Statistics (BBS) and Department of Agriculture Extension (DAE) reported around 9.1 million ha of agricultural land [2].

Table 1: Availability of agricultural land from 1976-77 to 2010-11 [2]

Year	Land area of Bangladesh (million ha)	Cultivable land (million ha)	% cultivable land
1976-77	14.28	9.39	65.75
1980-81	14.29	9.38	65.64
1985-86	14.48	9.44	65.19
1990-91	14.84	9.72	65.50
1995-96	14.84	8.72	58.76
2000-01	14.85	8.40	56.57
2005-06	14.84	8.42	56.74
2010-11	14.84	8.52	57.41

With this much population and less cultivable land, the conventional cultivation process cannot meet the demand for food for this large number of people. The demand for food is much higher than the production capacity, and the country is facing a food shortage crisis. In Bangladesh, one-third of the population continues to live below the poverty line as a result of the poor growth of the gross national product (GNP) and the rapid population growth [3]. The limited availability of arable land and water resources, combined with traditional farming practices, poses significant challenges to the agriculture sector. Bangladesh has only 0.06 hectares of arable land per person, significantly lower than the global average of 0.22 hectares per person. Moreover, the country is facing severe water scarcity due to climate change, excessive use of groundwater, and pollution [2]. These issues are all leading to a sharp decline in the agricultural sector.

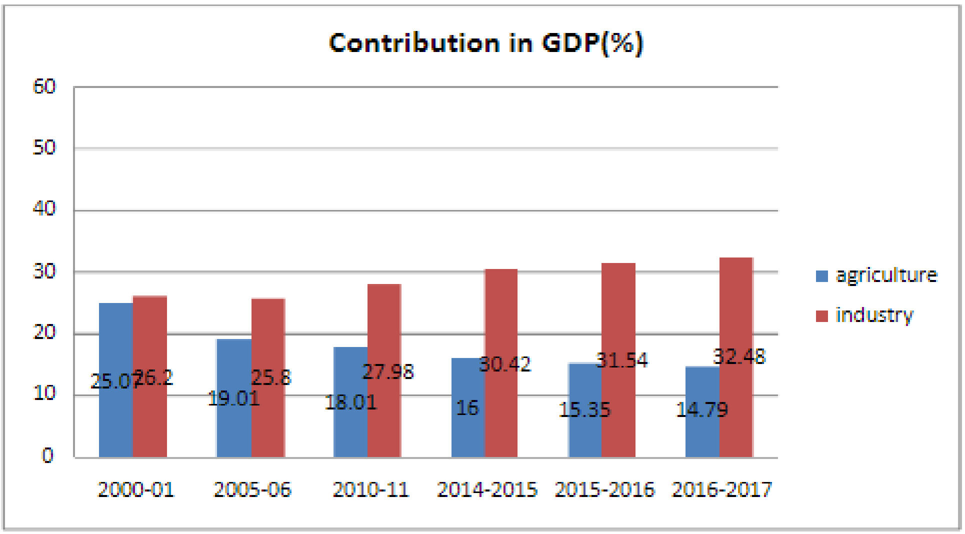


Figure 1: Contribution of industrial and agricultural sector to national GDP [4]

From Figure 1, it is seen that recently the agriculture sector has been growing less rapidly, which has in turn slowed the country's GDP growth. It shows us that the trend of economic growth has been accelerating downward since 2000 until 2016. In 2016–2017, there was some hope that the rate might increase slightly by shifting from a decreasing to an increasing mode, but it is unclear how long this expectation will last [4]. The introduction of an automated indoor horticulture system can solve many of these problems and provide a sustainable solution for food production. The primary challenge in the implementation of the horticulture system is the lack of knowledge and expertise of the farmers and the high initial investment cost. Therefore, there is a need to develop a low-cost, automated indoor horticulture system that can be easily maintained by the farmers and produce a significant yield.

The increased interest in sustainable living and urban agriculture in Bangladesh has led to an increase in the popularity of indoor horticulture. Indoor horticulture systems provide an effective and practical answer for cultivating a range of plants in a controlled environment when space and resources are restricted. The practice of growing plants in a soilless media with a nutrient-rich solution is known as hydroponics, and it is one of the most widely utilized indoor gardening methods in Bangladesh. Faster growth, a larger yield, and less water use are just a few benefits of this approach over conventional soil-based farming. Even so, there are still several issues that must be resolved before indoor horticulture can be widely adopted in Bangladesh, despite the growing interest in it. A major obstacle to indoor horticulture in Bangladesh is the high cost of tools and technology. The cost of a small-scale hydroponic system can range from BDT 50,000 to BDT 300,000, according to a World Bank analysis. Small-scale farmers and company owners who want to launch an indoor horticulture venture may find this to be a substantial impediment. The ignorance and lack of education of the general public is another problem. Only 28% of survey participants knew about automated indoor horticulture technology, according to a study that was published in the International Journal of Horticulture and Agriculture [5]. This lack of knowledge could limit the use of automated indoor horticulture and prevent it from having a positive impact on economic growth and food security. It is important to note that automated indoor horticulture still contributes only a small amount to Bangladesh's agriculture sector to highlight the impact of these difficulties. The value of vegetable output in Bangladesh was BDT 706.2 billion (USD 8.3 billion) in the 2019-2020 fiscal year, according to data from the Bangladesh Bureau of Statistics, however, the contribution of automated indoor horticulture is not specifically stated [6].

In conclusion, the use of automated indoor horticulture systems can provide a long-term solution to issues associated with conventional agricultural practices. However, it is critical to solve the issues of high initial setup costs, energy consumption, technical skills, and the need for more research and development to ensure their profitability and scalability. Furthermore, to guarantee food safety and quality assurance in this developing industry, regulatory frameworks and standards must be implemented.

1.1.3 Literature Gap

Due to the potential to improve food production and encourage sustainable agriculture, vertical hydroponic systems are growing in popularity. However, there are still certain gaps in our knowledge of these systems and their efficacy, especially when it comes to developing countries like Bangladesh. Firstly, the financial sustainability of vertical hydroponic systems is one of the main research gaps. It has been demonstrated that these systems work well in small-scale applications, but it is unknown whether they can be scaled up to fulfill the needs of bigger populations in terms of food production. Moreover, the long-term viability of vertical hydroponic systems in terms of the environment is another issue that needs more research. While it has been demonstrated that these systems are efficient at using less water than conventional farming techniques, it is unknown whether they have any adverse effects on the environment, such as increased energy use or greenhouse gas emissions. The scalability of vertical hydroponic systems also needs additional research. Although the effectiveness of these systems has been demonstrated in small-scale applications, it is unknown whether they can be scaled up to satisfy the needs of bigger populations in terms of food production. The ideal size and structure of these systems for widespread application, as well as any logistical difficulties or constraints, require more study. Finally, more study is required to determine whether vertical hydroponic systems are accepted in society and culture. It is uncertain if local people and farmers would adopt these methods, even though they have the potential to boost food security and promote sustainable agriculture.

1.1.4 Relevance to current and future industry

In the complicated tapestry of Bangladesh's agricultural landscape, the suggested automated indoor horticulture system emerges as a light of revolutionary relevance for both the existing issues and future opportunities of the industry. The serious worry of growing urbanization, consuming agricultural expenses, highlights the vital need for innovative solutions. Herein lies the fundamental significance of our system's avant-garde approach—nurturing crops without the limits of traditional soil, so presenting a sustainable option amongst the continual decrease of cropland.

The pertinence of this system assumes heightened importance in the backdrop of the increasing population, expected to surge towards almost 5 billion by 2030. As the demographic pressures rise, our system's space-efficient design and vertical scalability become significant assets, ingeniously addressing the conundrum of shrinking land availability for farming. The addition of sophisticated technology, such as nutrient water and LED lighting, further increases its importance by improving resource consumption and increasing agricultural efficiency.

Delving into the intricacies of its design and functionality in the subsequent chapters, the system's transformative potential will unfold, showcasing its ability to secure food production in the face of urban encroachment, foster economic stability through enhanced productivity, and empower individuals—particularly farmers—toward self-reliance. This novel paradigm offers not simply to address the current agricultural issues in Bangladesh but to pave the path for a resilient, sustainable, and technologically sophisticated future for the industry.

1.2 Objectives, Requirements, Specification and Constant

1.2.1 Objectives

- Design and implementation of an automated indoor horticulture system.
- Monitor and control different parameters of this system (pH level of nutrient water, temperature, intensity of lights).
- Giving access to social benefits like fresh produce and job creation, cultural benefits like promoting cultural identity by growing crops that are significant to certain communities and environmental benefits like resource conservation, reducing transportation emissions and increased biodiversity.

1.2.2 Functional and Non-functional Requirements

Functional Requirements

- **Nutrient water:** Nutrients are essential elements that are used for plant’s growth, development and reproduction.
- **Intensity of light:** All plants require light for photosynthesis, the process within a plant that converts light, oxygen and water into carbohydrates (energy**)**. Plants require this energy in order to grow, bloom and produce seed. We will fix the intensity of the light in a way that plants can grow at a maximum level.
- **Power source:** Power source is required to power up the whole electrical system.
- **pH level:** The pH level of the nutrition water must be maintained. The plant won't receive the right amount of nutrients if the pH level rises or falls, which would hamper its growth.
- **Water pump:** It is required to pump water and nutrients into the system for the plant. Without the water pump the nutrient water cannot be supplied to the system.

Non-Functional Requirements

- **Reservoir:** It stores the water and nutrient solutions that the plants need to grow healthy and strong.
- **Structure of the system**: It is required to design our whole physical setup.
- **Storage system of crop:** It is required to store the produced crops.

1.2.3 Specifications

Table 2: System Specifications

Subsystem	**Components**	**Specification/Details**
Horticulture subsystem	Pipe	Loose pipe (Diameter: 8mm)
	Tube	PVC spaghetti 5mm
	Drip emitters	1-2 GPH (Gallon Per Hour)
	Height of the system	Maximum 9ft
	Reservoir	1 to 1.5 gallons per plant
Electrical subsystem	Water pump	Power:60 watt 10-Feet Lift Height, 792 GPH (3000 L/H)
	Microcontroller	Operating Voltage 5V; Digital I/O Pins 20 PWM Channels 7; Analog Input Channel 12 DC Current per I/O Pin 40 mA; Clock Speed 16 MHz.
	Motor Driver	5-12V
	Power supply	12V
	Converter	5V
	Timer	100 to 240 VAC 50/60 Hz 12 to 24 VDC/24 VAC 50/60 Hz
	Sensors	pH sensor, Temperature sensor, Humidity sensor
Light subsystem	LED	280 nm to 420 nm 700 nm,24 VOLT for Deep red LED
	Potentiometer	0 Ohm - 1K Ohm
Nutrient subsystem	pH level	5.5-6.5

1.2.4 Technical and Non-technical consideration and constraint in design process

Non-technical Constraints

- **Height of room:** As our system is an indoor system and the standard height of a room is 9ft, we cannot make the length of our system above 9ft.
- **System leaking:** Since we will be building our system with PVC pipes, there may be some possibility of pipes leaking.
- **Plant disease:** Although the hydroponic system produces fresh and clean products, sometimes some diseases of the crop can hamper the system.

Technical Constraints:

- **pH level of nutrient water:** Sometimes due to variations in pH level some errors may occur in the function of the system. That's why the pH level is also a constraint here.

- **Lighting Technology:** A technological limitation may be the lighting technology selection. It is important to carefully analyze factors including light spectrum, energy efficiency, and starting costs.

- **Pest and Disease Management:** When putting into practice efficient pest and disease management techniques, technical obstacles could appear. Technical factors may have a role in the choice of pest management strategies, such as integrated pest management or biological controls.

1.2.5 Applicable compliance, standards, and codes

Table 3: Applicable Standards and Codes

Standard Title	**Standard No.**	**Definition**
Water pump	ISO 5199 (JIS B 8308)	In order to standardize, streamline production and usage, and enhance quality, standards for centrifugal pumps class II with single stage, horizontal or vertical general use, as well as all drives and installed techniques, were defined. It could be used with chemical pumps.
LED	IEEE 1789-2015	The concept of modulation frequencies for light-emitting diodes (LEDs) is defined in this document, along with a discussion of how they are used in LED lighting, a description of LED lighting applications where modulation frequencies may be harmful to users' health, a discussion of how to dim LEDs by varying the frequency of driving currents or voltage, and recommendations for modulation frequencies (flicker) to help guard against known potential harmful health effects.
Microcontroller	IEEE 802.11	This standard defines the specifications for wireless local area networks (WLANs). The ESP8266 supports IEEE 802.11b/g/n, which specifies the wireless network standard for data transmission rates of up to 54 Mbps
Motor Driver	IEEE 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems - This standard provides guidelines for controlling harmonics in electrical power systems, which can be important when using motor drivers like the L298N. Additional filtering components may be necessary to meet the harmonic limits specified in this standard.
Power Supply	IEEE 1547	Requirements for the Interconnection of Distributed Energy Resources (DERs) with Electrical Power Systems, including those with 12V Power Supplies, are outlined in the Standard for Interconnecting Distributed Resources with Electric Power Systems.
Converter	IEEE 1547	The requirements for the interconnection of distributed energy resources (DERs) with electrical power systems, including those that employ power supplies to convert AC power to DC power, are outlined in the Standard for Interconnecting Distributed Resources with Electric Power Systems.
Potentiometer	IEEE 1727	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - This standard provides guidelines for protecting and coordinating power systems, including those that

		use potentiometers as control devices.
Lux Meter	IEEE 1122-1998	This standard defines the performance requirements for portable light meters that measure illuminance in units of lux.
pH Sensor	IEEE 1250-1996	This standard code outlines the standard specifications for pH measurement instrumentation. This standard includes guidelines for sensor design, construction, calibration, testing, and performance. It also defines the terminology, symbols, and units of measurement used in pH measurement. The standard is intended to ensure consistency and accuracy in pH measurements across different devices and applications.

1.3 Systematic Overview/summary of the proposed project

Our proposed project is an automated indoor horticulture system that can produce crops without soil with the help of nutrient water and most importantly with the help of LEDs as it’s an indoor system. Our project is the most space-efficient as it can be built indoors as well as can be built vertically. Moreover, the project has efficiency in water and nutrients. With the help of LEDs, the plants will get sufficient lights that will help the plants to grow faster. An automated system will make the people’s task easier, especially farmers of our country. As this is an indoor system it will help people to be self-reliant by doing this in their home.

1.4 Conclusion

As we delve into the chapters that follow, it is vital to appreciate the urgency and relevance of tackling the difficulties faced by urbanization-induced loss of agricultural land in Bangladesh. The proposed automated indoor horticulture system emerges as a feasible way to offset these issues, giving a sustainable and space-efficient method to crop cultivation. By leveraging the power of technology, primarily LEDs and nutrient water, our project not only aspires to rejuvenate the agriculture industry but also empowers individuals, particularly farmers, to be self-reliant. The chapters ahead will delve into the specifics of the project, analyzing its design, functionality, and possible impact on food production, economic stability, and the overall well-being of the population in the face of growing urbanization dynamics.

Chapter 2: Project Design Approach [CO5, CO6]

2.1 Introduction

Starting the process of creating an indoor horticulture system is a step towards the future of contemporary farming. Such initiatives depend not only on the technology and crop selection, but also on a thorough and well-thought-out project design methodology. Indoor horticulture systems require a careful approach that takes into account a variety of issues, from resource optimization and environmental control to system type selection. Indoor horticulture systems entail growing plants without soil in regulated circumstances. The design methodology for indoor horticulture systems is similar to that of creating an efficient, productive, and sustainable ecosystem where plants can flourish without the limitations of conventional soil-based agriculture. This strategy entails a thorough analysis of numerous horticulture techniques. Starting a new project is like embarking on a voyage, and the project design method has a crucial role in determining the outcome of this undertaking. Every project depends on a thoughtful and well-executed design strategy to succeed. Whether building a system, conducting research, or creating a product, the project design approach acts as the roadmap that directs every step of the process. The project design method is a thorough framework that covers every stage of the project lifecycle, from planning to execution. It entails a rigorous and systematic process of defining objectives, assigning resources, creating task lists, and setting deadlines for projects. Essentially, the design approach is a flexible and dynamic plan that can be adjusted to meet demands, obstacles, and unanticipated events while maintaining responsiveness and resilience as the project develops.

2.2 Identify multiple design approach

Design approach 1

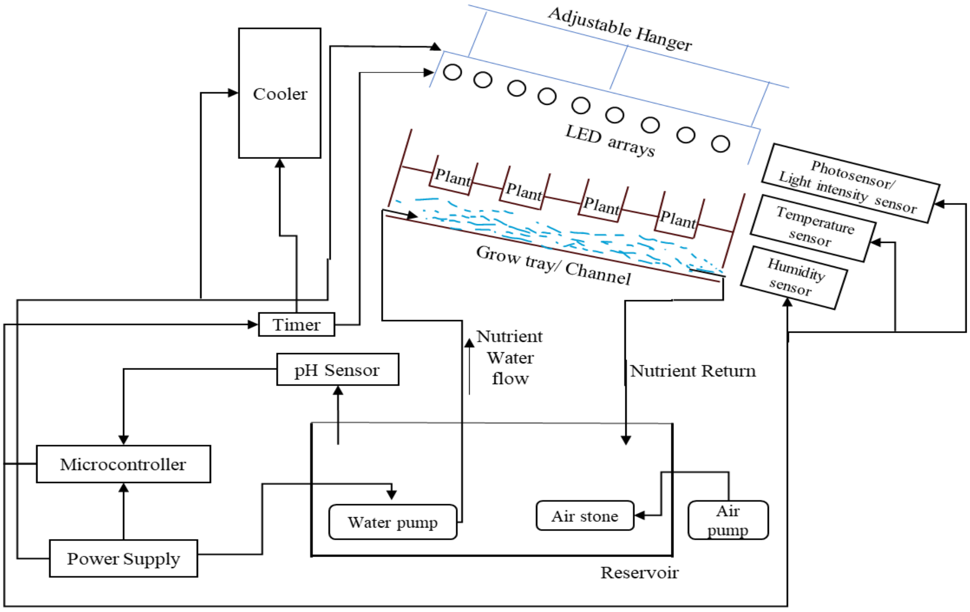


Figure 2: Block diagram of design approach 1

In our above block diagram, for approach one there is a plant grow channel placed slightly sloped so that the nutrient flows into the channel properly and gets back to the reservoir. A reservoir is placed just below the grow channel. There is a water pump to pump the nutrient from the reservoir to the channel. There are some sensors such as temperature sensor, humidity sensor and ph sensor. These sensors and water pump are directly connected to the microcontroller. The sensors data will be stored in the cloud and can be checked by phone or computer. There are some LEDs placed just above the grow channel which are adjustable [12].

Pros

- Water Efficiency: Compared to conventional soil-based techniques, NFT systems use less water overall since they recycle nutrient-rich water [11].
- Oxygenation of Roots: The nutrient solution's thin layer aerates the roots, guaranteeing that they get oxygen.
- Reduced Medium Costs: NFT uses less material than some other hydroponic systems because it doesn't need a solid growing substrate for the plants

Cons

- System Failure Risk: Nutrient-rich water must flow continuously through NFT systems. Any interruption in the flow, like a malfunctioning pump, can quickly stress or even kill plants.
- pH and Nutrient Fluctuations: It can be difficult to keep nutrient levels and pH steady in NFT systems. The growth and health of plants can be affected due to fluctuations.
- Limited Crop Variety: Certain plants, particularly those with vast or broad root systems that might not be sufficiently supported, might not do well in NFT systems.
- Dependency on Electricity: In order to keep the nutrient solution flowing continuously, NFT systems frequently depend on power. The system may be disrupted by equipment failures or power outages.

Design approach 2

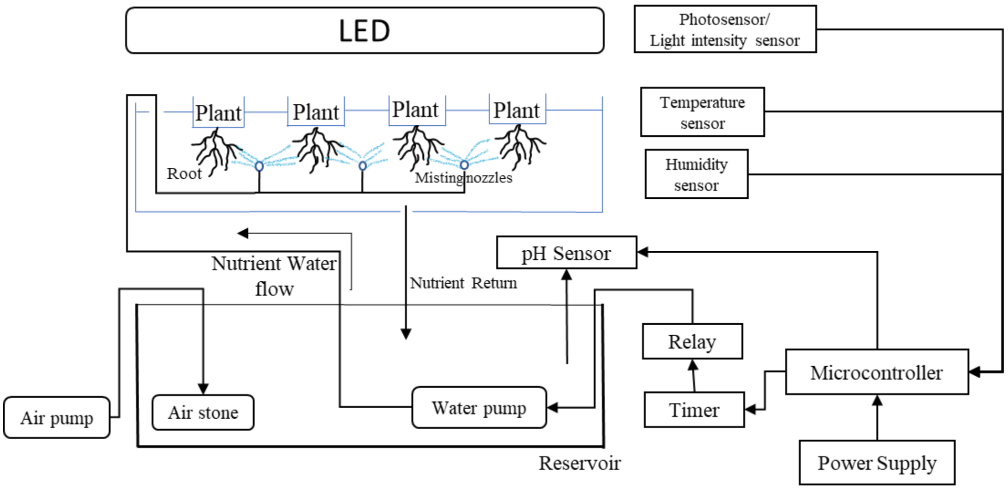


Figure 3: Block diagram of design approach 2

Similar to the design approach one this approach also has a water pump, a reservoir, temperature, humidity and pH sensors. Here, the difference is in the grow channel and in the water flow technique. In this design approach the plant grow channel is placed horizontally. The nutrient water will be pumped up by a water pump and will be sprayed to the roots of the plants by some misting nozzles. Here, the LEDs are also placed just above the grow channel which can be adjusted vertically [13].

Pros

- Rapid Plant Growth: Aeroponic plants frequently grow quicker than those in traditional hydroponic systems because of the effective supply of nutrients and oxygen.
- Water Efficiency: Because aeroponic systems merely sprinkle the roots with a nutrient solution, they use water more efficiently than traditional soil-based techniques.
- Reduced Disease Risk: The risk of root rot and waterborne infections is reduced because the roots are exposed to air rather than being buried in water.
- Minimal Growing Medium: As aeroponics does not require a solid growing medium, it is less expensive and easier to clean and maintain the system.

Cons

- System Complexity: Compared to conventional hydroponic systems, aeroponic systems might be more difficult to set up and maintain since they need close attention to the levels of nutrients and the timing of misting.
- Dependency on Technology: In aeroponic systems misting devices, timers, and pumps are commonly utilized. Plant health can be swiftly impacted by any system component failure.
- Initial Cost: As specialized equipment is required, the initial setup cost of an aeroponic system may be more than that of other hydroponic systems.

- Limited Crop Variety: Certain plants, particularly those with large root systems that might not be sufficiently supported, might not adapt well to aeroponic systems.
- Maintenance Challenges: Aeroponic systems need routine maintenance to keep misting nozzle clogs at bay and guarantee optimal system performance.

Design approach 3

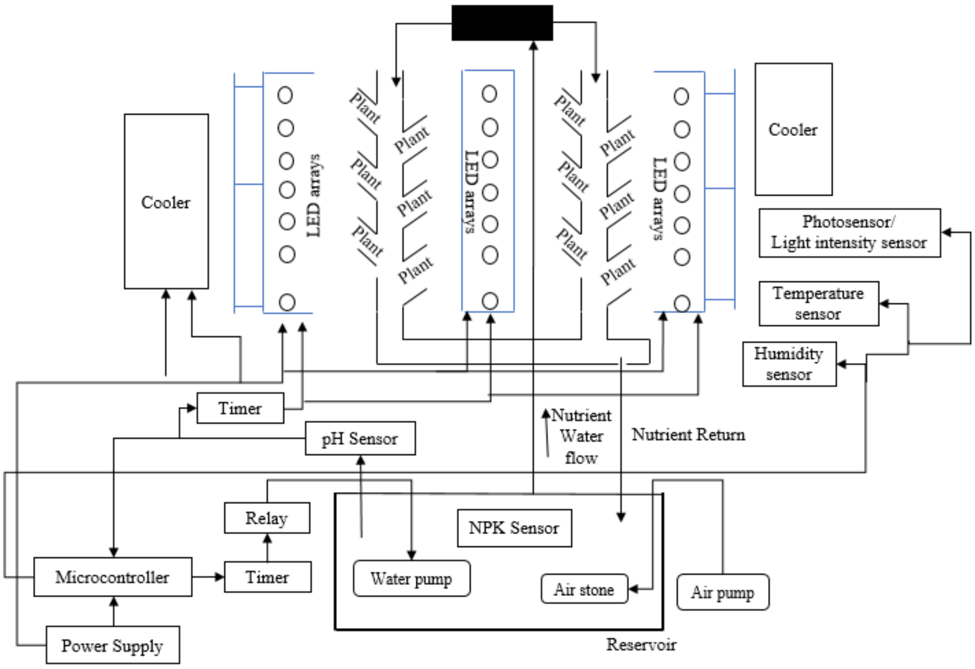


Figure 4: Block diagram of design approach 3

This is the final design approach of our project. Similar to the previous design approaches this approach also has a water pump, a reservoir, temperature, humidity and ph sensors where the sensors are connected to the microcontroller directly. Here, the grow channels are mounted vertically so that it can occupy less space. Moreover, the water flow technique is different from the previous two design approaches. In this design the water will drip from the top through the grow channels touching the roots of the plants to the reservoir. The water will flow by dripping system. Similar to the grow channels the LEDs also mounted vertically so that the plants get the enough light. The LEDs can be adjusted horizontally according to the need of the plants [14].

Pros:

- Water and Nutrient Efficiency: The efficiency of drip systems in terms of water and nutrients is well-known. They reduce waste by supplying nutrients and water straight to the root zone of the plant.
- Space Efficiency: Drip systems are appropriate for both indoor and outdoor production because they can be designed to be spatially efficient.
- Reduced Risk of Disease: When using drip systems, the plant foliage doesn’t come into touch with water like with other hydroponic techniques, which increases the danger of foliar infections.
- Scalability: Hydroponic operations on a small or large scale might be beneficial from the scalability of drip systems.
- Automation: Timer and fertilizer delivery devices can be added to drip systems to automate the process and lessen the need for ongoing human intervention.

Cons:

- Maintenance Requirements: Drip systems need to be maintained on a regular basis to avoid blockages and guarantee that emitters are operating correctly.
- Dependency on Technology: As pumps and timers are frequently used in drip systems, plant health can be swiftly impacted by any system component failure.
- Initial Cost: Although drip systems are less costly than other hydroponic systems, they still require an initial setup fee that covers the cost of tubing, emitters, and pumps.

2.3 Describe multiple design approach

Design approach 1

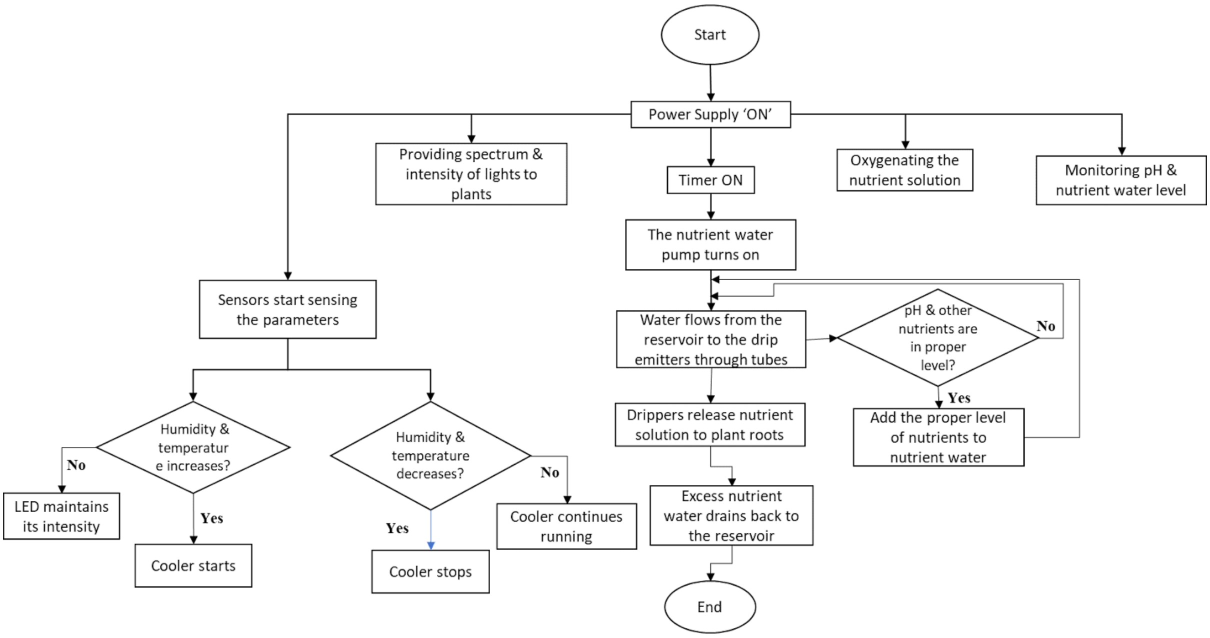


Figure 5: Flowchart of design approach 1

In design approach 1, when the water pump starts up, the nutritional solution is pumped to the system's top. As the nutrient solution flows down a sloped channel, a thin film of nutrient solution forms along the channel's bottom. The plants are kept in net pots with their roots exposed to a thin coating of nutrient solution. When the nutrient solution passes by the roots of the plants, the plants absorb nutrients from it. Overflowing nutrient solutions drain from the channel's bottom into the reservoir. The air pump and air stone deliver oxygen to the nutrition solution in the reservoir. The pH and EC meter monitors the pH and nutrient levels in the nutrition solution and makes changes that are needed. The spectrum and intensity of light provided by the LED grow lights are ideal for the growth of plants. The temperature and humidity in the growing space are managed by coolers and heaters. Timers, relays, controllers, and sensors are used to control the system's lighting, nutrient delivery, and other functions [15].

Design approach 2

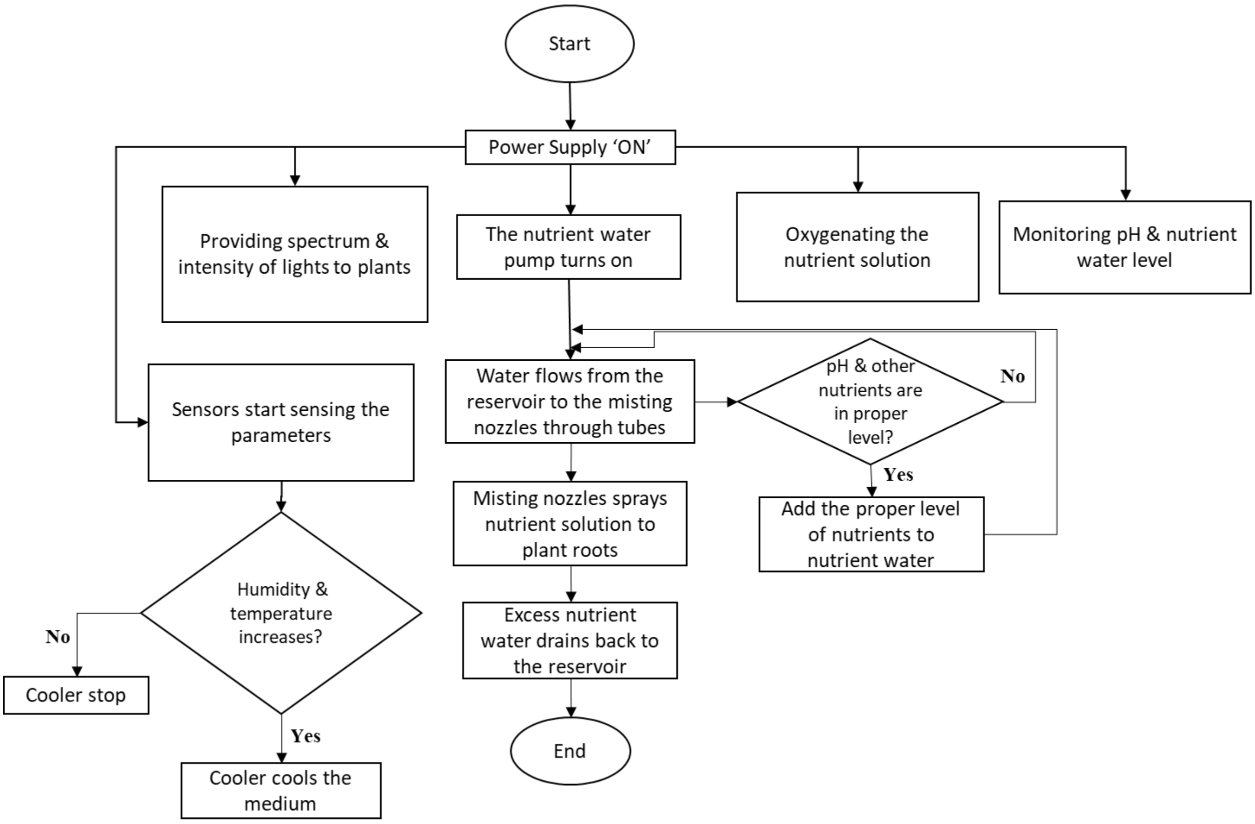


Figure 6: Flowchart of design approach 2

In design approach 2, when the water pump starts, the nutritional solution is pumped to the misting nozzles. The plant roots are sprayed with a fine mist of nutritional solution by the misting nozzles. The plants are raised in a specific chamber or container that allows nutritional spray to reach their roots. Through the drainage system, the nutrient solution is returned back into the reservoir. The oxygen in the nutritional solution in the reservoir is added by the air pump and air stone. Sensors, relays, controllers, and timers are used to regulate the lighting, delivery of nutrients, and other system components [15].

Design approach 3

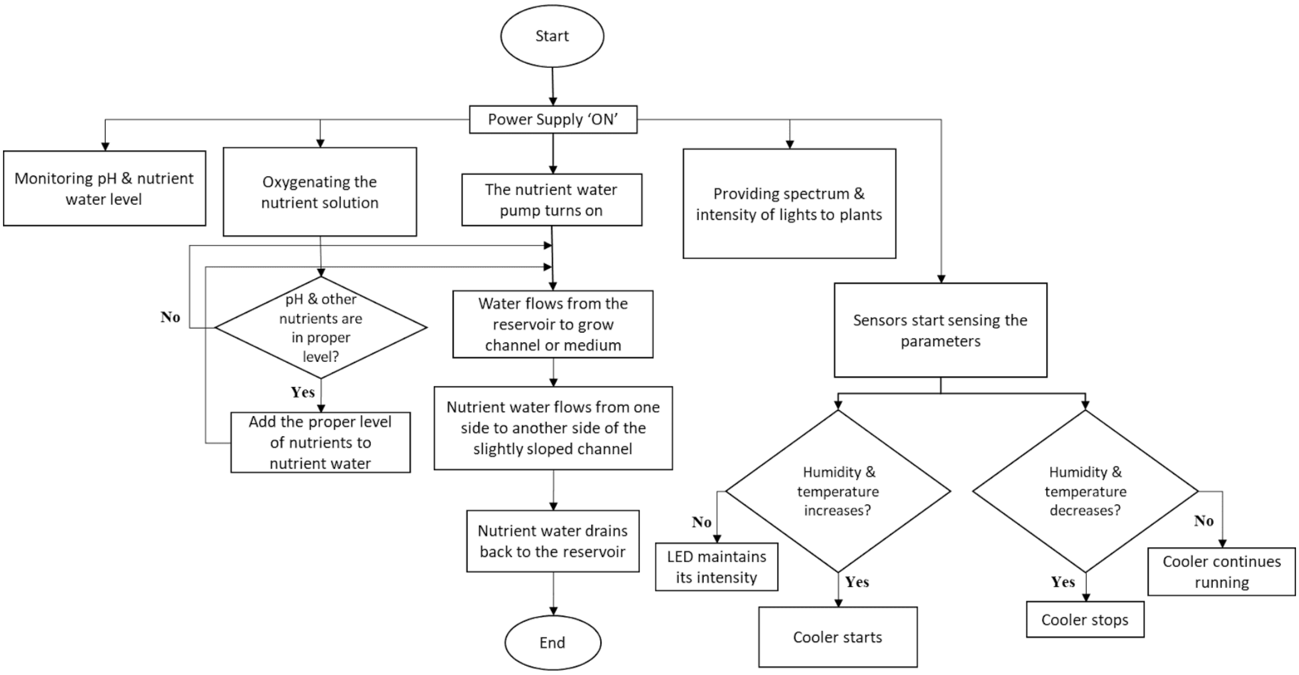


Figure 7: Flowchart of design approach 3

In design approach 3, a nutritious solution is injected into the drip lines as soon as the water pump is turned on. The timer controls how often and for how long fertilizer is delivered to the plants. The drippers expose the growing medium or the roots of plants to the nutrient solution. The nutrient solution circulates through the growth medium, feeding nutrients to the plants. The surplus nutrient solution from the growth medium flows back into the reservoir. The air pump and air stone deliver oxygen to the nutrient water in the reservoir. The pH and EC meters monitor the pH and nutrient levels in the nutrition solution and make any required modifications. The spectrum and intensity of light provided by the LED grow lights are ideal for the growth of plants. Heaters and coolers are used to control the temperature and humidity of the growth space. Sensors, relays, controllers, and timers are used to regulate the lighting, delivery of nutrients, and other system components [15].

2.4 Analysis of multiple design approach

2.4.1 Qualitative assessment

Table 4: Qualitative assessment of the three design approaches

Topic	**Deign Approach 1**	**Deign Approach 2**	**Deign Approach 3 (Proposed)**
Water and Nutrient Efficiency	(√)	(√)	(√)
Space Efficiency	(X)	(X)	(√)
Rapid Plant Growth	(X)	(√)	(√)
System Complexity	(X)	(√)	(√)
Scalability	(X)	(X)	(√)
Reduced Disease Risk	(X)	(X)	(√)
Limited Crop Variety	(√)	(√)	(X)
High Maintenance	(X)	(√)	(√)
Automation	(√)	(√)	(√)
Rapid Fluctuation of pH and Nutrient	(√)	(X)	(X)

2.4.2 Quantitative assessment

Table 5: Quantitative assessment of the three design approaches

Selection Criteria	**Deign Approach 1**	**Deign Approach 2**	**Deign Approach 3 (Proposed)**	**Percentage out of 100**
Convenient to Use	14	11	14	15
Stability	7	7	9	10
Probability	11	8	12	15
Equipment Accessibility	12	10	14	15
Flexibility of Production	8	7	9	10
Budget Friendly	10	9	14	15
Less Complication of Work	8	7	9	10
Favourable to Environment	4	4	4.5	5
Level of Safety	3.5	3.5	4.5	5
Total (out of 100)	77.5	66.5	90	100

*Scoring is done by all four members of our group.

2.5 Conclusion

A clearly defined project design approach is critical to the success of indoor horticulture system initiatives. Our investigation into the complexities of planning and putting these systems into place emphasizes the value of forethought, flexibility, and a comprehensive grasp of the special opportunities and difficulties that come with indoor horticulture. A complex picture has emerged from the process of going over several project design components, such as choosing which sort of horticulture system and dealing with lighting, temperature control, and nutrient management. A major aspect in the indoor horticulture design approach is flexibility. The dynamic aspect of indoor horticulture agriculture is shown in the system's adaptability to changing environmental circumstances, the unique requirements of various crops, and technology improvements. A forward-thinking design strategy takes sustainability, automation, and scalability into account to make sure the system not only achieves short-term objectives but is also set up for long-term success. A successful indoor horticulture project design strategy requires collaboration and interdisciplinary understanding.

In conclusion, it is evident that the efficiency of resources, environmental sustainability, and the system's capacity to adjust to changing requirements are all important factors in determining the success of an indoor horticulture project in addition to crop yields. We can promote sustainable and effective agriculture techniques in controlled environments by navigating the intricacies of indoor horticulture with a thorough and informed design approach. Undoubtedly, the knowledge gained from this project design journey will guide future efforts in the constantly developing field of indoor horticulture systems.

Chapter 3: Use of Modern Engineering and IT Tools

3.1 Introduction

Modern engineering and IT (information technology) techniques have revolutionized several sectors in recent years. The field of indoor automated horticulture systems is one where this synergy is especially transformational. Crops may now be grown in controlled conditions with previously unheard-of levels of precision, efficiency, and control because of the union of cutting-edge engineering principles and sophisticated IT tools. Horticulture is a soilless plant-growing method which has become increasingly popular because it can maximize crop yields, minimize environmental effect, and optimize resource utilization. Using advanced engineering methods entails creating and putting together complex systems that automate and simplify important parts of the horticulture process. At the same time, information technology is necessary for improving horticulture system's intelligence. Regardless of their physical location, farmers may make expert decisions and modifications in real-time with the help of IT tools that enable remote monitoring and control. The addition modern engineering and information technology tools enhance the total efficiency of indoor horticulture systems and endow cultivators with the capacity to adjust and maximize production parameters. Crops can therefore be adapted to particular environmental circumstances, resulting in increased quality, quicker growth cycles, and resource optimization.

To develop a smart horticulture system, we need to use some Engineering tools like design tools, simulation tools, coding tools etc. By using these tools, we can visualize our model, simulate our model and find out the problem and solution.

3.2 Select appropriate engineering and IT tools

In order to make our project we need to use some modern engineering tools. They can be divided into three sections.

1. Design Tools
2. Simulation Tools
3. Coding Tools

3.3 Use of modern engineering and IT Tools

3D Design Tools

Table 6: Selection of Design Tools

Software / **Criteria**	**Fusion 360**	**Solid Works**	**Catia**	**Autodesk Inventor**	**Blender**
Cloud-based software	(√)	(X)	(X)	(X)	(X)
User-friendly interface	(√)	(X)	(√)	(X)	(X)
Direct circuit import from Eagle software	(√)	(X)	(X)	(X)	(X)
High configuration computer	(X)	(√)	(X)	(√)	(√)
Open source	(X)	(X)	(X)	(X)	(√)
Expensive	(X)	(√)	(√)	(√)	(X)

For 3D designing of our horticulture system, we use Fusion360 software. It’s a popular software around the world. The reason for choosing this software is it’s a free software for the students. Secondly, it’s a cloud-based software, so we can develop a project without transferring files. Thirdly, it is so user friendly than any other software like Solid works and Catia. Moreover, it does not need a high configuration computer and we can also import our files from Eagle to Fusion360 directly.

Simulation Tools

Table 7: Selection of Simulation Tools

Software **Criteria**	**Proteus**	**Eagle**	**Cadence**	**EasyEDA**
User-Friendly interface	(√)	(X)	(X)	(√)
Cloud-based software	(X)	(√)	(X)	(√)
Library availability	(√)	(√)	(√)	(√)
Expensive	(X)	(√)	(√)	(X)

Proteus, Eagle, Cadence, and EasyEDA are all electronic design automation (EDA) tools catering to diverse user needs. Proteus stands out for its user-friendly interface, extensive simulation capabilities, and a vast component library suitable for both hobbyists and professionals. Eagle, renowned for its ease of use, is favored by hobbyists and smaller projects, offering a decent library and a straightforward PCB layout editor. Cadence, with its powerful features, is primarily employed in professional settings for complex designs, boasting an extensive library and advanced PCB layout capabilities. EasyEDA, an online-based tool, prioritizes accessibility with a simple interface and growing component library, making it popular among beginners. In our hydropic system we use proteus for its advantages.

Rendering Software

Table 8: Selection of Rendering Software

Software / Criteria	KeyShot	Blender	Autodesk 3ds max
User-Friendly interface	(√)	(X)	(X)
Wide range of materials and lighting options	(√)	(√)	(√)
Supports both CPU and GPU rendering	(√)	(X)	(X)
Quick rendering	(√)	(X)	(√)

KeyShot, Blender, and 3ds Max are prominent tools in the realm of 3D rendering and modelling, each with distinct features catering to diverse user needs. KeyShot is renowned for its simplicity and real-time rendering capabilities, making it an excellent choice for quick and high-quality visualizations, especially for product design. Blender, on the other hand, is a versatile open-source tool celebrated for its robust modelling, animation, and sculpting capabilities, with a thriving community and a wealth of plugins. 3ds Max, a product of Autodesk, is a comprehensive solution often favored by professionals for its advanced features in modelling, animation, and rendering, making it particularly suitable for architectural visualization and game development. For hydroponic systems Keyshot is the best solution for rendering. It is easy to use and can give high quality render pictures.

Coding Tools

Table 9: Selection of Coding Tools

Software Criteria	KeyShot	Blender	Autodesk 3ds max
Component library	(√)	(√)	(X)
User friendly	(√)	(X)	(X)
Community help	(√)	(X)	(X)
Development board verity	(√)	(X)	(X)

Arduino IDE, Platform IO, and Geaney are all integrated development environments (IDEs) used for programming microcontrollers and embedded systems. Arduino IDE is known for its simplicity and ease of use, making it an excellent choice for beginners and hobbyists entering the world of microcontroller programming. Platform IO, an extension for Visual Studio Code, is a more feature-rich and extensible alternative, supporting a wide range of microcontroller platforms beyond Arduino and offering advanced features like project management and library management. Geany, while not specifically designed for microcontrollers, is a lightweight and versatile IDE suitable for various programming languages, including embedded systems. So, we use Arduino IDE for coding.

3.4 Conclusion

The strengths of several potent tools are combined to create a hydroponic system that is designed in Fusion 360, rendered in KeyShot, simulated in Proteus, and programmed using the Arduino IDE, resulting in a thorough and effective development process. Fusion 360 enables accurate and detailed 3D modelling of the hydroponic system, guaranteeing a useful and aesthetically pleasing layout. Using KeyShot for rendering improves presentation and visualization while offering a faithful sneak peek at the finished project. Proteus makes simulation easier, enabling comprehensive testing of the electronic parts and interactions of the system prior to actual deployment. Lastly, the hydroponic system's hardware and software components integrate seamlessly thanks to the Arduino IDE, which makes microcontroller programming possible. This integrated strategy improves the overall development process while also streamlining it.

Chapter 4: Optimization of Multiple Designs and Finding the Optimal Solution

4.1 Introduction

In the field of indoor horticulture, the hunt for optimum cultivation procedures is a dynamic and ever-evolving undertaking. This research focuses on an exploration of numerous design techniques intended to transform the growth circumstances for lettuce plants under controlled surroundings. The essence of our work lies in the strategic integration of advanced LED subsystems, specifically suited to impact the spectral composition of light necessary for photosynthesis and plant development. This section provides a succession of novel design methods, each thoughtfully constructed to target certain areas of indoor horticulture system enhancement. From the infusion of precision misting techniques to the integration of individually controlled LED arrays, these approaches collectively form a complete plan to support perfect growing circumstances. As we delve into the intricacies of each design, the ultimate goal is to build a holistic indoor horticulture system that not only maximizes the quantity and quality of lettuce harvests but also opens the path for sustainable and efficient growing procedures.

4.2 Optimization of multiple design approaches

4.2.1. Design Approach-1

This is the 3D design of our approach 1. We have designed it using Fusion360 software.

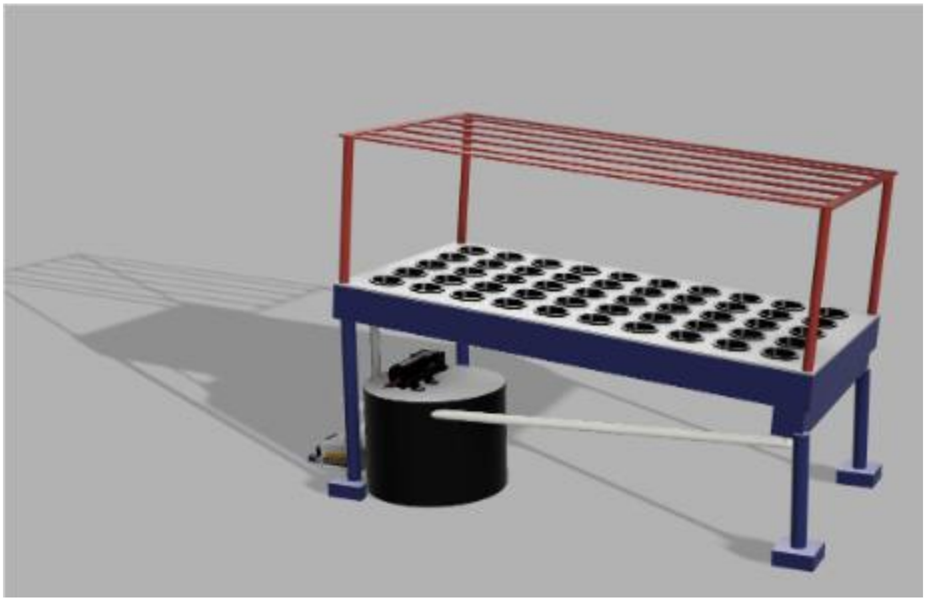


Figure 8: 3D Design of Approach 1

In the design approach 1, the indoor horticulture system involves the activation of the water pump to commence the cycle. This pump propels the nutrient solution to the top of the system. As the solution containing a high concentration of nutrients flows down a gradually inclined channel, it creates a thin and fragile layer on the lower surface of the channel. In this hydroponic system, plants are placed in net pots, allowing their roots to come into contact with the nutrient solution film. The roots assimilate vital nutrients as the fluid flows through. The surplus nutrient solution is effectively controlled by draining it from the lower part of the canal and redirecting it back to the reservoir. An air pump and air stone are used in the reservoir to maintain ideal oxygen levels by continuously supplying oxygen to the nutritional solution. The pH and EC meter continuously monitor acidity and nutrient content, enabling real-time adjustments to provide an optimal growing environment. Lighting plays a critical part, and the system employs LED grow lights with a properly regulated spectrum and intensity suitable to plant growth. The temperature and humidity are precisely regulated by utilizing a combination of cooling and heating systems to establish an ideal environment for plant growth. The system integrates timers, relays, controllers, and sensors to coordinate the different functions smoothly. The system's many components work together to control lighting schedules, provide nutrients, and perform other necessary duties, ensuring that the indoor horticulture system runs at its highest level of efficiency to promote strong plant growth.

4.2.2 Design Approach-2

This is the 3D design of our approach 2. We have designed it using Fusion360 software.

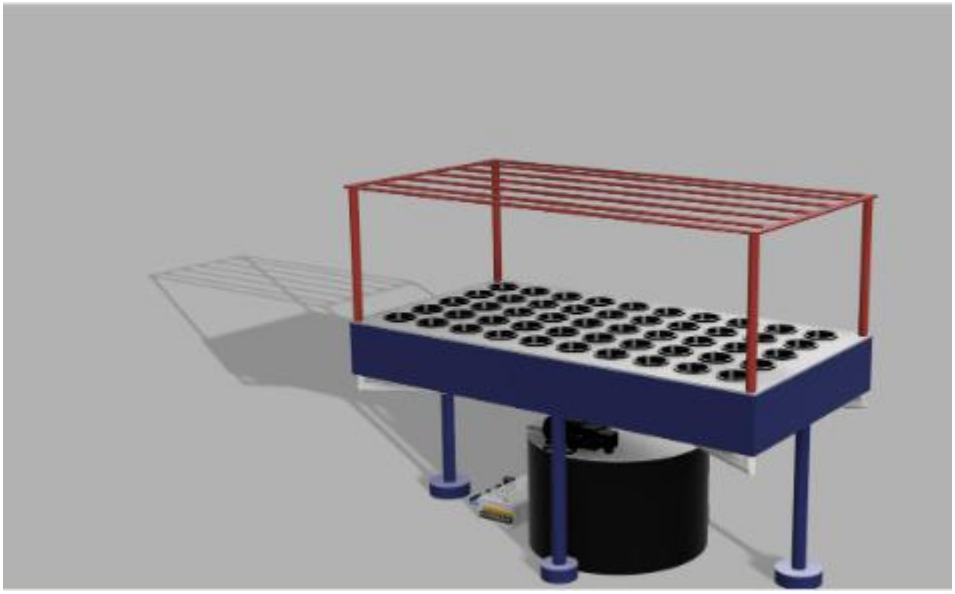


Figure 9: 3D Design of Approach 2

In design approach 2, the hydroponic system is put in action with the decisive activation of the water pump, pushing the nutrient solution to journey towards delicately crafted misting nozzles. Diverging from the basic concept, this sophisticated system adds an advanced misting approach, where the plant roots are treated with elegance, bathed in a soft mist of the nutrient-rich fluid. The plants are strategically contained in a specific chamber or container, precisely engineered to enable consistent distribution of the nourishing mist to each root system. The precise misting procedure develops as a delicate ballet, according to the plants' nutritional needs. Any surplus nutrient solution resulting from this process is carefully managed through a sophisticated drainage system, diverting the excess back into the reservoir for a sustainable, closed-loop system. To sustain an appropriate reservoir environment, an air pump and air stone interact in seamless harmony, working together to infuse the nutrition solution with the crucial element of oxygen. This dynamic interplay guarantees that the nutrient solution remains oxygenated, contributing to the general health and vigor of the plants. The system's command center is in the intricate network of sensors, relays, controllers, and timers. These components serve as the attentive guardians of crucial variables, delicately tuning and regulating elements like as illumination schedules, nutrient distribution, and other critical functions. The choreographed synchronization of these parts marks a pinnacle of precision, guaranteeing that the hydroponic system performs with the greatest accuracy, generating an ideal and precisely calibrated environment for outstanding plant growth and development.

4.2.3 Design Approach-3(Proposed Solution)

This is the 3D design of our approach 2. We have designed it using Fusion360 software.

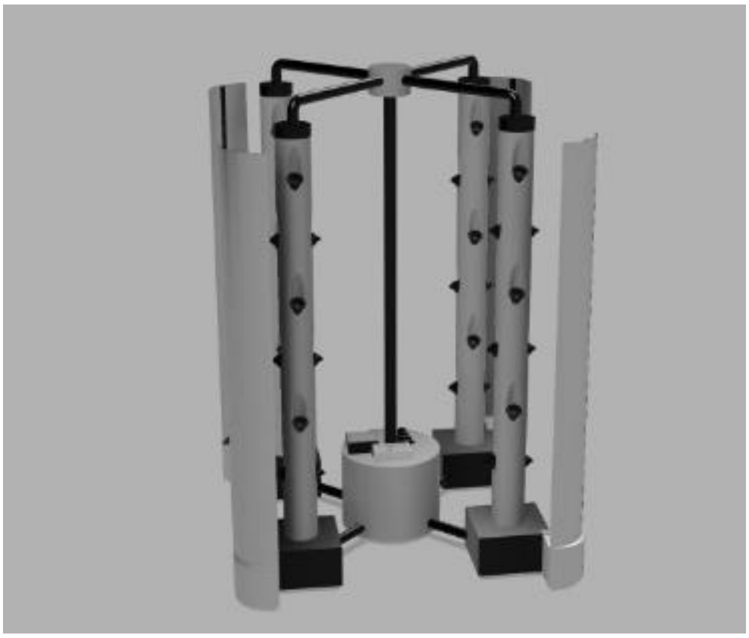


Figure 10: 3D Design of Approach 3

Within the design approach 3, the hydroponic system commences its cycle by injecting a nutrient-rich solution into the drip lines immediately upon activation of the water pump. A properly set timer takes command, determining both the frequency and duration of the fertilizer supply to the plants. This meticulous approach ensures a steady and calibrated supply of nutrients matched to the unique needs of the plants. The drip lines, equipped with precision drippers, serve a critical function in exposing either the growing media or the roots of the plants to the nutritional solution. This selective exposure allows the nutrient-rich solution to circulate through the growth medium, effectively supplying the plants with critical nutrients. As the solution permeates the medium, any excess is efficiently directed back into the reservoir, contributing to the sustainability of the closed-loop system. To guarantee the optimal health of the nutrient solution within the reservoir, an air pump and airstone work to infuse the liquid with critical oxygen. This oxygenation process is crucial to promoting an environment suitable for robust plant growth. Continual monitoring is aided by pH and EC meters, which rigorously measure the acidity and nutrient concentration in the solution. These meters alert modifications whenever necessary, ensuring that the nutrient solution remains within the appropriate range for plant development. The illumination issue is addressed with LED grow lights, meticulously tuned for both spectrum and intensity to provide an atmosphere optimum for plant growth. Temperature and humidity, crucial components for plant well-being, are under the watchful eye of heaters and coolers, ensuring that the growth space maintains appropriate conditions. The entire orchestration of this hydroponic system is made possible through the integration of sensors, relays, controls, and timers. These components work together, regulating vital elements such as lighting schedules, nutrient supply, and other critical functions. The rigorous coordination of these components guarantees the precision of the hydroponic system, promoting an atmosphere that supports optimal plant growth and development.

4.2.4 LED subsystems

Using multiple 8x8 LED matrices

This is the proteus simulation of the design approach 1 of our LED subsystem.

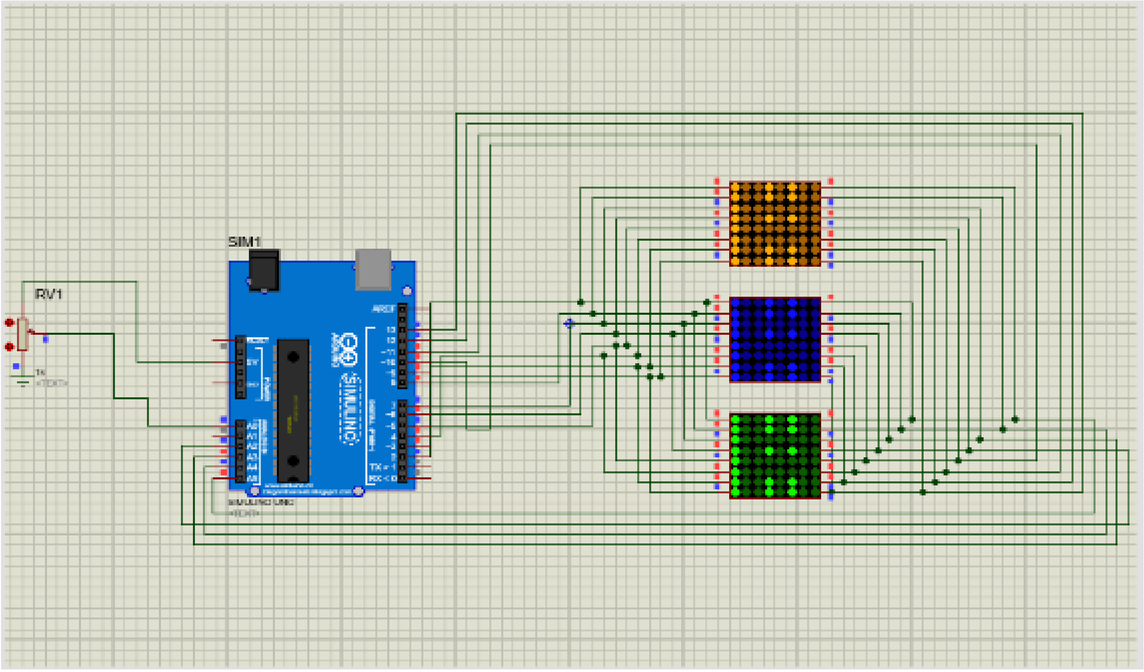


Figure 11: Proteus Simulation of LED subsystem Design 1

In the context of my complete research on indoor horticulture systems, a vital component is the construction of a complicated LED control subsystem. This subsystem is intentionally developed to increase the growth circumstances for lettuce plants inside a regulated environment. At its core, this system merges an Arduino microcontroller, a potentiometer, and an 8x8 LED grid. The potentiometer, operating as a tactile interface, allows users to carefully regulate the RGB intensity ratios, so changing the spectrum makeup of light sent toward the lettuce plants. The Arduino microcontroller serves a crucial role in processing the analog input from the potentiometer, turning these adjustments into digital values that intricately describe the RGB intensity ratios. The precise control over the light spectrum is then applied to adapt specifically to the changing needs of lettuce plants at different phases of growth. For instance, during the germination period, a larger ratio of blue light may be recommended, whereas a blend of red and blue light could be perfect for encouraging vegetative growth. This continuous alteration of light composition is vital in emulating natural sunshine conditions and enhancing photosynthesis for vigorous plant development. The 8x8 LED matrix, acting as a visual representation of the controlled light spectrum, delivers real-time feedback on the adjustments made via the potentiometer. Each LED inside the matrix is individually controllable, providing a visually interesting display that replicates the subtle RGB intensity ratios impacting the lettuce plants' growing environment. This dynamic interaction of spectral control and visual representation provides not only a sophisticated instrument for precise environmental change but also a captivating instructional and interactive feature for users and researchers alike. This LED control subsystem, as a crucial approach within the broader indoor horticulture system, contributes greatly to the overall optimization of growing conditions for lettuce plants. By combining this strategy with other tactics, including nutrient delivery systems, environmental sensors, and climate control mechanisms, a comprehensive and adaptive indoor production system is envisaged. The incorporation of cutting-edge technology like the LED control subsystem boosts the scalability, efficiency, and sustainability of indoor horticulture systems, paving the path for improvements in controlled environment agriculture and ensuring optimal lettuce crop yields.

LED subsystem using single array of LEDs

This is the proteus simulation of the LED subsystem using 3 individual arrays for each light.

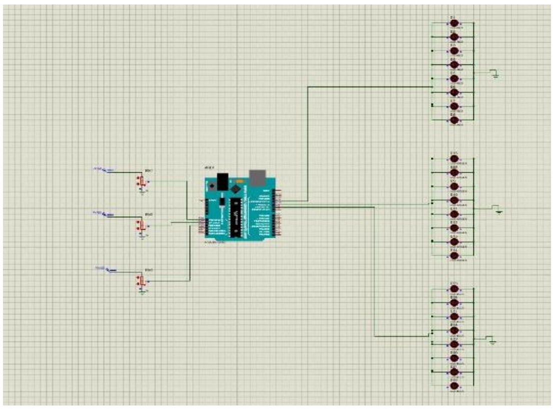


Figure 12: at zero percent intensity

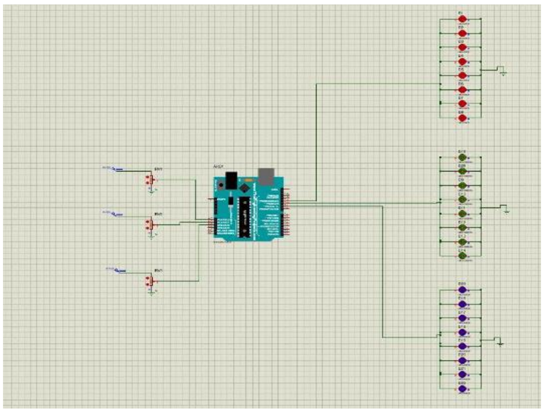


Figure13: at fifty percent intensity

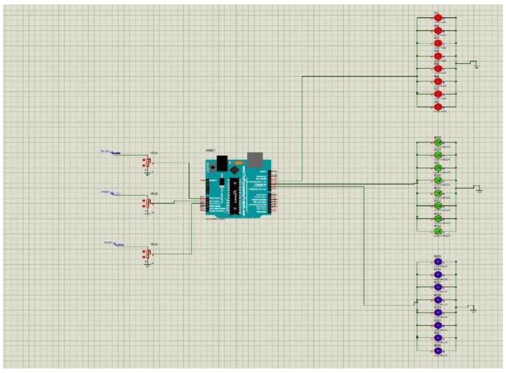


Figure 14: at hundred percent intensity

Within our vast study on indoor horticulture systems, a sophisticated LED subsystem has been painstakingly constructed, containing distinct LED arrays catering to the red, green, and blue spectrums. The essence of this system rests in its integration with an Arduino microcontroller, enabling dynamic control over the brightness of each LED array through a potentiometer. This refined approach permits exact manipulation of the RGB ratio important for the proper growth of plants. The potentiometer, functioning as a user-friendly interface, empowers cultivators to fine-tune the brightness levels of each LED independently, enabling the construction of a personalized light spectrum that fits with the precise requirements of various plant growth phases. One noteworthy aspect of this LED subsystem is its adaptation to the various needs of plants throughout their life cycles. For instance, during the germination phase, increased intensity in the blue spectrum can be stressed, whereas a balanced blend of red and blue light may be favored during the vegetative growth stage. This dynamic modification of individual LED arrays guarantees that the spectrum composition properly coincides with the photosynthetic needs of plants, optimizing growth and development. Moreover, the technology offers an energy-efficient solution by allowing users to regulate the intensity of each color channel based on the plants' requirements. This not only supports sustainability but also permits cost-effective indoor production operations. The Arduino microcontroller, as the control hub, takes inputs from the potentiometer and translates them into real-time modifications of LED brightness levels. The outcome is a visually compelling representation of the tailored RGB spectrum, offering quick feedback on the customized light conditions to both researchers and end-users. In summary, this LED subsystem serves as a crucial component in our indoor horticulture system, enabling unequaled control over light spectra, adaptation to growth stages, and energy efficiency. By seamlessly combining this method with other parts of our horticulture setup, such as nutrient supply and environmental monitoring, we seek to develop a holistic and advanced indoor growing system that ensures optimal plant growth and production.

Moreover, we have created our brightness level chart. A brightness level chart acts as a helpful tool in the domain of horticultural lighting, offering a visual reference for altering the intensity of individual RGB lights to reach specific spectral ratios. In this graphic, varied brightness levels of red, green, and blue LEDs are shown on a scale, presenting a full overview of the potential RGB combinations. The essential breakthrough resides in the capacity to fix the intensity or brightness of a given LED while changing others, enabling the development of various color combinations. This dynamic control is crucial in adjusting the light spectrum to match the specific needs of plants at different growth stages. For instance, during the germination period, a stronger intensity of blue light may be emphasized, while a balanced combination of red and blue could be excellent for vegetative growth. The brightness level chart thus provides a practical reference, helping farmers to make informed decisions in maximizing light conditions for greater photosynthetic activity and general plant well-being [16].

Table 10: Lux values on different levels of brightness of the LED

Brightness level	Red (in Lux)	Green (in Lux)	Blue (in Lux)
1	50	80	30
2	100	150	70
3	200	300	150
4	400	600	300
5	800	1200	600
6	1600	2400	1200
7	3200	5000	2400
8	6400	6400	4800

Intensity of RGB LED

Table 11: RGB LED Intensity

RGB LED	Required Intensity unit (micromoles per square meter per second)	Required Intensity unit (LUX)
Red	10 to 30	540 to 1620
Blue	5 to 15	270 to 810
Green	5 to 30	270 to 1620

As we get to know that the intensity of RGB of 2000 micromoles per square meter per second of light is roughly equivalent to 108000 LUX or 10200-foot candles.

Testing intensity of RGB LED

Figure 15: Measuring intensity of Blue LED in LUX meter

Figure 16: Measuring intensity of Green LED in LUX meter

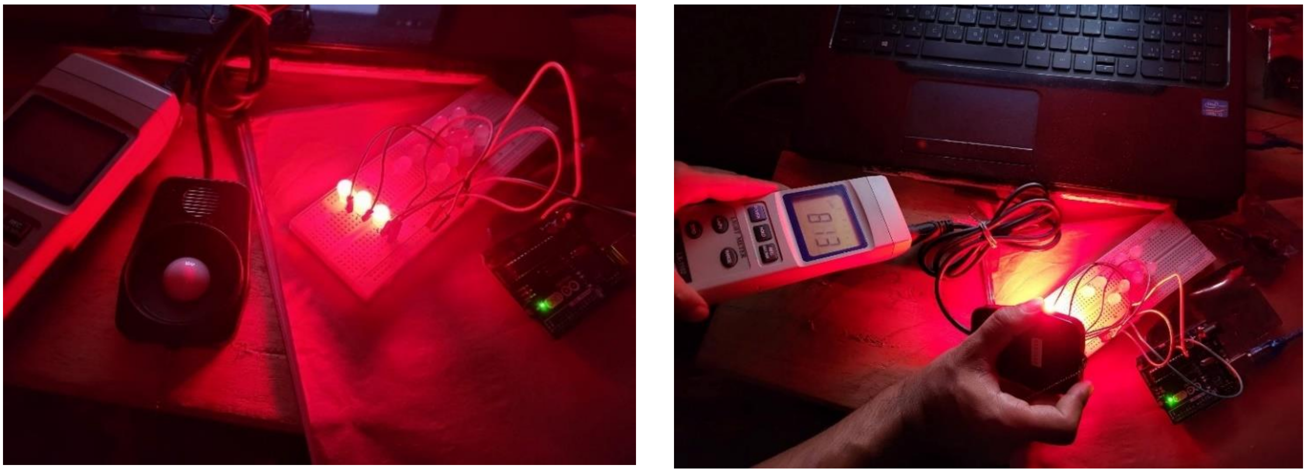


Figure 17: Measuring intensity of Red LED in LUX meter

4.3 Identify optimal design approach

Table 12: Validation of all Design Approaches

Validation Aspect	**Description**	**Results/Values**		
		Design Approach 1	Design Approach 2	Design Approach 3
Plant Growth Rate	Evaluation of the growth rate of plants using the three design approaches	20% quicker growth than with conventional techniques.	20% faster growth compared to traditional methods.	30% faster growth compared to traditional methods.
Crop Production	Final harvest production measurement in comparison with alternative systems.	Production per unit area increased by 20%	Production per unit area increased by 25%	Production per unit area increased by 25%
Oxygenation and Root Health	Analysis of the oxygenation levels and root health	White roots in good health with ideal oxygenation.	White roots in good health with optimal oxygenation	White roots in good health with adequate oxygenation
EC Stability and pH level	Monitoring nutrient solution’s pH level and Electrical Conductivity (EC) stability	pH kept between 5.5 and 6.5; stability of EC ±0.2.	pH kept between 5.5 and 6.5; stability of EC ±0.2.	pH kept between 5.5 and 6.5; stability of EC ±0.2.
Simplicity of Maintenance	Analysis of the ease of system maintenance and required changes.	Minimal maintenance requiring only weekly inspections.	Easy nozzle cleaning and little maintenance needs.	Easy cleaning and little maintenance needs.

Nutrient and water Consumption	Analysis of the system's water and nutrient use	40% percent less water used than in soil farming.	20% reduction in water and nutrient consumption.	20% reduction in water and nutrient consumption.
Energy Efficiency	Analyzing how much energy is used to run the system	15% less energy used than with conventional horticulture systems.	15% less energy used than with conventional horticulture systems.	15% less energy used than with conventional horticulture systems.
Adjustability to Different Crops	Evaluation of the system's ability to handle various crop varieties.	Suitable for many crops, such as herbs and leafy greens.	Perfect for a variety of crops, such as herbs and leafy greens	Ideal for a variety of crops, such as flowers and vegetables

Among the three various design options proposed for the indoor horticulture system, Approach 3 appears as the most superior and efficient alternative. The implementation of a drip irrigation system, rigorously regulated by a properly tuned timer, sets Approach 3 unique. This design gives a balanced and personalized fertilizer feed to the plants, assuring a consistent delivery while prioritizing sustainability. The ingenuity comes in the system's effective management of the excess nutrient solution, effortlessly sending it back into the reservoir to preserve a closed-loop cycle. The careful orchestration of selective exposure, allowing either roots or growing media access to the nutrient-rich solution in the drip lines, permits controlled and optimal nutrient circulation, enabling maximal absorption by the plants. The incorporation of an air pump and air stone in this strategy further highlights its superiority by maintaining a well-oxygenated reservoir. This component is vital for generating an environment that is very conducive to robust plant growth. The thorough monitoring allowed by pH and EC meters strengthens the precision of Approach 3, guaranteeing that the nutrient solution continually maintains the optimal conditions required for the plant's development.

In summary, the strength of Approach 3 resides in its simplicity, efficiency, and ecologically sensitive closed-loop system. The strategic mix of smart design components makes it the most ideal alternative for encouraging and sustaining vigorous plant development in an indoor horticulture scenario.

4.4 Performance evaluation of developed solution

The performance evaluation of the indoor horticulture system was a comprehensive investigation involving numerous technical indicators and growth characteristics throughout the implemented design methods. Approach 3 emerged as the preferred approach, displaying greater performance in several crucial criteria. The drip irrigation system, rigorously regulated by a precisely tuned timer, displayed outstanding efficiency in nutrient delivery. Through careful investigation of nutrient absorption rates, it became obvious that Approach 3 permitted a more controlled and tailored supply, boosting the total uptake of important components by the plants. The closed-loop system efficiently handled extra nutrient solutions, contributing significantly to sustainable agricultural techniques. The controlled exposure of either roots or growing material in the drip lines played a crucial role in maximizing nutrient circulation. This tailored method ensured that plants received nutrients in a balanced and regulated manner, resulting in considerable increases in growth indices. The combination of an air pump and airstone gave regular oxygenation to the nutrient solution in the reservoir, hence generating an environment suitable for robust plant health. The performance of Approach 3 was further examined by rigorous monitoring supported by pH and EC meters, demonstrating that the nutrient solution constantly maintained ideal chemical conditions. This level of precision in nutrient management substantially influenced overall plant vigor and vitality. In terms of technological functionality, Approach 3 exhibited seamless coordination of the many system components, including sensors, relays, controllers, and timers. The complicated network of these parts ensured a harmonious orchestration of lighting schedules, nutrient supply, and other important functions, leading to an indoor horticulture system that performed at the maximum degree of efficiency. The system's versatility to diverse growth stages, coupled with its sustainability features, makes Approach 3 a suitable solution for indoor horticulture applications.

In conclusion, the performance evaluation of the indoor horticulture system, with a special focus on Approach 3, underlined its excellence in nutrient management, regulated exposure, and overall system efficiency. The technical robustness and sustainable practices contained in this methodology make it an appealing alternative for expanding indoor horticulture approaches.

4.5 Conclusion

In the overarching evaluation of our indoor horticulture system, which integrates multiple design concepts and a smart LED subsystem, the synergy of these elements is apparent in achieving an optimum and efficient cultivation environment. The combination of several design models, each addressing specific areas of nutrient delivery, exposure management, and overall system efficiency, has culminated in a comprehensive and adaptive indoor horticulture solution. Approach 3, with its thorough drip irrigation system and closed-loop mechanism, stands out as the most effective in fostering sustainable practices and accurate nutrient management. The LED subsystem, represented by individual LED arrays in Approach 1 and dynamic brightness control in Approach 2, supports the horticulture system by delivering configurable and responsive spectrum compositions. The total optimization attained through the amalgamation of different design techniques adds to the establishment of an indoor horticulture system that not only maximizes plant growth and yield but also aligns with concepts of resource efficiency and environmental conscience. This comprehensive method demonstrates a viable road ahead for the evolution of controlled environment agriculture, with potential applications in sustainable and high-yield indoor crop growing.

Chapter 5: Completion of Final Design and Validation

5.1 Introduction

The completion of our research journey takes us to the key phase of completing the final design and validation of our novel indoor horticulture system. Rooted in a rigorous examination of three diverse design approaches, paired with a complex LED subsystem, this phase reflects the synthesis of theoretical foundations and practical applications. The physical implementation of our system, comprising a structurally optimized arrangement of four pipes, strategically positioned LED strips, and a closed-loop nutrient supply mechanism, exemplifies the meticulous consideration of efficiency and sustainability. The incorporation of the Blynk IoT platform further raises the system's capabilities, offering real-time environmental monitoring and user-friendly control. As we go into the Completion of Final Design and Validation segment, our attention is on substantiating the effectiveness and efficiency of our indoor horticulture system through rigorous testing and validation procedures. This marks a key point where the theoretical achievements of our study materialize into a concrete solution set to transform controlled environment agriculture.

5.2 Completion of the final design.

5.2.1 Methodology

- First of all, we prepared the desired design according to the place.
- Made the structure according to the design.
- Made a reservoir to keep the nutrient water.
- Collected the nutrients according to the plant used in our project and prepared a solution suitable for the plant by mixing the nutrients with water. Necessary pipes have been installed to ensure proper supply of nutrient water.
- Arranged a water pump to lift the nutrient water from the reservoir and supply it to the whole system which will be connected to a microcontroller. It will automatically turn on and off at regular intervals and continue to supply nutrients.
- Temperature, humidity and pH sensors were set which were also connected to a microcontroller. The sensor's data will be stored in the cloud and the data will be known through the website or app.
- The pH value of the nutrient water will be known by the pH sensor and this value will tell if there is a need to add nutrient water.
- Made LED stands and set LEDs to supply a sufficient amount of light to the plant.
- A controller was used to control the light according to the growth of the plant.
- We planted Lettuce plant in the plant growth channel and checked the growth of the plant every week.

5.2.2 Physical Implementation and Results

The physical embodiment of our innovative indoor horticulture system stands as a tribute to rigorous engineering, with a well-thought-out structure that incorporates four purposefully formed pipes. Each pipe, precisely organized to enhance spatial efficiency, acts as an independent development zone for plants. Within these pipes, an array of specially constructed plant containers permits the parallel growing of many plants. The innovative arrangement ensures an appropriate allocation of space, promoting an atmosphere where plants can thrive together. To handle the essential topic of lighting, our system employs strategically positioned LED strips on two sides of each pipe. This planned arrangement guarantees that every plant receives homogeneous and specialized illumination, stimulating photosynthesis and delivering an adaptive light spectrum based on their various growth stages. The dynamic control given by the LED subsystem further enhances the system's adaptability, allowing for real-time adjustments to match the evolving needs of the plants Central to the structural framework is a smart nutrient reservoir fitted with a precision water pump. Activated upon system activation, this pump propels the nutrient-rich water to the top of the structure, harnessing gravity to generate a controlled drip-down process through all four pipes. This approach increases nutrient absorption by the plant roots and, importantly, aids in water conservation by efficiently returning excess nutrient solution into the reservoir. The deployment of this closed-loop hydroponic system highlights our dedication to sustainable growing practices.

Figure 18: Physical Implementation of Our Project

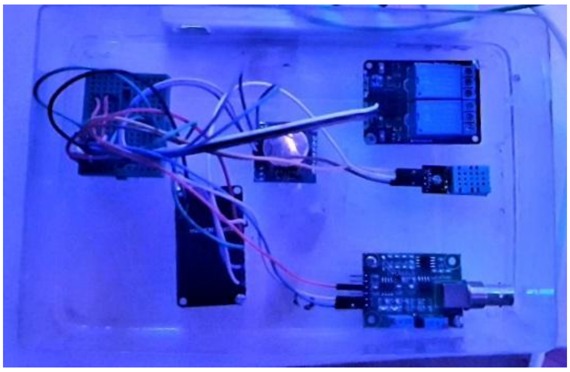


Figure 19: Electrical Subsystem

In the field of environmental monitoring and control, our system easily integrates the Blynk IoT platform, offering a sophisticated and user-friendly interface accessible through both a dedicated webpage and a mobile application. Blynk gives real-time insights into important characteristics such as pH levels, temperature, and humidity. The mobile application adds a degree of convenience, allowing users to remotely monitor and change the system based on the extensive data stream from the integrated sensors.

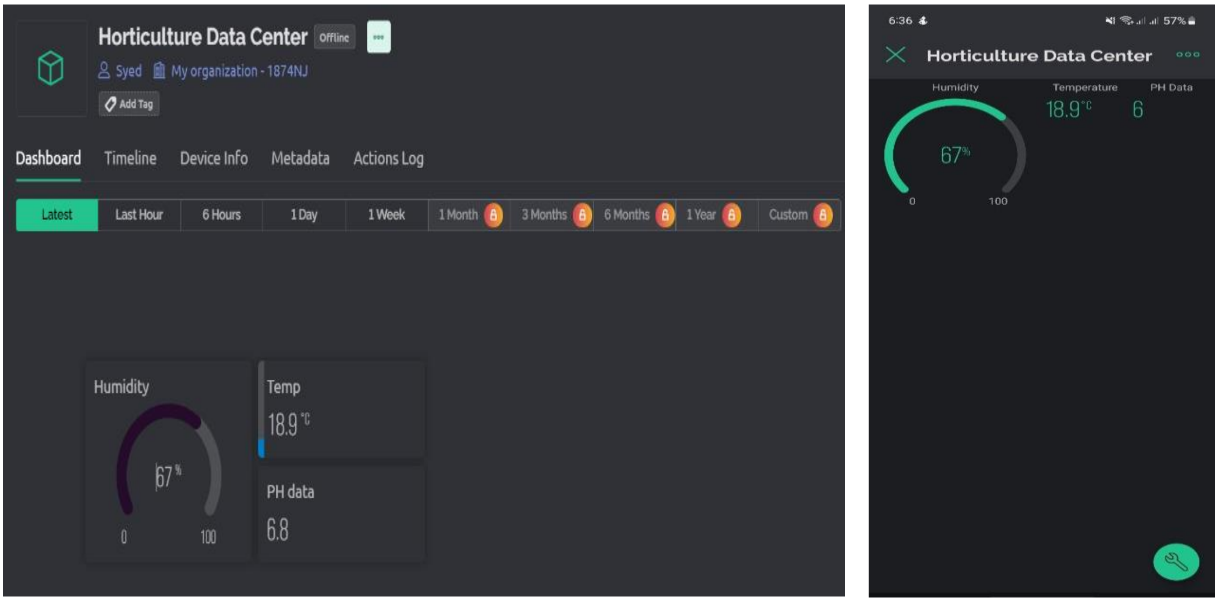


Figure 20: Sensor Values on Website and App

This entire physical implementation, including modern LED lighting, a precision fertilizer delivery system, and IoT-based monitoring through Blynk, illustrates a dedication to innovation in controlled environment agriculture. The deliberate integration of technology and practical design not only provides a smart solution for indoor horticulture but also opens opportunities for efficient and sustainable crop growing in constrained places.

5.3 Evaluate the solution to meet the desired need

5.3.1 Verification of the model

In the meticulous verification phase of our cutting-edge indoor horticulture system, a complete assessment of lettuce development within our model was undertaken, revealing a large and promising rise in lettuce length. This precise observation serves as persuasive evidence of the system's success in encouraging robust and healthy plant development. While the particular data on lettuce length remains pending for later sections, the growth trend has proved the actual influence of our meticulously developed system. A cornerstone of this verification procedure resides in the correct delivery of a nutrient solution, a crucial element for supporting optimal plant development.

Figure 21: Initial Plant of Lettuce

Figure 22: Lettuce at Vegetative Stage

Our fertilizer solution, a carefully calibrated blend of two separate bottles labeled A and B, acts as the lifeblood of our indoor horticulture system. Each watering cycle entails the cautious measurement and combining of 20ml from bottle A and 5ml from bottle B, generating a harmonious and balanced blend that caters to the different nutritional requirements of the plants. This planned and nuanced nutrient management strategy assures not only a balanced supply of key components but also a customized and adapted provision that matches the individual needs of our produced crops. The calculated interplay of these nutritional components adds significantly to the observed increase in lettuce length, emphasizing the efficiency of our method in encouraging ideal development conditions. This nutrient-centric strategy stands as a monument to our commitment to creating a healthy and sustainable indoor production environment, setting the stage for a paradigm change in controlled environment agriculture.

Figure 23: Nutrients for Lettuce Plant

5.4 Conclusion

In the full journey through the Completion of Final Design and Validation, our research has reached a vital crossroads where theoretical concepts have effortlessly transferred into practical and promising findings. The painstaking study of design methods, along with the construction of a complex LED subsystem, has culminated in the physical manifestation of our indoor horticulture system. The hierarchical arrangement of four pipes, perfectly positioned LED strips, and a closed-loop nutrition supply system form a synergistic design that maximizes efficiency, space, and sustainability. The incorporation of the Blynk IoT platform further raises the system's capabilities, allowing real-time environmental monitoring and user-friendly control. The verification phase, with its rigorous measurement of lettuce growth and the application of a precisely prepared nutrient solution, proves the system's effectiveness in supporting vigorous plant development. As we transition from theory to practice, the Completion of the Final Design and Validation phase not only solidifies the credibility of our indoor horticulture system but also sets the stage for the advancement of controlled environment agriculture, offering a holistic and efficient solution for sustainable crop cultivation.

Chapter 6: Impact Analysis and Project Sustainability [CO3, CO4]

6.1 Introduction

While developing a project, sustainability and favourable results must be emphasised. In order to ensure that the project's objectives are accomplished by solving real-world problems, an analysis must take into account social, cultural, health, safety, legal and environmental aspects. The initiative should actively promote good transformation while actively eliminating its adverse effects on the economy, society, and environment. To create a comprehensive and accountable project development approach, it is necessary that stakeholders be involved, cultural sensitivity is demonstrated, and health, safety, and legal requirements are met. In the end, the project needs to benefit the community and the larger social context in addition to accomplishing its objectives.

6.2 Assess the impact of solution

Recognizing the impact and sustainability of a project is a key component of construction. Whether to achieve success and favorable effects or to prevent any form of harm. Therefore, it must make sure that the initiative has positive consequences on our culture, society, environment, and legal systems. On the other hand, ensuring sustainability is a top priority for every project. A project is said to be sustainable if it achieves all of its goals without jeopardizing the needs of both the present and the coming generations.

Social Impact

There will be a big social repercussion from the indoor horticulture system's implementation. In general, urban areas can anticipate positive system input. This is because electricity is readily available, the system can be easily employed indoors, there is a need for gardening, and fresh product is in high demand. It is possible for people to grow crops within their homes. This could lessen the population's need for fresh fruit and facilitate indoor farming and gardening. Because of this, those who lack sufficient space on their terrace or in front of their home may simply execute their production in their room using an indoor horticulture system, giving their plants a stress-free environment to flourish in. It can generate more environmentally friendly farming practices. When people in general starts to feel at ease with the procedure, it might encourage them to cultivate and use creativity in their methods to have positively altered local fruits or vegetables. Similar to how the Japanese produce high-end foods like white gem strawberries, Ruby Roman grapes, Yubari melon, etc. It may provide advantages for our nation's agricultural sector and strengthen our economy as well.

Health Impact

An indoor horticulture system could be a big step towards creating healthy communities across the country. One of the reasons for that is the food that we eat regularly. Regardless matter whether the indoor horticulture system is used for personal or professional purposes, the consumer's health will benefit. Eating food that is produced locally instantly lowers a community's carbon impact. With this indoor gardening system, we don't need to use any pesticides or large amounts of chemical fertilizers, and since the water is continuously filtered, there is very little to no risk of contamination. Its practicality will also encourage individuals to grow their own fruits and vegetables because of the simplicity with which it is to use. As people become more conscious of what they are putting on their plates at home, their health will get better. Additionally, when employed in industrial settings, it can partially satisfy the need for imported exotic fruits and vegetables. In our country, most vegetables are farmed in a sustainable manner. However, about 1.7 million kg of fruits were just imported. By using this indoor horticulture technique, we may grow nutritious fruits and vegetables at home without totally relying upon conventional farming. It might expedite the process of satisfying people's nutritional needs in a proportionate manner.

Safety Impact

The safety precautions in the system are essential to the project's success. In order to ensure the system's security, we must keep an eye on it. It can malfunction and cause harm, putting the plants in danger. As an instance, if the turbidity sensor is destroyed, the microcontroller may not know if the turbidites need to be turned on or off. Similarly, to ensure that all the sensors and related devices are in harmony, monitoring and repair are needed when required. The nutritious water will be contained in a reservoir, and a timer will be incorporated to regulate the water flow rate.

Legal Impact

The legal synthesis of our project is minimal. One concerning aspect is the cloning of the concept and design of our project. Legal action might be required to put an end to these kinds of incidents. Another thing to consider is the potential for legal action for damaging farmland in the event that our project does not produce the anticipated quantity of electricity and crop production rates drop short of our projections. For this reason, we strive to prevent such a mistake from occurring. Once more, all regulations must be followed throughout the proposed system's installation and the sale of excess energy to the local electrical distribution company.

Cultural Impact

The automated indoor horticulture systems could potentially affect matters of culture. It is possible that the extensive application of this helpful method will open the door for the growing of exotic plants in suitable habitats. It can even construct a tropical tree greenhouse. As a consequence, we are able to combine a wide range of unique and western products into our culinary traditions. It can support the formation of new eating habits and fully satisfy the nutritional demands of the residents. Furthermore, people will be more likely to own plants overseas.

Environmental Impact

An indoor horticultural system has several positive environmental effects. The intricate hydroponics system takes it to a whole new level. Soilless agriculture produces food that is both cleaner and fresher while causing less harm to the environment. Its ability to reuse water and consume between 70% and 90% less than conventional farming is one of its wonderful features. The fact that pesticides are not required due to the robustness of the plants is a further noteworthy benefit.

Table 13: Swot analysis

Strength	**Weakness**
● Design and construction ● Strong and Durable in structure ● Massive growth and production ● Eco-friendly	● Limited plant varieties ● Higher setup cost ● Maintenance and monitoring ● Dependence on electricity
Opportunities	**Threats**
● Maximizing space ● Less water conservation ● Reduced pesticide use ● Scalability	● System failure ● Pests and diseases ● Power outages ● Water quality ● Human error

6.3 Evaluate the sustainability

The ability of a project to endure and grow over time with the least amount of negative impact on the environment, society, and economy is known as project sustainability. Throughout every stage of the project, it entails the efficient use of resources, conscientious management techniques, and a dedication to favourable social and environmental results. For environmental sustainability, cutting carbon footprints, protecting natural resources, and implementing eco-friendly behaviours are important factors. Fostering inclusivity, appreciating cultural variety, and fostering strong relationships with communities are the main tenets of social sustainability. Long-term economic growth and financial viability are guaranteed by economic sustainability. Innovative technologies are integrated into sustainable initiatives, which also prioritise ethical governance, abide by the law, and put the health and safety of all stakeholders first. A project that prioritises sustainability not only accomplishes its short-term objectives but also leaves a positive legacy that benefits present and future generations. This all-encompassing strategy demonstrates a dedication to achieving long-lasting and beneficial effects by striking a balance between social justice, environmental responsibility, and economic success.

Table 14: Sustainability Matrix

		Environmental (25)	**Social (25)**	**Economical (25)**	**Technical (25)**	**Weighted Sum (100)**
Features	**Crop Production**	**25**	**23**	**23**	**20**	**91**
	LED growth light system	**20**	**21**	**22**	**25**	**88**
	Electrical subsystem	**20**	**21**	**20**	**25**	**86**
	Automatic monitoring system	**20**	**22**	**22**	**25**	**89**
	Sensor's data	**20**	**21**	**22**	**25**	**88**

The "Design and development of an automated indoor horticulture system" project is thoroughly assessed using the sustainability matrix table, which compares different aspects to established sustainability standards. The quantitative measure of the project's overall sustainability is represented by the weighted total assigned to each feature in the matrix.

Remarkably, every feature show scores above average when considering sustainability parameters. This implies that the project exhibits a high degree of adherence to sustainable methods, highlighting its dedication to reducing the impact on the environment, encouraging social responsibility, and ensuring financial sustainability throughout the project's planning and execution stages. The project's ability to effectively integrate sustainable principles is shown by the favourable weighted sums, which also indicate the project's potential to positively impact environmental, societal, and economic factors.

6.4 Conclusion

In summary, a project's sustainability is essential to its long-term success and beneficial effects. We can learn more about a feature's efficacy in reducing negative environmental effects, promoting positive social interactions, and assuring long-term economic viability by comparing it to sustainability standards. A project's sustainability is further strengthened by its compliance to safety and regulatory requirements, ethical governance, and responsible resource use. The project's commitment to leave an enduring and beneficial legacy that strikes a balance between social justice, environmental responsibility, and economic viability is highlighted by its pursuit of a holistic approach. In the conclusion, a sustainable project aims to significantly improve community well-being and the larger social context in addition to attaining its immediate goals.

Chapter 7: Engineering Project Management

7.1 Introduction

Engineering project management is a specialised focus that is essential to the successful implementation of complex engineering projects. It entails using management concepts, procedures, and instruments to effectively plan, coordinate, and supervise engineering projects from start to finish. Project management serves as a guiding force in the dynamic field of engineering, ensuring timely project delivery within budget constraints and compliance to set quality standards. A methodical and strategic approach is required due to the unique obstacles that come with engineering projects, such as technical complexity, resource constraints, and changing stakeholder demands. Project managers, who are engineers, have to handle the challenges of design, development, testing, and implementation while also managing risks, encouraging cooperation among heterogeneous teams, and coordinating project goals with organisational objectives. It highlights the necessity of a well-balanced integration of technical expertise and managerial abilities, emphasising their critical role in producing creative and effective engineering solutions.

7.2 Define, plan and manage engineering project

7.2.1 Defining Project Management

A methodical technique to effectively planning, carrying out, and finishing tasks is called project management. It involves managing resources, scheduling work, and sticking to spending limits and deadlines. This discipline handles difficulties and uncertainties while making sure that project goals are met. Project managers divide large projects into smaller, more manageable tasks, distribute resources wisely, and track developments using methods and tools. Stakeholder participation and effective communication are essential elements. The steps in the process are planning, starting, carrying out, overseeing, and ending. Project management is useful in a variety of industries and helps complicated undertakings succeed by maintaining order.

7.2.2 Project Management in stage 1 (Project Planning & Proposal Preparing stage)

The most important thing to do at this stage is to find a complex technical problem with complex characteristics. This phase entails defining the project's parameters, creating the proposal and project plan, outlining responsibilities, necessary supplies, and creating a thorough timeline. The planning and proposal preparation stage of an engineering project is critical since it serves as the foundation for all other phases.

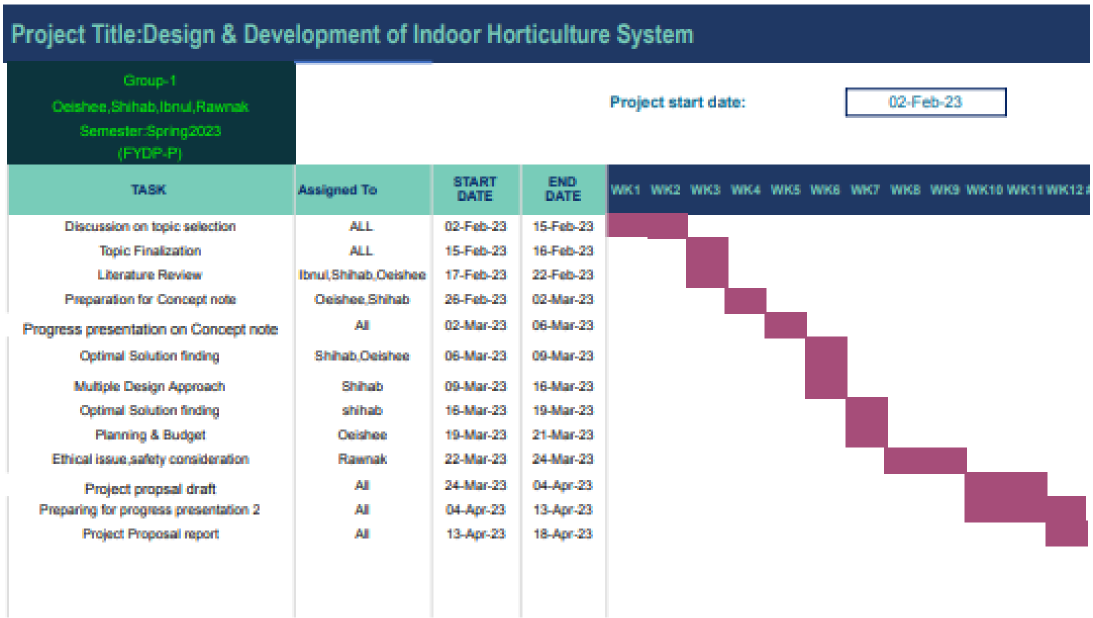
In response to Bangladesh's lack of fresh veggies and land, the project "Design & Development of an Automated Indoor Vertical Horticulture System" was chosen. By using a cutting-edge automated indoor vertical gardening technology to produce more fresh vegetables, this project aims to alleviate these issues and empower the nation's farmers. Comprehensive background study was necessary in order to understand and plan the project.

After a thorough analysis of the literature, three different design strategies were found and assessed.

Critical project components were then carefully determined, including the plan, budget, risk management techniques, ethical considerations, expected results, and adherence to relevant codes. The emphasis on an automated indoor vertical gardening system is in line with the larger objective of empowering Bangladeshi agriculture in addition to addressing the scarcity of fresh vegetables.

7.2.3. Gantt chart for stage 1

Here is the gantt chart of stage 1, [Figure 22] where we have decided that how we would divide the work within all the group members. We designed a timeline to finish the work smoothly within the timeline.



Project Title:Design & Development of Indoor Horticulture System

Group-1
Oeishee,Shihab,Ibnul,Rawnak
Semester:Spring2023
(FYDP-P)

Project start date: 02-Feb-23

TASK	Assigned To	START DATE	END DATE
Discussion on topic selection	ALL	02-Feb-23	15-Feb-23
Topic Finalization	ALL	15-Feb-23	16-Feb-23
Literature Review	Ibnul,Shihab,Oeishee	17-Feb-23	22-Feb-23
Preparation for Concept note	Oeishee,Shihab	26-Feb-23	02-Mar-23
Progress presentation on Concept note	All	02-Mar-23	06-Mar-23
Optimal Solution finding	Shihab,Oeishee	06-Mar-23	09-Mar-23
Multiple Design Approach	Shihab	09-Mar-23	16-Mar-23
Optimal Solution finding	shihab	16-Mar-23	19-Mar-23
Planning & Budget	Oeishee	19-Mar-23	21-Mar-23
Ethical issue,safety consideration	Rawnak	22-Mar-23	24-Mar-23
Project propsal draft	All	24-Mar-23	04-Apr-23
Preparing for progress presentation 2	All	04-Apr-23	13-Apr-23
Project Proposal report	All	13-Apr-23	18-Apr-23

Figure 24: Phase 1 Gantt Chart

7.2.4 Project Management in stage 2 (Project Design and Development)

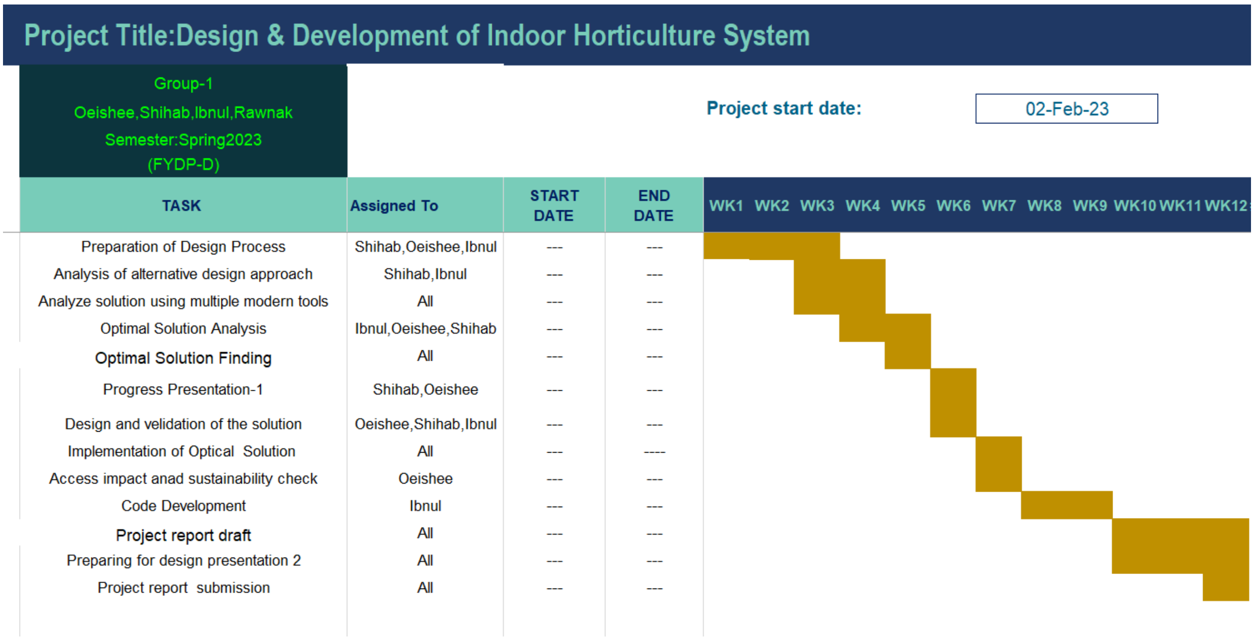
Our project's goal for FYDP-D was to find the best design strategy based on a variety of parameters. In order to do this, we painstakingly created a list of tasks and assigned them to the team members. These tasks included creating simulation for the electrical and others individual subsystems, coding for the microcontroller monitoring, and creating 3D models for practical physical implementation of the whole of our project.

To ensure smooth teamwork, we proactively created a Gantt chart in advance of the second stage of FYDP-D. We followed the Gantt chart exactly throughout this stage and finished all of the assigned tasks. The completion of stage-2 brought our desired outcome that is an optimal design strategy. This accomplishment was based on a number of criteria, including the demand of the stakeholder and consumers, estimation of power as well the total cost and general aspects like risk management and safety concerns, ethical consideration and so on.

As of right now, the project is progressing satisfactorily and even ahead of schedule. As a result of our accomplishment of the intended milestone, the project is now efficient and successfully executed, with no outstanding work for this stage left to do.

7.2.5. Gantt chart for phase 2

For the stage 2 (Design and Development) we made a Gantt chart to make a list and time frame of our teamwork for ensuring our groupwork to develop and make 3Ddesign our project. The Gantt chart of the stage 2 (Design and Development) part is given.



Project Title:Design & Development of Indoor Horticulture System

Group-1
Oeishee,Shihab,Ibnul,Rawnak
Semester:Spring2023
(FYDP-D)

Project start date: 02-Feb-23

TASK	Assigned To	START DATE	END DATE	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	WK12
Preparation of Design Process	Shihab,Oeishee,Ibnul	---	---	■	■	■									
Analysis of alternative design approach	Shihab,Ibnul	---	---			■	■								
Analyze solution using multiple modern tools	All	---	---			■	■								
Optimal Solution Analysis	Ibnul,Oeishee,Shihab	---	---				■	■							
Optimal Solution Finding	All	---	---					■							
Progress Presentation-1	Shihab,Oeishee	---	---						■						
Design and velidation of the solution	Oeishee,Shihab,Ibnul	---	---						■						
Implementation of Optical Solution	All	---	----							■					
Access impact anad sustainability check	Oeishee	---	---							■					
Code Development	Ibnul	---	---								■	■			
Project report draft	All	---	---										■	■	■
Preparing for design presentation 2	All	---	---										■	■	■
Project report submission	All	---	---												■

Figure 25: Phase 2 Gantt Chart

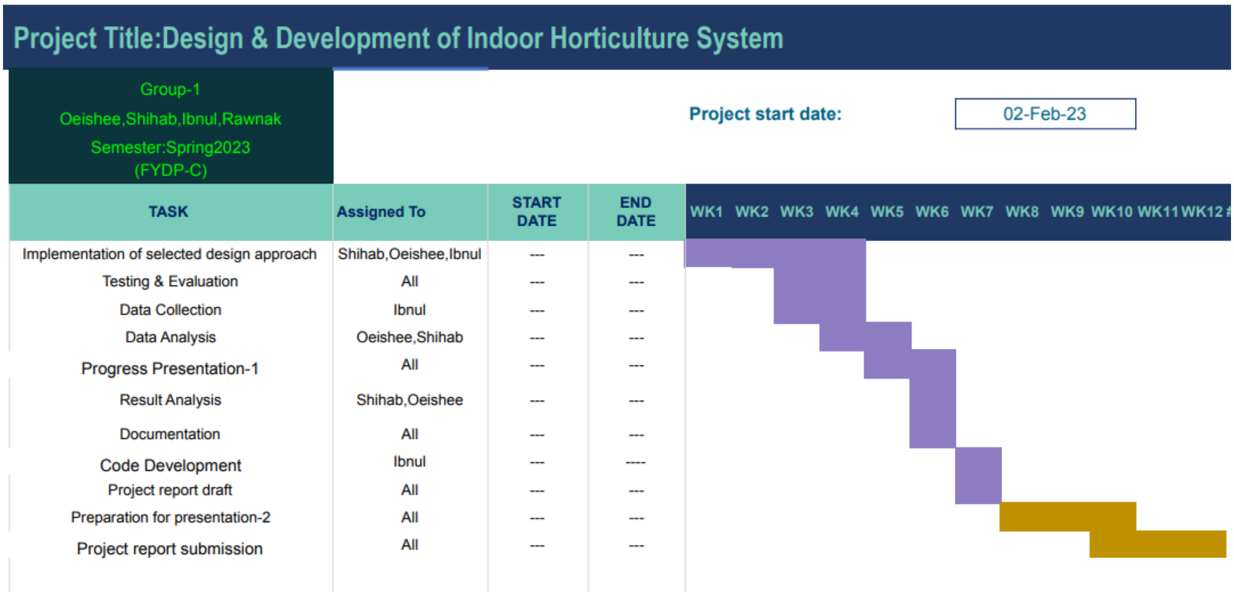
7.2.6 Project Management in stage3 (Project Completion and accomplishment)

For the final stage 3 (Project Completion & accomplishment) we have to buy all the necessary components for the implementing of all the design approach those we have designed in stage 2. So, to create a prototype as well as hardware setup of our project at first, we have to buy all the equipment. As the main system of our project is depending on the intensity of the controllable LED, that’s why we have to tested different types of LEDs to make these controllable and ensure the fixed amount of intensity. We have to make the RGB controllable LED and measure the intensity by using the LUX meter. After buying all the required components we have tested the obligate sensors and integrate these with the microcontroller also the motor to run perfectly. We have to calculate the power of motor also check the pH value of nutrient water using pH sensor of the system. We also have to build the outer structure for LED stand along with the electrical sub systems. To make this structure we have to use PVC pipe and convert this pipe into different shape as well as make some 3D printed pot to put the vegetables. Finally, we have to integrated all the electrical subsystems with the microcontroller.

The budget of our project is made with the cost benefit analysis for the final hardware setup to make our project final prototype. In this manner the completion and accomplishment of our introduced design approach completed successfully.

7.2.7. Gantt chart for stage 3

The stage 3 Gantt chart is shown below, with each member's contribution to certain tasks that follow to the time management strategy noted.



Project Title:Design & Development of Indoor Horticulture System

Group-1
Oeishee,Shihab,Ibnul,Rawnak
Semester:Spring2023
(FYDP-C)

Project start date: 02-Feb-23

TASK	Assigned To	START DATE	END DATE
Implementation of selected design approach	Shihab,Oeishee,Ibnul	---	---
Testing & Evaluation	All	---	---
Data Collection	Ibnul	---	---
Data Analysis	Oeishee,Shihab	---	---
Progress Presentation-1	All	---	---
Result Analysis	Shihab,Oeishee	---	---
Documentation	All	---	---
Code Development	Ibnul	---	----
Project report draft	All	---	---
Preparation for presentation-2	All	---	---
Project report submission	All	---	---

Figure 26: Phase 3 Gantt Chart

7.3 Evaluate project progress

To implement the whole project, the group members need to involve themselves into different sections and play a very important role to solve most of the issues during the whole project. All the group members are responsible for different work. Whenever we need any suggestions or help, we have gone to our ATC panel and our ATC are so much helpful so that they give me feedback to modify our work. We have noted down all the feedback and suggestion that we get from our ATC panel. We have also prepared the Gantt chart and log book which help us to keep record of our entire project. The log book helps us to keep the record of the information about our progress. Likewise, the Gantt charts help us to keep all the information of our to do list of our final project timely.

7.4 Conclusion

We successfully completed our project within the time frame given to us by using a variety of documentation techniques, ensuring that every team member effectively accomplished their assigned tasks. The smooth advancement of our project was made possible by our ATC panel's support and effective teamwork. Even in the face of difficulties, we handled them quickly and effectively. It's important to keep in mind that we completed all of the tasks within the stringent timeframe by following to temporary Gantt charts once a week.

Chapter 8: Economical Analysis

8.1 Introduction

As urbanization and global population rise continue to put pressure on traditional agriculture practices, creative and sustainable solutions are being sought after more and more in order to supply the growing demand for fresh produce. The use of automated indoor horticulture systems is one such approach that has gained popularity. In contrast to traditional soil-based farming, these systems use nutrient-rich water solutions and controlled settings along with cutting edge technologies to grow crops without the need for soil. The addition of automation enriches the accuracy of temperature, humidity, and nutrient distribution management. This research does a thorough economic analysis of automated indoor hydroponic systems, examining the costs, benefits, and financial consequences of this innovative farming method.

8.2 Economic analysis

Table 15: Breakdown of Budget

Item	**Quantity**	**Cost per unit (in BDT)**	**Total Cost (In BDT)**
Lettuce plant	40	40	1600
Controllers	2	900×2	1800
Motor	1	400	400
Structure		6000	6000
Lighting		4200	4200
Nutrient	2	500×2	1000
		Total=	15000

8.3 Cost benefit analysis

Power consumption of water pump

We have used a 12volt 60W water pump for nutrient water flow. For our project the pump needs to operate for 15minutes after every 2hours.

So, in 24 hours, there are 24hours/2hours per cycle = 12 cycles.

Total running time = 15×12 = 180minutes

Total time in hours = $\frac{180}{60}$ = 3hours

Total power consumption of the pump per day = (3×60) = 180watts-hour = 0.18kWh

Power consumption of LEDs

We have used 220volt RGB LED for the plant growth which consumes 14.4 watts/meter.

We have used total 12meters of RGB LED for our project.

So, total power consumption for 12meters = (12×14.4) = 172.8watts = 0.1728kW

For our project, we have to light up the LEDs for 18hours a day for the perfect growth of plants.

Total power consumption per day = (0.1728×18) = 3.1104kWh

Per unit cost

As of November 16, 2023, the cost of electricity in Bangladesh is 3.80Tk/kWh for 1-75 units.

For pump

Cost for the water pump = $(\frac{Power\ of\ wate\ pump(Watts) \times Hours\ of\ usage}{1000}) \times$ Electricity rate

$= (\frac{60\times3}{1000}) \times 3.80 = 0.684$ taka per day

Cost for the water pump in one day = 0.648 taka

Cost for the water pump in thirty days = (0.648×30) = 19.44 taka

For LED

Cost for LED = $(\frac{Power\ of\ LED(Watts) \times Hours\ of\ usage}{1000}) \times$ Electricity rate

$= (\frac{172.8\times18}{1000}) \times 3.80 = 11.82$ taka per day

Cost for the LED in one day = 11.82 taka

Cost for the water pump in thirty days = (11.82×30) = 354.6 taka

Let’s assume that the maximum bill for other incidentals is one hundred taka per month.

So, the total maximum bill costs = (19.44 + 354.6 + 100) = 474.04 taka ≈ 500 taka approximately.

Labor cost = 500 taka (One labor per unit)

So now the total cost of our project = (15000+500+500) = 16000 taka

It takes 30days for lettuce to go into perfect vegetative stage. After the growth we can sell them at least 60taka per piece.

Monthly income = (40×60) = 2400 taka

So, investment will be recovered in (16000÷2400) = 8 months

8.4 Evaluate economic and financial aspects

In comparison to conventional soil-based agriculture, our proposed automated indoor horticulture system can provide higher crop yields, increasing productivity and possibly earning income. Year-round farming made possible by this technology minimizes the effects of seasonal changes and provides a steady supply to the market. Compared to traditional farming, indoor horticulture systems require less land, which makes them appropriate for urban areas or places with little arable land. Additionally, this system uses less water than conventional agriculture, which might reduce water expenditures and promote water conservation. In horticultural systems, controlled conditions maximize the utilization of resources, especially nutrients, leading to more productive and sustainable agriculture. Specialty crops can be produced using horticulture systems, which may have greater market demand and fetch higher prices.

The horticulture system, automation tools, grow lights, and other infrastructure are all included in the upfront cost. Regular maintenance charges, fertilizer solutions, and electricity for lights and equipment are all considered ongoing expenses. Automation in our project lowers labor expenses by handling jobs like harvesting, climate control, and nutrient management. Faster crop development is frequently possible with horticulture systems, which leads to quicker turnover periods and maybe more harvests annually. Horticultural crops are frequently of superior quality, and their capacity to yield chemicals-free or organic crops may enable them to fetch higher prices on the market.

8.5 Conclusion

In summary, the economic study of automated indoor hydroponic systems shows a remarkable array of efficiency and opportunity in modern agriculture. It's clear that automated indoor hydroponic systems could revolutionize farming methods. Ongoing technology developments, market forces, and administrative frameworks, however, must be taken into account in order to fully comprehend the economic viability of these systems. The integration of automated indoor hydroponic systems may in fact affect the future of agriculture by promoting innovation and tackling problems together, bringing in an era of resource-efficient, high-yield, and commercially viable food production.

Chapter 9: Ethics and Professional Responsibilities [CO13, CO2]

9.1 Introduction

In any task, prioritising moral and professional standards is more than just necessary. It is an indication of a dedication to producing really social and economic advantages. We maintained honesty and integrity in our professional responsibilities while ensuring the success of our project by putting ethical and professional conduct first through a planned and systematic strategy. In addition to producing the intended outcomes, this firm commitment to moral behaviour. This also promoted confidence and trust, which had a good effect on society and the economy. By completing our project's technical criteria, we showed that we were firmly committed to the larger principles of ethical and sustainable project management. The development of a project is greatly influenced by the integration of ethical values and professional obligations which ensures ethical, legal, and diligent management while taking moral standards, regulatory compliance, and potential effects on everyone also the stakeholders involved into consideration.

9.2 Identify ethical issues and professional responsibility

Moral questions and problems resulting from activities' possible effects on people, communities, and the environment are included in the category of ethical issues. Making decisions that are in line with justice, integrity, and society values is necessary to address these issues. Professional duty, on the other hand, is carrying out tasks and responsibilities inside an organization or specialty. It includes a dedication to the highest moral, professional, and ethical standards. It is required of professionals to put stakeholders' well-being first, work hard to accomplish their tasks, and keep learning new things. Maintaining professional responsibility promotes a good influence on the larger community in addition to enhancing individual and organizational reputation. Fundamental decision-making and conduct in a variety of professional situations are based on ethical considerations and professional responsibilities. There are several ethical and professional obligations while using an indoor automated vertical horticulture system. Here are some important things to think about:

Effect on the Environment

Ethical Concern: In order to maintain sustainability, the system's effects on the environment, including resource usage and energy consumption, must be properly controlled.

Professional Responsibilities: In order to reduce their environmental impact, professionals engaged in the planning, development, and administration of these systems ought to give top priority to environmentally friendly methods and energy-efficient technologies.

Management of Resources

Ethical Concern: Appropriate resource management is called into question by the hydroponic systems' usage of resources like water and nutrients.

Professional Responsibilities: In order to ensure responsible resource usage, professionals must implement effective nutrition delivery systems, recycle water, and minimise waste.

Chemical Utilisation

Ethical issue: Using pesticides and fertilisers in hydroponic systems may cause environmental contamination, which is a worry.

Professional Responsibilities: Taking into account the possible effects on the environment and public health, professionals should abide by regulations for the safe and responsible use of chemicals.

Transparency and Consumer Expertise

Ethical Concern: One ethical issue with horticultural cultivated fruit may be the lack of openness in its consumer marketing.

Professional Responsibilities: It is the responsibility of professionals to ensure that customers are informed accurately about the cultivation methods used, and that labelling and marketing activities are transparent.

Automation and Security of Data

Ethical Concern: Privacy and security issues are brought up by the gathering and utilisation of data in automated systems, including sensor and user data.

Professional Responsibilities: To protect data and guarantee ethical data handling procedures, professionals must put strong cybersecurity guarantees in place.

Impact on the Community

Ethical Concern: Employment in traditional agriculture may be impacted by the adoption of automated technology, which could have impact on society.

Professional Responsibilities: Professionals ought to think about how these systems affect society as a whole and take appropriate actions that lessen their negative effects on nearby communities.

Observance of Regulations

Ethical Concern: It is unethical to disregard regional, governmental, or global laws.

Professional Responsibilities: In order to ensure legal compliance, professionals must remain aware of and abide by the applicable legislation governing the use of horticulture systems.

9.3 Apply ethical issues and professional responsibility

9.3.1 Apply ethical issues and professional responsibility

Consent Form

Date: ………….

Project information:

Title: Design and Development of an Automated Indoor Horticulture System

I …Property owners name…. give permission to this group of BRAC University for …. **Automated Indoor Horticulture System**…. to use the property located at …Place…. for the term of ……years beginning………. and ending……….

This agreement may be renewed with the approval of the property owner and the group implementing the 'Automated Indoor Horticulture System' at the end of the agreement period. All questions about the project, its nature, risks, or hazards, have been discussed with my workers and stakeholders to my satisfaction.

This group agrees to indemnify and save harmless the property owner from all damages and claims arising out of any act, omission, or neglect by the community garden, and from any and all actions or causes of action arising from the Automated Indoor Horticulture system's occupation or use of the property.

As the property owner, I agree to notify this group implementing 'Automated Indoor Horticulture System' of any change in land ownership, development, or use 60 days prior to the change in status.

____

Please sign above the line

Signature of the Property owner

Date: ………….

9.3.2 Risk Management and Contingency Plan

Equipment failure: It is a heavy structured system. So, any fault on the structure will cost a huge amount of money. So, we need to be aware of this and maintain the whole system carefully so that no fault could happen here.

Water and nutrient management: We need to monitor the system carefully. Because the hydroponic system is a water-based system where plants are growing mainly with water. Plants take nutrients from water. So, we need to take care of continuous water supply and also need to monitor nutrients in perfect condition. If there is any fault in nutrient management it will hamper the plants.

Pest and disease management: Hydroponic system is an indoor farming system, that's why the risk of diseases will be reduced. We need to use a little amount of chemicals and fertilizer so that diseases will also be decreased. But we will need to monitor the system properly. If any harmful diseases happen, we need to take action against them.

Climate control: Though the hydroponic system is an indoor system, climate change can affect the whole system. Because we are not controlling the temperature of it. So any change of climate like temperature, humidity, lightning can make a huge effect on the system. So we need to be careful about it.

Economic viability: To implement a hydroponic system is very much costly. So we need to be aware of crop selection. Because our ultimate goal is to increase production for generate more revenue. So, if we select wrong crops or bad maintenance our system will decrease our revenue and the whole business will collapse.

Table 16: Contingency Planning

Risk Case	**Consequence**	**Cause**	**Response**
Physical Erosion	Leakage in pipe, interrupt nutrient water flow, wastage of nutrient water	Mechanical pressure, congestion in drip pipe	Accurate installation, ensure proper structure, assure protection
Electrical System Collapse	Whole system will close down. Pump, sensors and LED will stop functioning.	Short circuit, fault in wiring, components damage, fault in power supply	Emergency shut down, detach faulty components, check wiring
LED System Collapse	LED will be turned off, plants will not get proper intensity, hampers plant's growth	Faulty connection, adapter damage, over power supply, broken LED	Adequate power supply, proper wire connection, ensure proper functionality of LED control system
Sensor Defeat	System cannot provide proper data, system can be malfunction due to false data	Defective sensor, sensor overheating, false or loose connection with microcontroller	Correct interfacing, using high quality sensors
Water Pump Failure	Blockage of nutrient water flow, plants will not get nutrients	Air locked in the pump, power supply fluctuation, overheating	Maintain correct amount of power supply, monitor temperature, check for air lock
Microcontroller Defection	System will fall down; all electrical devices and sensors will be turned off	Faulty microcontroller, overload, inaccurate coding, false connection, improper power supply	Good quality microcontroller, check for overload, accurate coding, proper power supply,

Safety Consideration

Electrical safety: Whole hydroponic system is autonomous. So, a lot of electronic tools are used here like microcontroller, battery, motor, circuit board, power supply. So, any short circuit can happen. So proper grounding needs to be implemented there so that any kind of fault can't happen.

Chemical safety: Though less chemical is used here, we need to take care of it so that it can't harm the human who will be working there and proper disposal of chemicals should be in place.

Water safety: Hydroponic systems use water-based solutions to deliver nutrients to plants. Humans are involved here so we need to be careful about the amount of pesticide used in water. Besides, we need to maintain a fresh and pure water supply. Polluted water will hamper the plants.

Fire safety: Here we use electrical components. So, any accident can happen like firing. So, we need to maintain a proper ventilation and cooling system. We need to place a fire hydrant there. So, we can deal with any firing.

Structural safety: Vertical hydroponic systems are built with heavy structures. So, we need to use good materials for building the structure and need to monitor the system properly so that any climate changes can't hamper our system.

Self-Safety: Workers need to maintain safety. They need to use personal protective equipment (PPE), gloves, goggles, and respiratory protection. Workers need to be trained properly to maintain the system.

9.4 Conclusion

In conclusion, professional and ethical issues are crucial to the project development lifecycle because they assure correct and accountable completion. These components are essential to ensure that projects are carried out morally and in accordance with the required standards. Every project has to have ethical and professional obligations since they support responsible behavior. Project managers not only guarantee the project's performance and sustainability but also advance the community's well-being by evaluating the possible influence on stakeholders and following by legal and ethical standards. Therefore, it is essential for the overall success and responsible project execution that ethical and professional values are integrated.

Chapter 10: Conclusion and Future Work

10.1 Project Summary/Conclusion

Bangladesh's population growth and swift urbanization have led to a significant decrease in agricultural land, which has severely impacted food production and increased reliance on imports. The research suggests creating and implementing an automated indoor horticulture system as a creative way to address these acute issues. With the use of hydroponic system, nutrient-enriched water, and state-of-the-art equipment like LED lighting, this innovative method effectively grows crops without the use of conventional soil.

The project explores every aspect of the suggested system, carefully analyzing its functional needs, non-functional concerns, and technological specifications. Given the particular circumstances of developing countries like Bangladesh, particular attention is paid to potential socio-cultural and environmental benefits. The goal of the project is to fill up knowledge gaps and improve comprehension in this particular context by identifying areas with insufficient knowledge.

The study looks into the long-term financial sustainability, ecological effects, possibility for expansion, and societal acceptance of vertical horticulture systems in addition to the technical components. The analysis highlights the need of regulatory frameworks in assuring food safety and quality in this emerging sector.

To conclude, the automated indoor horticulture system that has been proposed shows an assurance for resolving the acute problems that Bangladesh's agriculture sector is currently facing. It provides a route forward for technical advancement, economic stability, and sustainability. The proposed proposal presents a vertically expandable and space-efficient alternative that addresses the dual concerns of increasing population growth and agricultural land loss caused by urbanization. Combining nutrient water with controllable LED lighting not only increases productivity but also creates a long-term strategy for increasing food production. This project lays the foundation for a research project that aims to navigate the challenges presented by urbanization and population increase while substantially enhancing food security, economic stability, and self-reliance in Bangladesh.

10.2 Future work

Future developments in indoor automated horticulture systems will focus on integrating technology more effectively and precisely. This involves robotics, machine learning, and artificial intelligence which can improve system automation through the use of predictive analytics, resource optimization, and environmental adaptation. Algorithms that make intelligent decisions can increase productivity and optimize yields. Prioritizing energy efficiency necessitates combining cutting-edge climate control systems with renewable energy sources. The goal of crop diversification is to increase the variety of plants that can be grown. For optimal plant growth, nutrient management techniques will be modified, and organic nutrient substitutes will be investigated. We will investigate how to best optimize our horticultural system to grow a wider variety of crops, such as longer-growing fruits and vegetables, to increase the variety of produce that can be produced inside economically and sustainably. Planting, harvesting, and trimming tasks will be more reliant on automation and robotics. Compatibility with more comprehensive smart agriculture systems will make data sharing and collaboration easier. Real-time management and tracking will be possible with reliable remote monitoring and control systems. Tools for advanced data analytics will shed light on crop performance and system effectiveness.

To conclude, we will also involve community education and engagement initiatives about the adoption of indoor horticulture systems. This entails raising community-based initiatives for sustainable agriculture, offering training programs, and raising awareness of the advantages.

Chapter 11: Identification of Complex Engineering Problems and Activities

11.1: Identify the attribute of complex engineering problem (EP)

Addressing complex engineering problems (EP) requires an in-depth knowledge of the various issues that come up in today's technological environment. When engineers handle complicated challenges, it's essential to break down and identify the characteristics of these challenging difficulties. These characteristics act as the foundation for comprehensive approaches to problem-solving that take into account environmental, socioeconomic, and technical factors. In this study, we explore the subtle aspects of complex engineering issues with the goal of identifying the key elements that characterize their complexity. For engineers looking for practical solutions that not only solve current problems but also make an eternal contribution to the development of technology and society, it is essential to comprehend these characteristics.

Attribute of complex engineering problem (EP)

P1	Depth of knowledge required	✓
P2	Range of conflicting requirements	
P3	Depth of analysis required	✓
P4	Familiarity of issues	✓
P5	The extent of applicable codes	
P6	The extent of stakeholder involvement and needs	✓
P7	Interdependence	✓

11.2: Provide reasoning how the project address selected attribute (EP)

P1. Depth of Knowledge required:

The knowledge about RGB LED, sensors, motor, microcontroller as well as basic engineering is required.

P3. Depth of analysis required:

We get various data from our project such as the data of LED intensity, humidity and temperature data, pH value. We have to analyze those data to acquire the correct and required result.

P4. Familiarity of issues:

Our project is basically related to agricultural field which is unfamiliar to us. So, to build an indoor horticulture system we must have a thorough understanding of plants, their required nutrients, required light intensity and cultivation period.

P6. The extent of stakeholder involvement and needs:

This automated indoor horticulture system must be designed according to the requirement of the users. Farmer, student, teacher, agricultural industry, people who want to do indoor plantation are the stakeholders of this project.

P7. Interdependence:

Our project depends on lots of subsystems as it’s an automated system. These subsystems are correlated with each other. These systems work according to the data that collected from the sensors.

11.3 Identify the attribute of complex engineering activities (EA)

The Attributes of complex engineering activities are given below

A1	Range of resource	✓
A2	Level of interaction	✓
A3	Innovation	
A4	Consequences for society and the environment	✓
A5	Familiarity	✓

11.4 Provide reasoning how the project address selected Attributes (EA)

Our project "Design and Development of an automated indoor vertical horticulture system has obtained the three attributes.

A1. Range of Resources

Our project completes the Range of resources because it is an IoT based project. we also have stakeholder involvement. We are working with the collaboration of Shere-Bangla-Agriculture University. Besides, we get nutrients for plants from our Stakeholder. Along with this we also make a budget plan and we use a proper work flow to complete our project in time.

A2. Level of interaction

In this project we have stockholders' involvement as well as we are working with the Shere-Bangla-Agriculture University. We have also interaction with the people who want to plant crops as well as the farmers and general people.

A4. Consequences for society and the environment

Our initiative will address the issue of nutritious food, which will have an impact on the environment. With this project, we can produce higher-quality crops. We can lessen the pressure on the grid load because our project is based on solar energy. Additionally, cultivating land is not necessary for our project in order to create wholesome food. Our initiative will not utilize any toxic chemicals, resulting in organic produce.

A5. Familiarity

We are not familiar with the agricultural field, which is essentially the focus of our project. Therefore, we need to have a solid grasp of plants, their needs for nutrients, light intensity, and cultivating time in order to construct an indoor horticulture system.

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Appendix

Logbook

FYDP (P, D and C) FALL22 Summary of Team Log Book/ Journal

Final Year Design Project			
Student Details	**NAME & ID**	**EMAIL ADDRESS**	**PHONE**
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Member 2	Mohaimenul Islam	mohaimenul.islam@bracu.ac.bd	

FYDP (P) FALL22 Summary of Team Log Book/ Journal

Date/Time/ Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
02-02-2023	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Topic: Introductory session by Mohaimenul Islam, Lecturer, Dept of EEE, BRAC University	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	N/A because ATC was not announced yet
9-02-2023	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Topic: Introduction to Engineering Design Process taken by MD Mosaddequr Rahman, Professor and chairperson, Dept of EEE, BRAC University	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
11-02-2023 Meeting 1(Discussion among group members)	1.Oeishee 2.Shihab 3.Ibnul	Discussed our field of interests and finalized topics Agriculture related, IoT, Green energy based projects,PCB Fabrication related	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
13-02-2023 Meeting 2(Discussion among group	1.Oeishee 2.Shihab 3.Ibnul	Evaluated if the selected topics are complex engineering problems or not	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
16-02-2323	1.Oeishee 2.Shihab 3.Ibnul	Topic: Complex Engineering Problem Identification taken by Prof. Arshad Mahmud Chowdhury, Dean, School of Engineering.	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
19-02-2023 Meeting 1 with ATC panel members	1. Prof.Dr.Md. Mosaddequr Rahman 2.Mohaimenul Islam 3.Oeishee 4.Shihab 5.Ibnul 6.Rownak	Finalized two topics to present in front of ATC Panel members	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Among two ideas we got the approval for 'Design and development of an indoor horticulture system'
21-02-2023	1.Mohaimenul Islam 2..Oeishee 3.Shihab 4.Ibnul 5.Rownak	Had a discussion regarding design approaches	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	1.Start our work and writing concept Note draft
23-02-2023	1.Oeishee	Topic: How to Identify a Complex Engineering Design Project and Fulfill CO Criteria	1.Oeishee 2.Shihab 3.Ibnul	

26-02-2023	1.Oeishee 2.Shihab 3.Rownak	by Dr. Abu S.M. Mohsin, Associate professor, Dept of EEE, BRAC University Mock Presentation on Concept note	4.Rownak	
27-02-2023	1.Oeishee 2.Shihab	Start working on slide and a small meeting with Mohaimenul Islam sir		Mohaimenul sir gave us feedback on our progress
2-03-2023	1.Oeishee 2.Shihab 3.Ibnul	Gave progress presentation in front of all ATC Panel	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	ATC gave us feedback on our presentation
9-03-2023	1.Oeishee 2.Shihab	Working on our mistakes and try to correct it		
15-03-2023 (ATC Meeting)	1.Mohaimenul Islam Sir 2.Oeishee 3.Shihab 4.Ibnul	Regarding final project proposal and also correction on design approach	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Gave us feedback and advised to work on it
23-03-2023	1.Oeishee 2.Shihab 3.Ibnul	Review of Project Proposal Preparation and Project Management by Mohaimenul Islam, Lecturer, Dept of EEE, BRAC University	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
30-03-2023	1.Oeishee 2.Shihab 3.Ibnul	Topic: Report Writing and Presentation Techniques by Taiyeb Hasan Sakib Lecturer, Dept of EEE, BRAC University	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
6-04-2023		No Class		
10-04-2023 (ATC Meeting)	1.Mohaimenul Sir 2.Oeishee 3.Shihab	Discussion on final project presentation and also report	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
11-04-2023	1.Mohaimenul Sir 2.Oeishee 3.Shihab 4.Ibnul	Meeting regarding the mock presentation and slides	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Got advice from Mohaimenul sir for the mistakes we have made.
13-04-2023	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Final Presentation	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	

FYDP (D) FALL22 Summary of Team Log Book/ Journal

Date/Time/ Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
01-06-2023	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Topic: Introductory session by Tasfin Mahmud, Lecturer, Dept of EEE, BRAC University	1.Oeishee 2.Ibnul 3.Rownak	Class
05-06-2023 Meeting 1(Discussion among group members)	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Discussed about the software	1.Ibnul 2.Rownak	Find Software and start working
12-06-2023 Meeting 2	1.Oeishee 2.Shihab 3.Ibnul 4. Rownak	Finding software & installation	1.Ibnul 2.Rownak	
19-06-2323	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	1.Designed and simulated the draft circuit for LED 2. Started working on 3D designs	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
26-06-2023 Meeting with ATC panel members	1.Mohaimenul Islam 2.Oeishee 3.Shihab 4.Ibnul 5.Rownak	Designed and simulated the draft circuit for Approach 2	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
10-07-2023	1.Mohaimenul Islam 2.Oeishee 3.Shihab 4.Ibnul 5.Rownak	1. Showed circuit portion of Design of LED circuit 2. Discussion about Design Approach3.	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Feedback Given
17-07-2023	1.Oeishee 2. Shihab 3. Rownak 4. Ibnul	1. Showed the Draft circuit part for Design approach3	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Figured out some mistakes and were advised to correct them
24-07-2023	1.Oeishee 2.Shihab 3.Rownak 4.Ibnul	Draft Circuit of draft Design Approach3 shown along with the updated circuits of		

		Design Approach1 &2.		
31-07-2023	1.Oeishee 2.Shihab 3.Ibnul	Preparation for Progress Presentation.	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
9-03-2023	1.Oeishee 2.Shihab	Corrections suggested in the Progress presentation were discussed and reviewed.		Suggestions to do some modifications in Design Approaches
7-08-2023 (ATC Meeting)	1.Mohaimenul Islam Sir 2.Oeishee 3.Shihab 4.Ibnul	Updated design Approaches showed.	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Got instructions to do 3D visualization for getting more clear understanding of Design Approaches
14-08-2023	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	1. Showed the updated Circuit of Design Approach 3	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
21-08-2023 (ATC Meeting)	1.Mohaimenul Sir 2.Ibnul	Showed Slide for final presentation	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Some corrections given
22-08-2023	1. Ibnul	Updated the presentation slide and started draft report writing	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
24-08-2023	1.Ibnul 2.Rownak	1.Final presentation 2.Showed draft report	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Feedback Given

FYDP (C) FALL22 Summary of Team Log Book/ Journal

Date/Time/ Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
02-10-2023	1.Mohaimenul Islam 2.Oeishee 3.Shihab 4.Ibnul 5.Rownak	Discussion about the final component list	1.Shihab 2.Ibnul 3.Rownak	Buy components as soon as possible
09-10-2023	1.Mohaimenul Islam 2.Oeishee 3.Shihab 4.Ibnul 5.Rownak	Blueprint of the work	1.Ibnul 2.Rownak 3.Shihab	Start working on component verification
12-10-2023	1.Shihab 2.Ibnul 3. Rownak	Component test	1.Ibnul 2.Rownak 3.Shihab	
14-10-2323	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Circuit building on a breadboard	All	
16-10-2023	1.Mohaimenul Islam 2.Oeishee 3.Shihab 4.Ibnul 5.Rownak	Building code to operate circuit	1.Ibnul 2.Rownak	
23-10-2023	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Checking whether the designed circuit is working correctly or not	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
30-10-2023	1.Oeishee 2. Shihab 3. Rownak 4. Ibnul	Code finalization	1.Ibnul 2.Rownak	
1-11-2023	1.Ibnul 2.Oeishee	Building code to synchronize the monitored data Blynk cloud website and App	1.Ibnul	

06-11-2023	1.Shihab 2.Ibnul 3. Rownak	Finalizing the setup of the prototype on a breadboard	All	1.Use a Veroboard to avoid wire mess. 2.Start working on report writing
13-11-2023	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Started working on slide and concept note	1.Oeishee 2.Shihab	
20-11-2023	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Completed writing 1,2	1.Oeishee	Took some instructions to write chapter 4 and 5 and got some feedback to rewrite some parts in previous chapters.
25-11-2023	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Completed full setup	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	
27-11-2023	1.Mohaimenul Islam 2.Oeishee 3.Shihab 4.Ibnul 5.Rownak	Showed final prototype	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Got some corrections
01-12-2023	1. Ibnul 2. Shihab	Poster making	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Feedback given about poster
4-12-2023	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Added chapters 3, 4, 5	1.Ibnul 2.Rownak	Feedback Given
10-12-2023	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Added rest of the chapters and completed FYDP report	1.Oeishee 2.Shihab 3.Ibnul 4.Rownak	Feedback Given

Related Code/Theory:

```
#include "Arduino.h"
#include "uRTCLib.h"
#include <DHT.h>
#define DHTPIN 2      // Pin where the DHT11 is connected
#define DHTTYPE DHT11 // DHT sensor type

//dht
DHT dht(DHTPIN, DHTTYPE);

//Motor
int enA = 35;
int in1 = 32;
int in2 = 33;
uRTCLib rtc(0x68);
char daysOfTheWeek[7][12] = {"Sunday", "Monday", "Tuesday", "Wednesday",
"Thursday", "Friday", "Saturday"};

//ph
float calibration_value = 21.34 - 0.7;
int phval = 0;
unsigned long int avgval;
int buffer_arr[10], temp;
float ph_act;

void setup()
{
  Serial.begin(9600);
  delay(3000); // wait for console opening
  dht.begin();
```

```
  //Motor
  pinMode(enA, OUTPUT);
  pinMode(in1, OUTPUT);
  pinMode(in2, OUTPUT);

  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  URTCLIB_WIRE.begin();

   rtc.set(0, 00, 12, 5, 30, 11, 23);
  // rtc.set(second, minute, hour, dayOfWeek, dayOfMonth, month, year)
  // set day of week (1=Sunday, 7=Saturday)
}

void loop()
{
  //RTC
 rtc.refresh();
  Serial.print("Current Date & Time: ");
  Serial.print(rtc.day());
  Serial.print('/');
  Serial.print(rtc.month());
  Serial.print('/');
 Serial.print(rtc.year());

  Serial.print(" (");
  Serial.print(daysOfTheWeek[rtc.dayOfWeek()-1]);
  Serial.print(") ");
```

```
  Serial.print(rtc.hour());
  Serial.print(':');
  Serial.print(rtc.minute());
  Serial.print(':');
  Serial.println(rtc.second());

  delay(1000);

//dht
//delay(2000); // Delay for 2 seconds between readings

  float humidity = dht.readHumidity();
  float temperature = dht.readTemperature();

  // Check if any reads failed and exit early (to try again).
  if (isnan(humidity) || isnan(temperature))
  {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }

  Serial.print("Humidity: ");
  Serial.print(humidity);
  Serial.print("%\t");
  Serial.print("Temperature: ");
  Serial.print(temperature - 4.5);
  Serial.println("°C");
```

```
//Motor
analogWrite(enA, 255);

if (rtc.second() == 10) {
  // Turn on motor A & B
  digitalWrite(in1, HIGH);
  digitalWrite(in2, LOW);
}

if (rtc.second() == 20) {
  // Turn on motor A & B
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
}

if (rtc.second() == 30) {
  // Turn on motor A & B
  digitalWrite(in1, HIGH);
  digitalWrite(in2, LOW);
}

if (rtc.second() == 40) {
  // Turn on motor A & B
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
}
```

```
if (rtc.second() == 50) {
  // Turn on motor A & B
  digitalWrite(in1, HIGH);
  digitalWrite(in2, LOW);
}

if (rtc.second() == 00) {
  // Turn on motor A & B
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
}

  //ph
  for (int i = 0; i < 10; i++)
  {
    buffer_arr[i] = analogRead(4);
  //  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 + 5;

  Serial.println("pH Val: ");
  Serial.print(ph_act);

// delay(1000); // Adjust the delay as needed
}
```