Autonomous Farming and Monitoring System of Vegetables in Sustainable Rooftop Environment

By

Walid Ahmad Mafuj
18321040
Meer Tahmidur Rahman
18321044
Shantanu Biswas
19121125
Tamanna Islam
19121062

A Final Year Design Project submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of
B.Sc. in Electrical and Electronic Engineering

Electrical and Electronic Engineering
Brac University
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ATC Panel Members:

Tasfin Mahmud
Lecturer, Department of Electrical and Electronic Engineering (EEE), BRAC University

MD. Rakibul Hasan
Lecturer, Department of Electrical and Electronic Engineering (EEE), BRAC University

MD. Mehedi Hasan
Lecturer, Department of Electrical and Electronic Engineering (EEE), BRAC University

Declaration

It is hereby declared that

1. The Final Year Design Project submitted is my/our own original work while completing degree at Brac University.
2. The Final Year Design Project 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 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.

Student's Full Name & Signature:

Walid Ahmad Mafuj 18321040	**Meer Tahmidur Rahman** 18321044
Shantanu Biswas 19121125	**Tamanna Islam** 19121062

Approval

The Final Year Design Project titled "Autonomous Farming and Monitoring System of Vegetables in Sustainable Rooftop Environment" submitted by

1. Walid Ahmad Mafuj (18321040)
2. Meer Tahmidur Rahman (18321044)
3. Shantanu Biswas (19121125)
4. Tamanna Islam (19121062)

of FALL, 2022 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of B.Sc. in Electrical and Electronic Engineering on 15th December, 2022.

Examining Committee:

Academic Technical Committee:
(Chair)

____

Tasfin Mahmud
Lecturer, Department of EEE,
BRAC University

Final Year Design Project Coordination Committee:
(Chair)

____

Abu S.M. Mohsin, PhD
Associate Professor, Department of EEE,
BRAC University

Department Chair:

____

Md. Mosaddequr Rahman, PhD
Professor and Chairperson, Department of EEE,
Brac University

Ethics Statement

The project “Autonomous Farming and Monitoring System of Vegetables in Sustainable Rooftop Environment” is dedicated to moral standards and ethical ideals. When designing, developing, and deploying our system, we adhered to the IEEE standard for ethical considerations as well as the recommendations made by the chair and members of our distinguished ATC panel. We place a high value on security, privacy, and openness when collecting and using data, and we respect the rights of people and communities impacted by the system. We encourage sustainable farming methods and work to reduce any negative environmental effects. We appreciate the important input and guidance provided by the chair and members of our ATC panel in ensuring that the project adheres to these moral standards.

Abstract/ Executive Summary

The Autonomous Farming and Monitoring System is designed for sustainable rooftop vegetable cultivation which is capable of seeding, weeding and watering. It utilizes a CNC form factor and focuses on organic farming methods to produce fresh vegetables without pesticides which prevents various human deceases. The system is equipped with a number of features, including rain detector, soil moisture sensor, flame detector, air quality, humidity monitoring capabilities and Real-time observation with internet-connected camera. These features work together to optimize growth conditions for the vegetables. Additionally, the system can be controlled through a user-friendly online platform, allowing for remote management from computer and smart phones. Furthermore, the system is completely scalable and expandable solution for autonomous rooftop farming system.

Keywords: Smart farming, Precision agriculture, Organic vegetable, CNC, IoT, Robotic farming system.

Dedication

Most of the city people are suffering from different types of diseases mostly in the city area because of consumption of the adulterated vegetables. People are deprived of proper nutrition values as the monitoring system is not up to the mark. Thus, this CNC based project is dedicated to the people of every age in the city so that they can lead a better life by having healthy organic vegetables daily that is produced and monitored by our automated technology. It is also dedicated to the technology enthusiast people who shares interest to develop new technologies like this in the agriculture field and bring further improvements.

Acknowledgement

We would want to extend our sincere gratitude to Tasfin Mahmud, the chair of our ATC, for his tremendous direction and support throughout the creation of the project, Autonomous Farming and Monitoring System of Vegetables in Sustainable Rooftop Environment. Members of our ATC panel MD. Rakibul Hasan and MD. Mehedi Hasan's perceptive comments and commitment to upholding the project's ethical standards are also acknowledged and appreciated. We would like to express our gratitude to the ATC panel for their assistance, direction, and knowledge, all of which were crucial to the project's success.

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List of Acronyms

CNC	Computer Numerical Control
IoT	Internet of Things
URF	Urban Rooftop Farming
IOS	iPhone Operating System
IEEE	Institute of Electrical and Electronics Engineers
LAN	Local Area Network
MAC	Media Access Control
PHY	Physical Layer
WLAN	Wireless local Area Network
ISO	International Organization for Standardization
IEC	International Electrotechnical Commission.
DOF	Degree of Freedom
pH	Potential of Hydrogen
UV	Ultraviolet
HTML	Hyper Text Markup Language
CSS	Cascading Style Sheets
PCB	Printed Circuit Board
IDE	Integrated Development Environment
GUI	Graphical User Interface
PHP	Hypertext Preprocessor
BLDC	Brushless DC
ESC	Electronic Speed Controller
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
PWM	Pulse Width Modulation
SWOT	Strengths, Weaknesses, Opportunities, and threats
NEMA	NEMA National Electrical Manufacturers Association
RAMPS	RepRap Arduino Mega Pololu Shield
ECC	Ethical Consideration Committee
CEA	CarcinoEmbryonic antigen.
DC	Direct current motor
DDT	Dichloro-Diphenyl Trichloroethane
RTC	Real Time Clock

Glossary

Circuit breaker or fuse:	Electrical safety device that operates to provide overcurrent protection of an electrical circuit
Computerized Numerical Control (CNC):	A computerized manufacturing process in which pre-programmed software and code controls the movement of production equipment
Consent:	Permission for something to happen or agreement to do something
Entrepreneur:	A person who sets up a business or businesses, taking on financial risks in the hope of profit
ESP32 microcontroller:	ESP32 can perform as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor
Gantry:	Crane shaped typically used for outdoor applications or for lifting capability below existing overhead bridge crane systems
IoT:	The Internet of Things in Engineering is embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet together constitutes the Internet of Things
IQAir:	Device that Measures air pollution from cooking, cleaning, wood burning, interior decoration, smoking and wildfire smoke and traffic pollution entering the building
Lucrative:	Earning or producing a great deal of profit
Lux sensor:	A light level sensor designed to be installed on a street light. Facing upwards, it detects the level of natural light, uninfluenced by the level of artificial light being reflected up from the street below

MyDLP:	A data loss prevention solution originally available released as free and open-source software
Open DLP:	A free and open source, agent and agentless-based, centrally-managed, massively distributable data loss prevention tool released under the GPL (General Public License)
Seer:	Forecaster of the future
Solar panel:	Solar panels capture sunlight as a source of radiant energy, which is converted into electric energy in the form of DC electricity
Wemos:	A WIFI development board based on ESP8266 12E. The functioning is similar to that of NODEMCU, except that the hardware is built resembling Arduino UNO

Chapter 1: Introduction

1.1 Introduction

In order to guarantee long-term food supply for humans, it is crucial to create a lucrative, sustainable, and environmentally friendly smart agricultural system which will ensure a vast production of food along with organic properties. In this context, our smart farming and monitoring system is brought to provide the backup for especially vegetable productions in the rooftop environment. This system consists of a CNC based monitoring system [1]. along with different sensors and electrical equipment to perform certain objectives such as weeding, seeding, watering and measurements of soil properties to produce organic vegetables. This report visualizes information regarding the whole procedure of building the project in detail.

1.1.1 Problem Statement

Vegetables are the most common necessities for human beings in their daily food cycle. It is consumed on a large scale daily which people mostly buy from the vegetable shop of the open marketplace. Though the shopkeepers claim that the vegetables are spick and span, enormous amounts of pesticides are still being used in different vegetables which are decreasing the food and nutritious value at a great rate. Moreover, many of them found in the local market are not hygienic enough to maintain a daily healthy life cycle. So, this has been a global issue for a long period of time as the international food safety standard for food is not properly maintained. A study has shown that Hazardous chemical reagents and preservatives are still used in vegetables in a very unorganized manner in different scenarios [2]. Another survey done in Dhaka city on the basis of food adulteration has explained the constant presence of different harmful substances in the food from the year 1995 to 2011 [3]. Toxic formalin, artificial colors, chemical solutions like Dichloro-diphenyl trichloroethane (DDT), Calcium Carbide, and Ethylene Oxide have been used in an indiscriminate manner.

1.1.2 Background Study

In order to minimize this problem, there are significant approaches such as the IoT-based solution that are used to determine the problems by testing the products [4]. From the old Texture Profile Analysis to image processing with electromagnetic spectrum to analyze the food values has taken food safety to a noticeable level [5][6]. International guidelines and standards have been introduced to maintain such quality [7]. But still, it is not maintained and the approaches are not implemented correctly. So, the problem remains and People are suffering from various diseases such as kidney problems, allergic problems, etc. They are not experiencing the maximum benefit they should get as the food value.

According to research by Lusby, M., & Al-Bahadly, I. (2009, February), automatic farm monitoring can be very beneficial to the existing infrastructure of our regular farms [8]. This problem can be solved in a more appropriate way to ensure a better and healthy lifestyle by providing enough resources to develop automated and multiple sensor-based systems that can ensure the proper growth of organic vegetables according to the needs of humans [9][10]. Instead of rushing to the open market every day, they can grow their own necessary vegetables in the nearest possible area.

Again, for the megacities, URF (Urban Rooftop Farming) [11] is now a doorway to stretch the food chain to a whole new extent because cities vastly rely on imported food that has to travel from long distances. To lessen this dependency, cities like New York, Chicago and Montreal have already established a number of URF in their locality [11]. Another exemplary data showed that they are generating about $1.8 million worth of fresh produce every year [12]. Even a dataset has already been published by Grewal, S. S., & Grewal, P. S. about the percentages of vegetable growth in a certain city [13]. Thus, there is a high possibility of growing such vegetables which can help a city become self-dependent on this sector.

1.1.3 Literature Gap

There may be a concern because roof gardening is not commonly done given that it may benefit the environment and produce a sizable number of veggies for urbanites. Local governments may be interested in enhancing urban landscape, decreasing traffic, creating jobs, and even lowering carbon emissions, but widespread adoption of this novel farming technique would probably call for the active involvement of business. A study by Grewal and Grewal shows that 62% of industrial and commercial rooftops were used for agriculture purposes and it could meet up 32% of vegetable needs in a particular city [14]. Moreover, shows an estimation of producing large amounts of food compared to conventional farming in China [15]. These estimations explain that there are possibilities in rooftop farming that have not been explored in a decent manner. Modern technology can add extra benefits to maximize production. This project is a form of representation of the modern use of the extra facilities that can be added in a form factor.

1.1.4 Relevance to current and future Industry

Rooftop farming is being practiced in several countries in a very organized manner. Regarding this, there are a number of companies like ZinCo, Rooftop Republic, Green City Growers etc. that are involved in farming in different rooftop areas such as restaurants, commercial buildings and shopping malls. For example, The Science Tower in Austria has implemented a smart farming mechanism in the 13th floor which consists of a hi-tech greenhouse which has a very positive impact on the growth of the plants and environment of the whole building. Again, Lufa farm is one of the biggest urban farms in the world which uses high technology and maintenance for good production of crops. Fifty different vegetables are produced in an organic way within the space of 15,217-meter square area [16]. The American Society of Agricultural and Biological Engineers also explained the model of Lufa farm in context of population, land and resources [17]. In addition, Brooklyn Grange provides the neighborhood with genuine organically grown fruits and vegetables, claiming to be the largest urban rooftop garden in the world with 40,000 square feet of areas for farming vegetables and herbs [18]. Thus, there are more farms like these being created day by day shows a sheer possibility of rooftop farming in a great number in the future. Our smart farming and monitoring system can add more flexibility to the farming process and enhance the production of our desired plants.

1.2 Objectives, Requirements, Specification and constraints

1.2.1. Objective

As described above in the problem statement, food adulteration is a big problem in big cities of developing countries like Bangladesh. According to a laboratory test in 2004, 76% of foods were found to be adulterated among all the items on the market and the level of adulteration was 70% to 90% [2]. This test was held in June 2004. This problem is getting serious day by day and we are now in 2022 where cities are getting bigger and bigger and the amount of food that is coming from the rural area has increased by a huge amount. Because of this, the use of pesticides and other chemicals has increased to transport foods and vegetables.

Food adulteration can cause various problems like kidney disease and much more, and this problem should be solved as soon as possible.

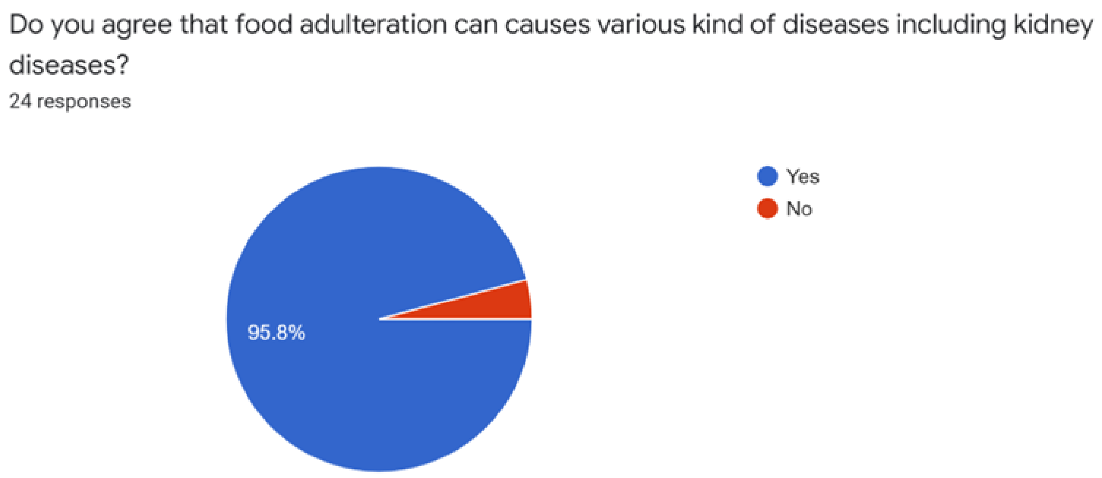

Figure 1: Survey from stack holders about kidney diseases

Especially, in cities like Dhaka, food adulteration is a serious cause for people to remain unhealthy all the time.

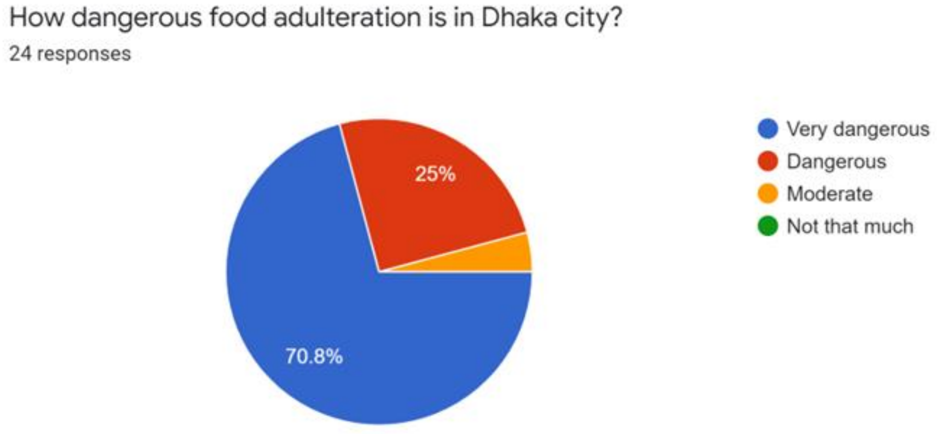

Figure 2: Survey from stack holders about food adulteration

As Dhaka city does not have enough space to cultivate food by itself, there are some objectives to use the spaces that we have in Dhaka city.

- Using rooftops as a base for seeding and growing vegetables
  - 5% of Dhaka city is empty space
  - Utilizing only space that we have

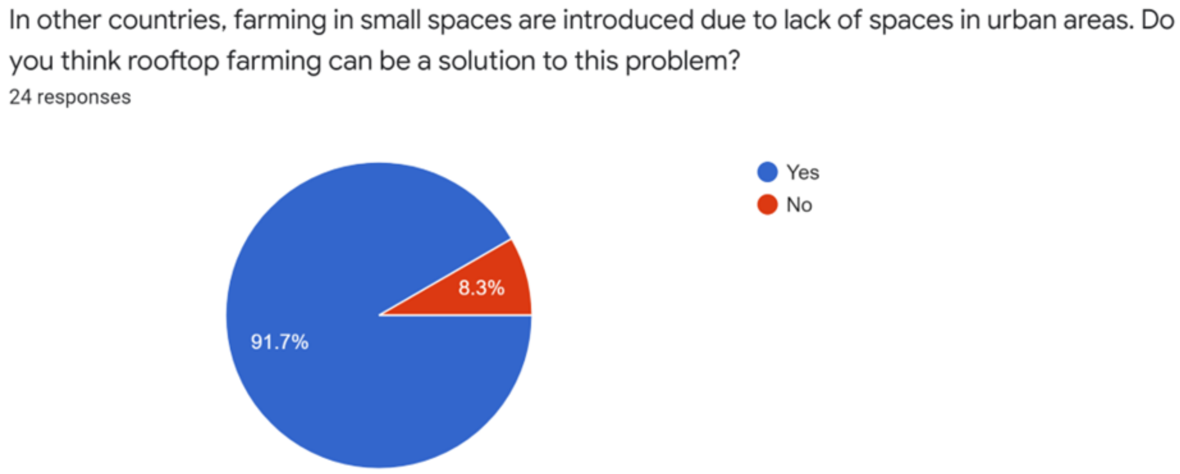

Figure 3: Survey from stack holders about possibilities of rooftop farming

According to a study of "The Financial Express", only 5% of Dhaka city is empty [13]. So, it is not possible to use any land that is left. The reason behind this is, according to "The World" magazine, Dhaka is the fastest growing city in the world [11]. This may require a debate to establish the position but it requires no knowledge to understand the fact that Dhaka is among one of the fastest-growing cities. So, it is not feasible to start farming in empty spaces like rural areas. So, the solution that we have come up with is to use the spaces on the roofs that we have. This is one of the core objectives of our final year project.

In Dhaka city, there are a lot of people who use their rooftops for gardening and growing fresh vegetables. The number is approximately 10% [20]. But these products are for self-consumption and are not planned properly. Because of that, the food chain coming from the rooftop is very narrow and has limited consumers.

The second core objective is to use that rooftop in such a way so that it can produce vegetables which will have a vast food chain and consumers. To achieve this, utilizing the space is very important.

The usage of technology is increasing day by day in the area of farming and cultivation. Man-driven machines have impacted farming and taken it to a different level. But it is not possible to use these huge machines in such places as rooftops. That is why an IoT-based or automated integrated system can be a solution to this problem. We want to build a system that is fully automated. A system that can automatically follow and execute the tasks that have been assigned to it.

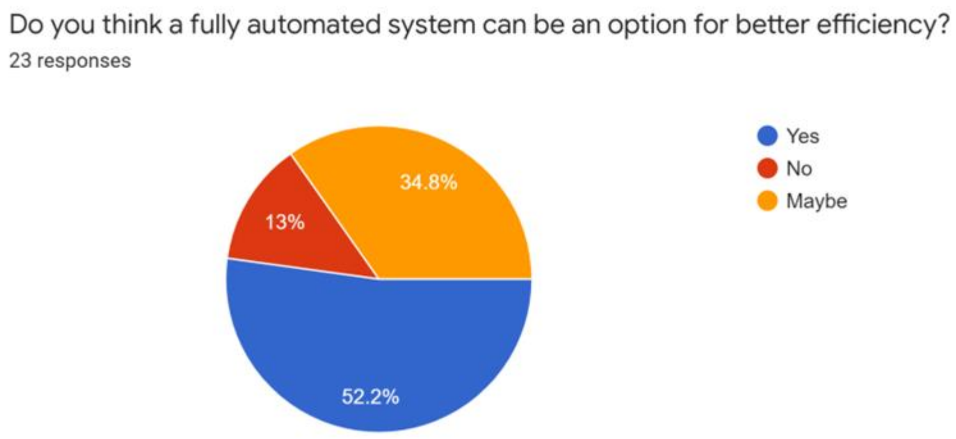

Figure 4: Survey from stack holders about automated system

- A fully functional automated system that will drive, control, and monitor
  - Maintaining Soil Moisture
    - Watering System
    - Sensing
    - Drainage System

The system needs to maintain a certain level of moisture in the soil in terms of seeding and growing plants in it. Otherwise, the plants will be dried out and the objective will not be fulfilled. A moisture sensor can sense and detect the level of moisture in the soil and the user can have this data as a level of voltages. Users can use this data to trigger the watering system.

In this case, it will automatically water the seeds and plants. A flexible drainage system is necessary to drain out the excess water.

The diagram below can show a little demonstration of the watering system and the soil moisture sensor.

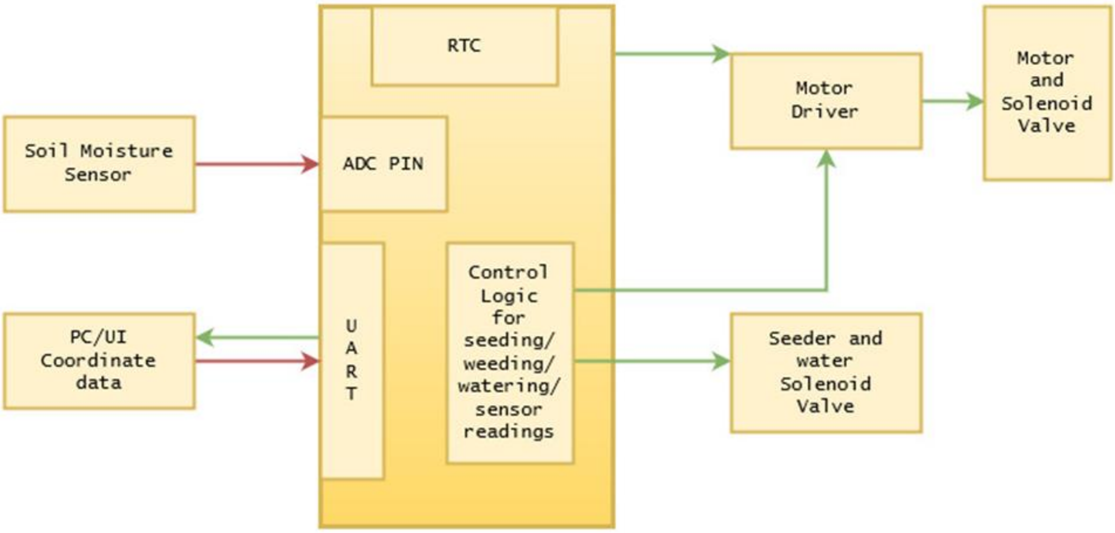

Figure 5: Electronic system-level block diagram [13]

- Automatic seeding
  - ❖ Position Control and monitor

To seed and water the plants, it is necessary to have the positional data of the robotic arm/nozzle. So that proper distance while seeding can be maintained and the system can water in the correct place. The system will be able to sense coordinates and send them to the user. The user can decide the coordinates where he wants to sow the seeds. The robotic nozzle will use the same data to water the plants.

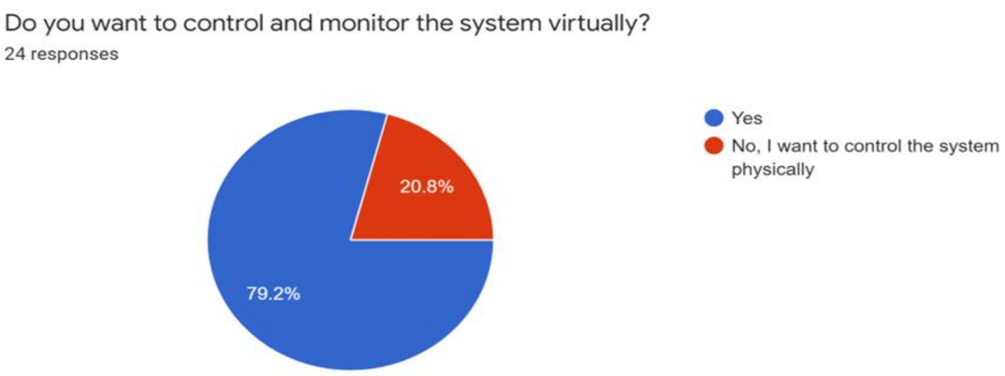

Figure 6: Survey from stack holders

- Monitoring and Feedback
    - ❖ Android-based application
    - ❖ Real-time footage and IoT-based monitoring
    - ❖ Command and execute

The most important part is to design the monitoring and feedback system so that users can have all the data which can be easily accessible. The system can be controlled and monitored through an android-based application. Users will be able to have the 24*7 real-time footage from the base. The user can be able to command the system or override any prefixed command. The application can also use the data to alarm the user if anything happens.

The main objective is to build a user-friendly automated system with an easy tool of application that can demolish the use of pesticides and can reduce food adulteration by using the rooftops of megacities where the cultivation of food is almost impossible.

1.2.2 Functional and Nonfunctional Requirements

To build a fully automated system that can use the space of the rooftops for farming –

Functional requirements:

- The system should automatically be able to detect the moisture level of the soil and start watering when the moisture level goes below 41%.
- Sowing the seeds should be automatically done by the system. The default spacing between two seeds will be 3 inches.
- The regularity of watering the plants should be maintained by the system. For this 18*36 square inch bed, approximately 1.6-gallon water will be needed.
- A proper drainage system should be maintained to drain out the excessive amount of water. If the water level rises up to the expectation or the moisture level goes up to 80%, the system will start draining.
- The system should monitor and send feedback to the user.
- The user should be able to override the command of the system using a user interface which will be an android/iOS-based application.

Non-Functional requirement:

- Allocating empty space
- Autonomous system
- Monitoring the system
- Control system from anywhere using a smartphone or PC
- Can cultivate any type of vegetables
- Any usage of pesticides should be avoided

1.2.3 Specifications

Technical specifications:

For a bed size of 18*36 inch -

Table 1: Specification and Requirements

Requirements	Components name	Specifications
Main circuit board for controlling the system	Arduino Mega	Atmega2560
To move through the 3-Dimensional space for seeding, weeding, and watering	Ramps	Stepper driver shield
	drv8825	Up to 1/32- step stepper driver
	Nema 17	52 N.cm torque 1.8° steps
	Gantry	V-slot
	Bearing	8mm inner diameter
	GT2 belt	76 pitches
	Pulley	76 pitches
	Idler pulley	76 pitches
Power source	Power Supply	12v30A
	Power Socket	220v socket
To calibrate the coordinates of the Gantry	Limit Switch	Push switch
Collecting sensors data	Moisture sensor (YL-69)	41% to 80%
	pH	6.0 to 7.0
	UV meter (GUVA-S12SD)	95% UV-A 5% UV-B
	Lux Sensor (TSL2561)	30000 to 35000
Watering	Water Pump (12V 60W 5L/min)	1.6 gallon approx.

Non-Technical Specifications:

Applicable Space

A decent amount of suitable area will be needed. Saha and Eckelman have calculated an estimation on the available spaces on rooftops in different areas [21]. According to the estimated area the number of plants that can be produced are estimated. These plants need to be watered, for watering them via our device we will need to maintain a decent amount of free space so that our device can go and come through that path. And it may block the access of the rooftops for the other people who are not related to this system. Many of the consumers will hesitate as they use their rooftops for entertaining purposes and consuming fresh air.

Budget

This project will be expensive. Generally, for any project, it is one of the constraints that the budget will be high. In the case of this project, the expenditure will be about 30-60 thousand BDT depending on our working area, designing methods and other factors. For this reason, the buyers may avoid purchasing it. But this system is budget-friendly compared to the works which were similar to this project.

Maintenance

The system will be made up of various components and services. To maintain the proper functioning of the system one or more than one parts may need to be changed. For example- rust may occur with time because of rainfall, maintenance work for water supply & drainage, and connectivity of the power source of the system. Therefore, for receiving good output maintenance is important.

Environmental uncertainty

With every season there is a change in weather. In Bangladesh, there are rainy seasons, winter, and also summer. During the rainy season, rainfall occurs at low to high levels. The parts of the device may get damaged when it comes in contact with water. Again, as with the change of climate, sometimes storms start to take place, and the robot may malfunction due to coming in contact with water so at that time the use of the device has to be avoided.

Manual harvesting & storing

The robot is efficient enough to detect the height change of the plant, the current condition of the vegetables i.e., whether they are ripened or not, water level, etc. But in the case of harvesting, the users may need to manually pick the vegetables. Or, the food will be kept somewhere by the device using its mechanical arm, and the humans have to take over the responsibility of storing the food by themselves.

1.2.4 Applicable compliance, standards, and codes

Table 2: IEEE Standards

IEEE Standards	Name
IEEE 802.11	Wireless Networking – “Wi-Fi”
IEEE 830 / IEEE 1233	Software requirements specification
IEEE 829	Software Test Documentation
IEEE 12207	Information Technology– Software life-cycle processes
IC22-055-01	Enabling a Smart and Equitable Agriculture Ecosystem with Accessible Tech and Data Tools

IEEE 830 / IEEE1233 - Software requirements specification

It is an explanation of a program structure to be developed. It is customized keeping in mind the trading essential designation. It lays out productive and unproductive needs and also may have a group of use occurrences that will explain a human's reciprocity that the computer program has to give to the human for ideal inter-activity.

IEEE 802.11 - Wireless Networking ("Wi-Fi")

It is a part of the IEE802 set of Local Area Network (LAN) technical standards, denoting the group of Media Access Control (MAC) and Physical Layer (PHY) rules for using Wireless Local Area Network (WLAN) systems.

IEEE 829 - Software Test Documentation

It is the important part that shows any experimental work to the extent of a software examination. International organizations like IEEE and ISO have established levels in IEEE829.

IEEE 12207 - Information Technology (Software life-cycle processes)

ISO/IEC/IEEE 12207 is a global benchmark for software lifecycle processes. It was recommended for the first time in 1995, it aims to be a basic level that describes every process required for making and keeping up-to-date software systems along with the results of each process.

IC22-055-01-Enabling a Smart and Equitable Agriculture Ecosystem with Accessible Tech and Data Tools

In order to analyze the data problems and opportunities associated with data collecting linked with producer planning and operations, this activity aims to bring together a number of cross-sector stakeholders in the agricultural production arena. Understanding producer and supply chain data is among the objectives. Better data integration and exchange must be supported by management throughout the entire production lifecycle.

1.3 Systematic Overview/summary of the proposed project

The main objective is to build a user-friendly automated system with an easy tool of application that can demolish the use of pesticides and can reduce food adulteration by using the rooftops of megacities where the cultivation of food is almost impossible.
There are certain outcomes that this system needs to meet in order to be fully functional.

- The system will be able to collect data of weather forecast and use this data turn on the shades above the base and protect the base from overflooded rain water

- The system can scan and for available space to be able to seed in the free available space
- The system will be able to recognize the coordinates of seed base, water pipe, and other sensors in order to move them to the space where it is required
- The movable part or gantry will be capable of seeding, weeding and watering properly
- This whole system will be controllable using the user interface which will be an android/iOS app or can be a website as well
- The system will reduce the transportation cost of vegetables coming from outside the city and will reduce the price of the vegetables as well
- The system will be able to use the space properly as it can accurately seed using the proper space gaps that are allocated to it by default or by the user. There is an approx. calculation of spaces that various vegetables need for proper and healthier growth.

Spacing for Different Plants

Table 3: Spacing for Different Plants

Vegetable	**Spacing between rows**	**Vegetable**	**Spacing between rows**
	Inches		Inches
Asparagus	36	Onions (dry)	15
Beans, Lima	21	Parsley	15
Beans, snap	21	Parsnips	21
Beets	21	Peas, shelled	15
Broccoli	30	Peas, snap	15
Brussels sprouts	30	Peppers	30
Cabbage	30	Pop corn	33
Carrots	21	Potatoes, Irish	30
Cauliflower	33	Potatoes, sweet	36
Celeriac	21	Pumpkins	60
Celery	28	Radishes	9
Chinese cabbage	27	Rhubarb	48
Collards	21	Rutabaga	21
Cucumbers	48	Salsify	21
Eggplant	30	Spinach	15
Endive	15	Squash, summer	42
Garlic	15	Squash, winter	60
Jerusalem artichoke	48	Sweet corn	30
Kale	21	Swiss chard	21
Kohlrabi	21	Tomatoes	36
Leeks	15	Turnips	21
Lettuce	15	Watermelons	72
Muskmelon	48	Okra	27
Mustard	21		

1.4 Conclusion

In this section, a complex engineering problem is detected and our engineering knowledge is used to come up with an appropriate solution considering different aspects. Background research has been done in this context and shown relevant works in the agricultural field justify the complex problem. The literature gap has been shown and the improvement our system can bring is also mentioned. Moreover, several objectives are set to be completed by the smart system. According to the working mechanism, a specification of tools and components have been listed to fulfill all the desired functional and non-functional requirements. In addition, a block diagram has been represented to demonstrate the simplified version of the whole structure. Lastly, the whole procedure is shortly summarized incorporating the whole project.

Chapter 2: Project Design Approach

2.1 Introduction

Project design approach indicates the possible solutions that can be implemented to solve the above-mentioned complex problem and which are compatible to choose from. With our knowledge and skill, several approaches are considered along with the specification of each approach with their individual configuration of versatile components and explained with work breakdown structure.

2.2 Identify multiple design approach

2.2.1 First approach: CNC Formfactor

The system will be developed based on 3-axis CNC (Computerized Numerical Control). It's like an autonomous robot with X, Y, and Z axes that uses interchangeable tools to precise seed, weed, and water. An Arduino Mega-RAMPS 1.7 stack, as well as an Internet-connected Wemos, NEMA17 motors will control the system. For building the structure or frame, Aluminum extrusions, Wood, Stainless steel and 3D printed parts will be used. It is decided to make the frame size 18x36sq inch. It can be scaled up or down as our requirements. There will be several sensors (moisture sensor, temperature sensor, humidity sensor, etc.) These sensor data will be continuously stored on an online platform thus the system can be monitored from anywhere.

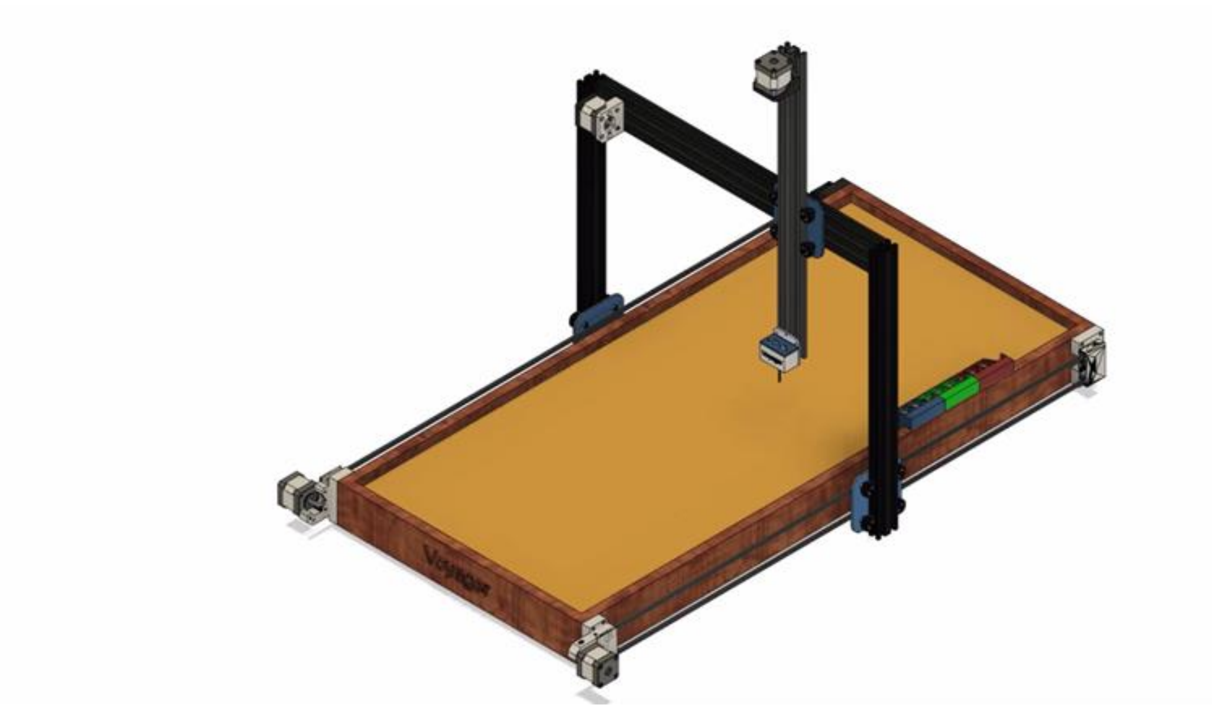

Figure 7: Design model of CNC Formfactor

Working Flowchart:

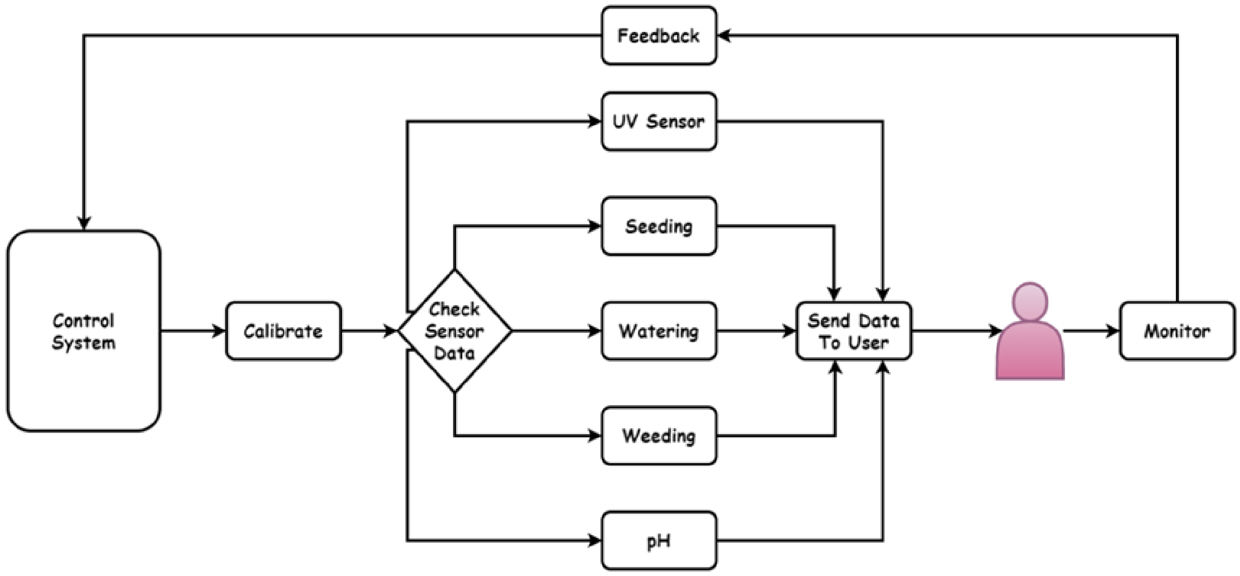

Figure 8: Working flowchart of CNC Formfactor

2.2.2 Second Approach: 6Dof-Robotic Arm

This method also works in 3 axes but has six degrees of freedom(6DOF). The arm of this robot can easily change its position in any direction. It can also be controlled by rotational motion like pitch, yaw, and roll. To keep mechanical balance, it cannot cover a large working area. So, the system needs to be added an additional linear axis to enlarge its working space. This system is highly used in industrial applications.

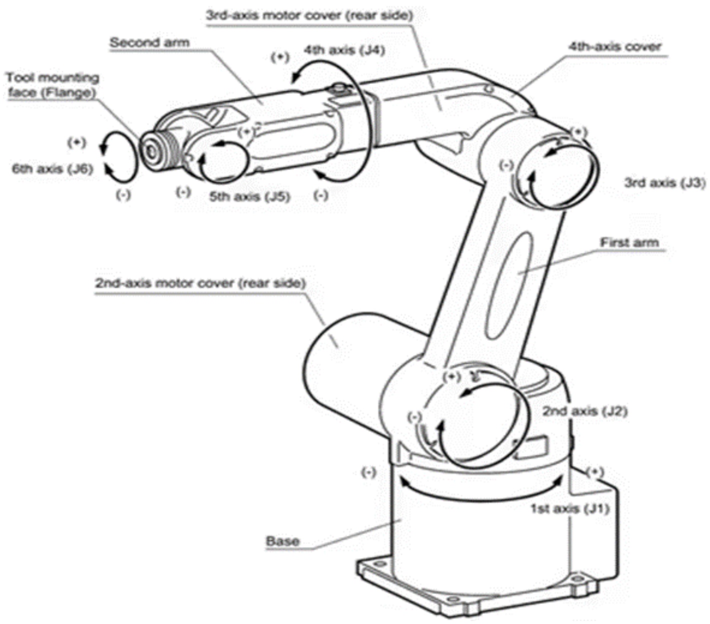

Figure 9: Design model of 6Dof-Robotic Arm

Working Flowchart

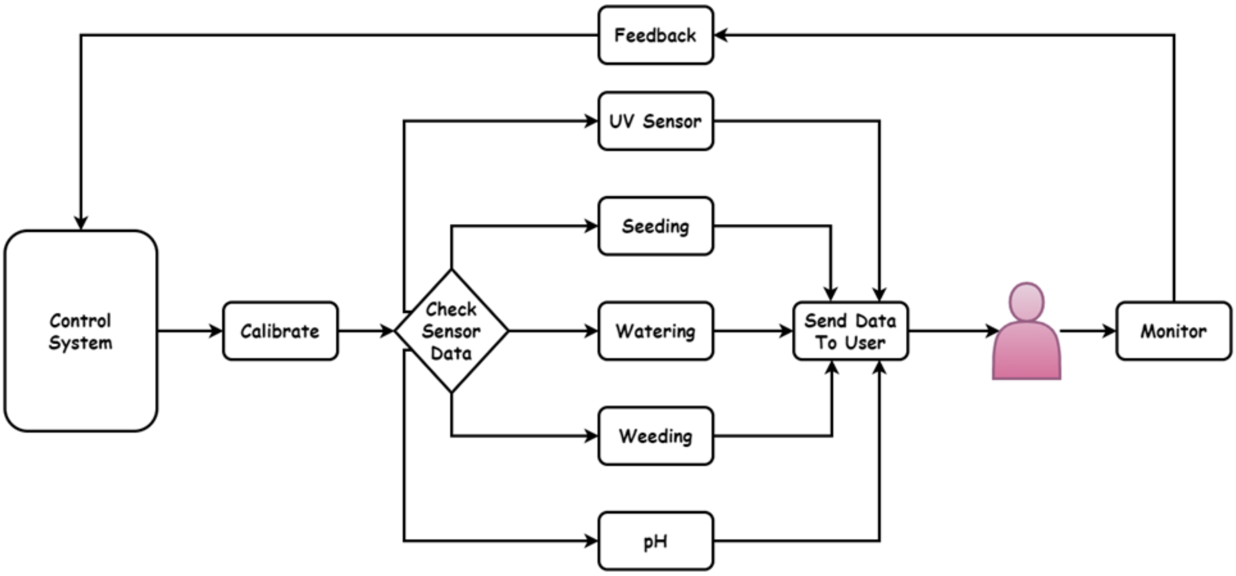

Figure 10: Working flowchart of 6Dof-Robotic Arm

2.2.3 Third approach: Cable-driven parallel robot

Flexible wire is used by this robot to move payload using controlling actuators parallelly. Each cable is controlled by a brushless motor by twisting the rotor. As a result, the robot can gain very high acceleration, velocities, large translational workspace, and high dynamic performances. But the only problem is it cannot handle high payload, and thus cannot be used for watering purposes.

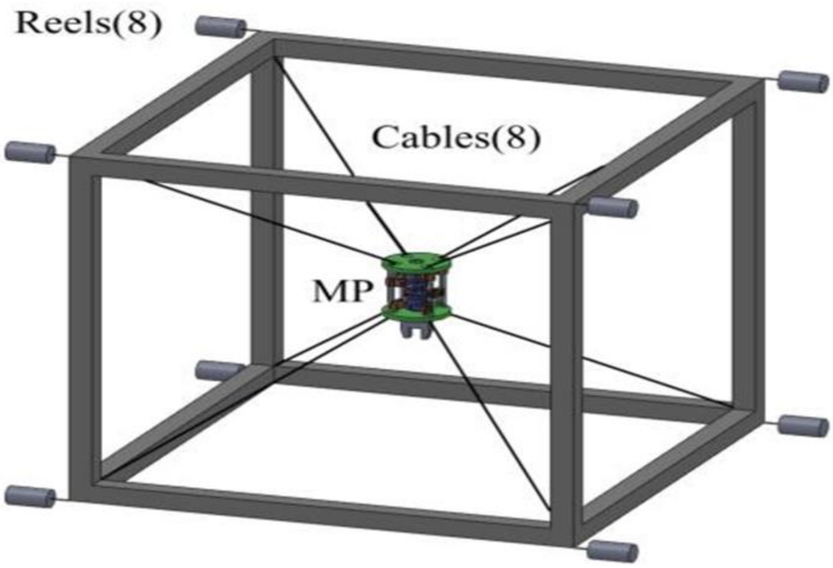

Figure 11: Design model of Cable-driven parallel robot

Working Flowchart

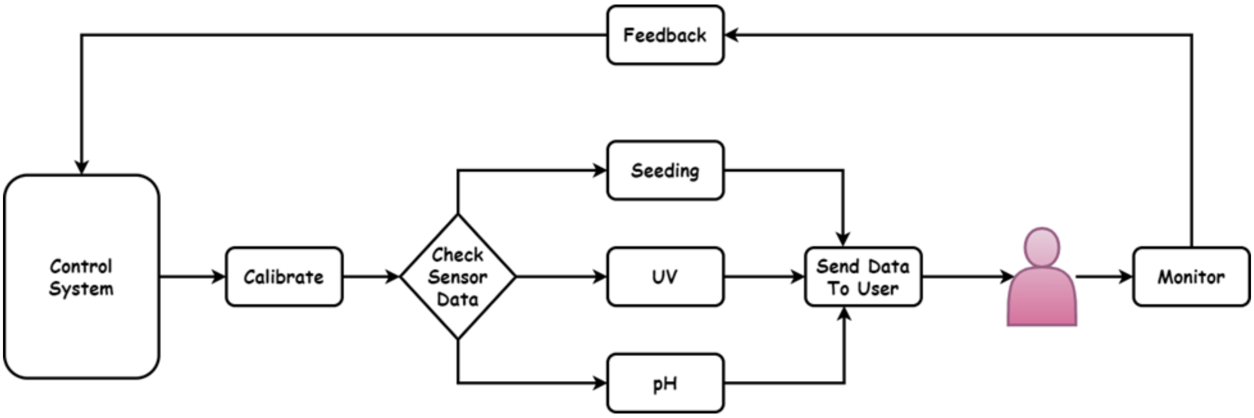

Figure 12: Working flowchart of Cable-driven parallel robot

2.2.4 Fourth approach: IoT-based Monitoring and watering system

If any of the methods cannot be managed, this very simple option can be chosen where a signal water line will be connected to the whole platform and controlled by a single water pump. For monitoring the progress, each plant has to use separate sensors. This progress can be viewed and controlled in an IoT platform.

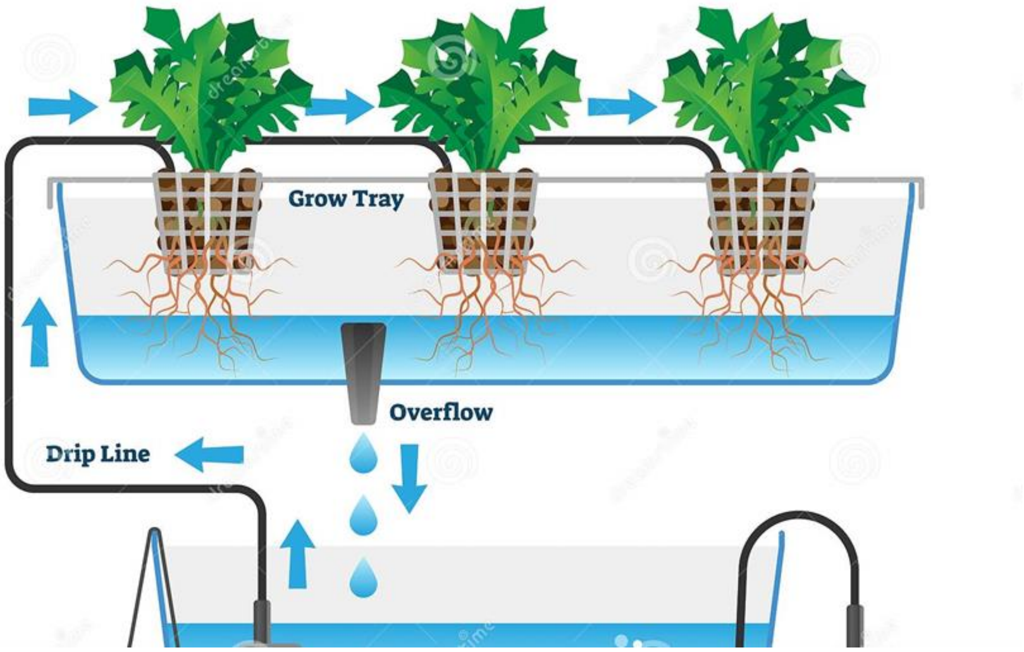

Figure 13: Design model of IoT-based Monitoring and watering system

Working Flowchart

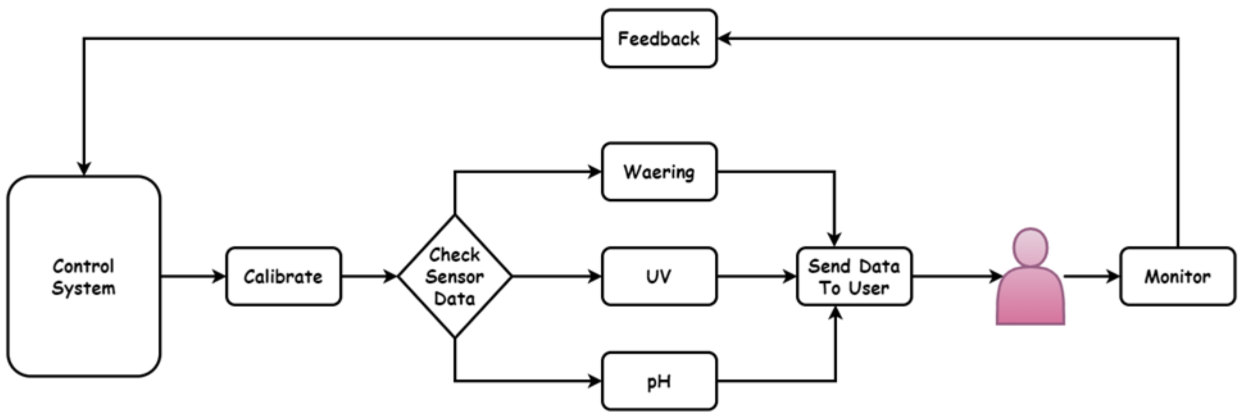

Figure 14: Working flowchart of IoT-based Monitoring and watering system

2.2.5 Compiled Working Flow Diagram

When the system is powered on the moving head or gantry of the CNC will start the calibration process. It will scan for free space available for seeding. It will ask for permission from the user for seeding. If there is no space available, it will collect soil moisture sensor data to check if watering is needed for the plants. It will continuously check the sensor's data like pH, lux, UV, soil moisture, and weather data and update the value on the IoT platform.

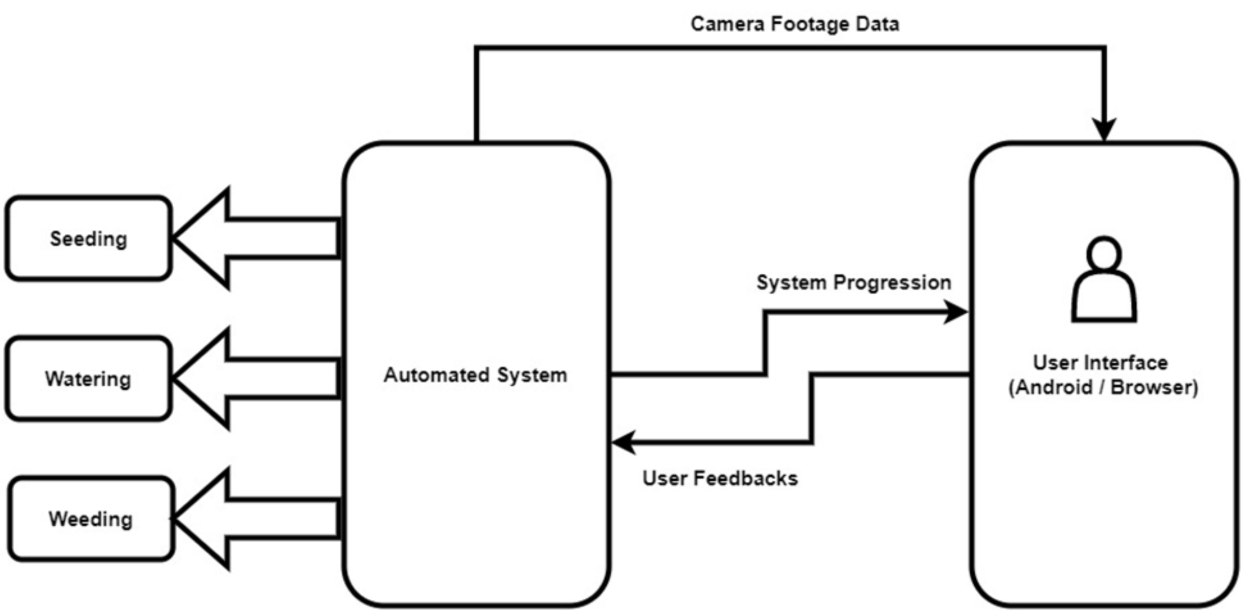

Figure 15: Compiled Working Flow Diagram 1

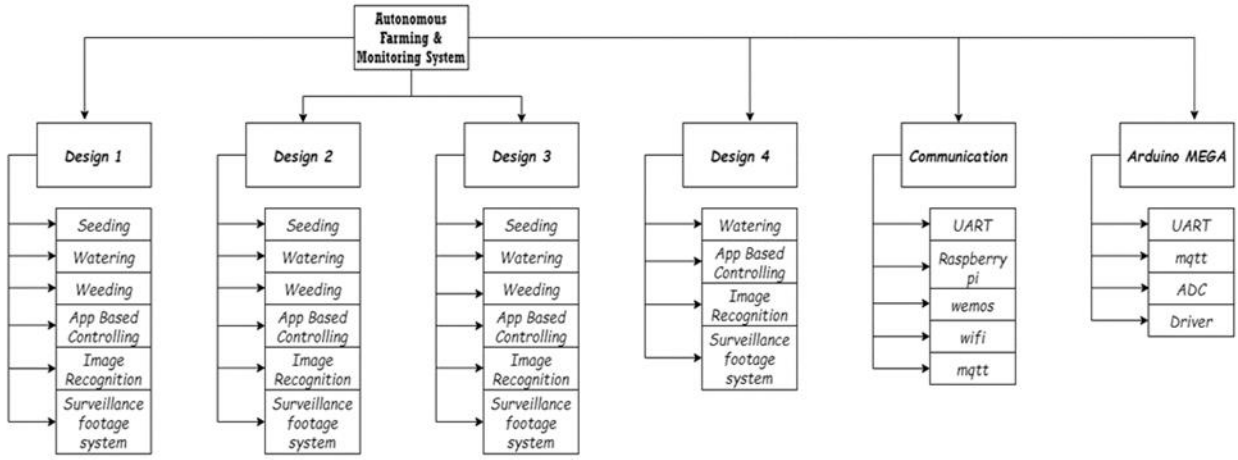

Figure 16: Compiled Working Flow Diagram 2

2.3 Describe multiple design approach

2.3.1 CNC-Formfactor/ 6-Dof-robotic-arm/ Cable-driven-parallel-robot

The first three approaches have many similarities in terms of working structure. It can be combined into one section. However, the mechanical and the electrical parts are different inside.

After powering up the system (CNC-Formfactor/ 6-Dof-robotic-arm/ Cable-driven-parallel-robot), the stepper motors will start moving the gantry /robotic-arm/ cable-driven moving part (MP) towards the origin until it hits the limit switch and calibrates its position. Raspberry pi will be used which will be connected to the internet to parse weather information of that specific location. Depending on weather conditions it will cover/uncover the base with a motorized shed. The wireless camera attached to the gantry will move around the space and scan the whole base using 'Open CV' for free space available for seeding. Open CV can also detect weeds and the system can automatically push the weeds under the soil. This process will create organic fertilizer for the veg plants. If there is available free space, it will ask the user where to seed and what to seed. The user can also override the default spacing data between the plants using the user interface. If there is no available free space for seeding, the system will check the soil moisture data using the sensor and update the data to the user interface. If the moisture of the soil is below 41%, the system will turn on the water pump to water the base and increase the moisture level. A flexible pipe will be attached to the gantry which can cover the whole base. The soil moisture sensor will continuously keep track of the moisture level until the soil moisture level reaches 80%, then it will turn off the water pump. Apart from that it will also continuously check and update the sensors data of Lux, UV. The Lux sensor will sense if there is a lack of available light. The sensor value should be between 30000 to 35000. A motorized mirror will position towards the low light area to provide redirected sunlight that is necessary for the vegetable plants. Moreover, the UV sensor will detect the UV-A value for each of the plants, and there will be UV stripped lights to maintain 95% UV-A. The suitable level of pH for vegetable plants is between 6.0 to 7.0. The user can measure the pH of the soil using the analog pH sensor. If any exception occurs the system will send a notification to users, the user may have to provide necessary arrangements for the soil to maintain the pH. The pH can be maintained through some organic fertilizer or changing the soil of the base. But once the plants are placed in the base, it is not possible to change the soil and the user may have to use the fertilizer instead. All this process should be done manually and this exception may not occur if the pH of the soil is checked in the first place. There will be a monitoring and feedback system so that users can have all the data which can be easily accessible. The system can be controlled and monitored through a web-based application. This application can be developed using html & CSS which is a system for developing website and web applications. Furthermore, a windows-based software can be developed using Python to configure and control the system.

2.3.2 IoT Based Approach

The IoT-based monitoring and catering system will not have any moving parts like a gantry. All the sensors will be placed at a certain distance to cover the whole area. It will unable to seed, which means the user has to do the seeding manually. But it is capable of completing all the other task that has been mentioned above.

2.4 Analysis of multiple design approach

2.4.1 First approach: CNC Formfactor

<u>Power Consumption</u>

Table 4: Power Consumption for CNC Formfactor

		Hours/Day					**Per Hour**	**Per Day**		
Components	**Power Rating**	**Summer**	**Rainy**	**Winter**	**Quantity**	**Runtime**	**kilowatt hour or Unit**	**Summer**	**Rainy**	**Winter**
NEMA 17	20 W	10	10	10	4x	2 at a time for x axis 1 at a time for y and z axis	(20*2*1)/ 1000 = 0.04 Unit	0.4	0.4	0.4
Sensors	0.025 W	24	24	24	4x	All	(0.025*4* 1)/1000 = 0.0001 Unit	0.0024	0.00 24	0.002 4
Water Pump	60 W	0.25	0.12 5	0.20	1x	All	(60*1*0.2 5/1000 = 0.06 Unit	0.015	0.00 75	0.012
							Total	0.8174	0.81	0.414

Budget

Table 5: Budget for CNC Formfactor

Section	Components	Unit Price	Total Price
Hardware	Ramps, drv8825, Nema17, Linear Rod, Bearing (Lm8uu), GT2 belt, Pulley, Idler pulley, Power Socket, Limit Switch, Frame, Screw, Thread, Coupler, lead screw nut, Gantry, Power Supply, Arduino Mega, Water Pump	32700	38750
Sensors	Moisture sensor, UV, Lux Sensor	1550	
Others	Server cost, Transportation cost, Steel cutting cost, Safety cost, 3D printing	4500	

Design Flowchart

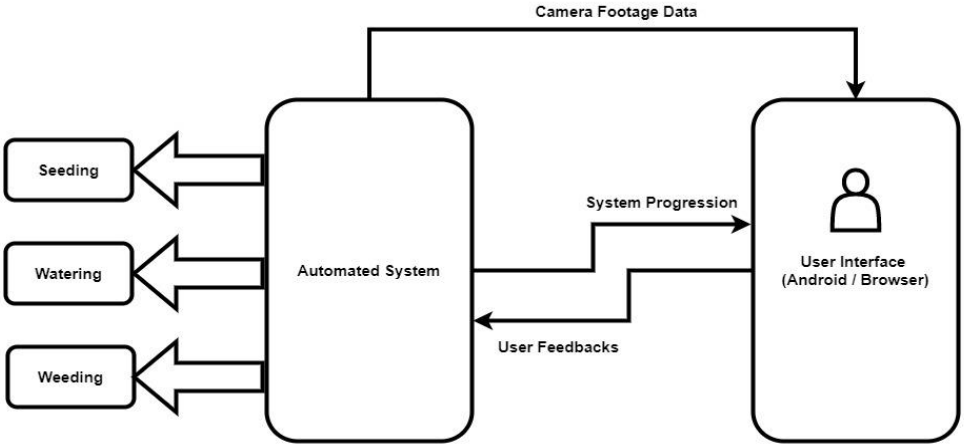

Figure 17: Design Flowchart for CNC Formfactor

2.4.2 Second approach: 6-dof Robotic Arm

Power Consumption

Table 6: Power Consumption for 6-dof Robotic Arm

		Hours/Day					Per Hour	Per Day		
Components	**Power Rating**	**Summer**	**Rainy**	**Winter**	**Quantity**	**Runtime**	**kilowatt hour or Unit**	**Summer**	**Rainy**	**Winter**
NEMA 17	20 W	10	10	10	4x	All	(20*4*1) /1000 = 0.08 Unit	0.8	0.8	0.8
Sensors	0.025 W	24	24	24	4x	All	(0.025*4 *1)/1000 = 0.0001 Unit	0.0024	0.0024	0.0024
Water Pump	60 W	0.25	0.125	0.20	1x	All	(60*1*0. 25/1000 = 0.06 Unit	0.015	0.0075	0.012
							Total	0.8174	0.8099	

Budget

Table 7: Budget for 6-dof Robotic Arm

Section	Components	Unit Price	Total Price
Hardware	Arduino, Driver, Nema17, Steel rod, Bearing (Lm8uu), GT2 belt, Pulley, Idler pulley, Power Supply, Power Socket, Limit Switch, Frame, Screw, Thread, Coupler, lead screw nut, Water Pump, Linear axis	23375	43030
Sensors	Moisture sensor, UV, Lux Sensor	1549	
Others	Server cost, App development cost, Transportation cost, Steel cutting cost, Safety cost	18106	

Design Flowchart

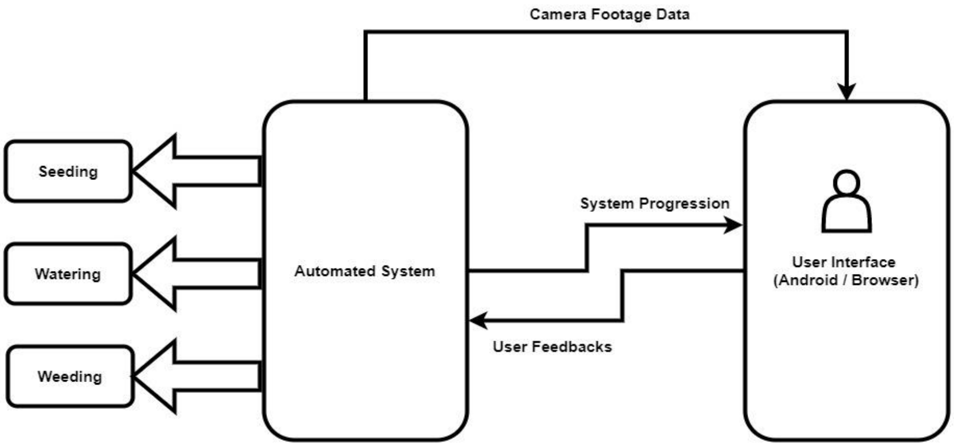

Figure 18: Design flowchart for 6-dof Robotic Arm

2.4.3 Third Approach: Cable Driven Robot

Power Consumption

Table 8: Power Consumption for Cable Driven Robot

		Hours/Day					Per Hour	Per Day		
Components	**Power Rating**	**Summer**	**Rainy**	**Winter**	**Quantity**	**Runtime**	**kilowatt hour or Unit**	**Summer**	**Rainy**	**Winter**
BLDC	48 W	10	10	10	4x	All	(48*4*1) /1000 = 0.192 Unit	1.92	1.92	1.92
Sensors	0.025 W	24	24	24	4x	All	(0.025*4 *1)/1000 = 0.0001 Unit	0.0024	0.0024	0.0024
Water Pump	60 W	0.25	0.125	0.20	1x	All	(60*1*0. 25/1000 = 0.06 Unit	0.015	0.0075	0.012
							Total	0.8174	0.8099	1.9344

Budget

Table 9: Budget for Cable Driven Robot

Section	Components	Unit Price	Total Price
Hardware	Arduino Mega, ESC, Brushless motor, Cable, Power Supply, Power Socket, Limit Switch, Frame, Screw, Water Pump	34185	48657.4
Sensors	Moisture sensor, UV, Lux Sensor	1549	
Others	App development cost, Transportation cost, Steel cutting cost, Safety cost, 3D printing	12923.4	

Design Flowchart

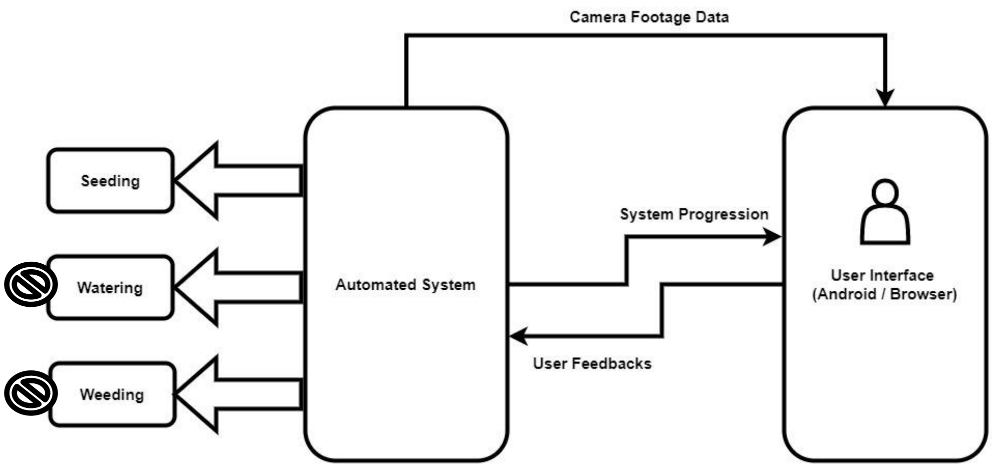

Figure 19: Design Flowchart for Cable Driven Robot

2.4.4 Fourth Approach: IoT Based Approach

Power Consumption

Table 10: Power Consumption for IoT Based Approach

		Hours/Day				Per Hour	Per Day		
Components	**Power Rating**	**Summer**	**Rainy**	**Winter**	**Quantity**	**kilowatt hour or Unit**	**Summer**	**Rainy**	**Winter**
Sensors	0.025 W	24	24	24	14x	(0.025*14*1)/ 1000 = 0.00035	0.0084	0.0084	0.0084
Water Pump	60 W	0.25	0.125	0.20	1x	(60*1*1)/1000 = 0.06	0.015	0.0075	0.012
						Total	0.0234	0.0159	0.0204

Budget

Table 11: Budget for IoT Based Approach

Section	Components	Unit Price	Total Price
Hardware	Main Board, Power Supply, Power Socket, Pipe, Frame, Miscellaneous, Water Pump	9210	22382.8
Sensors	Moisture sensor, UV, Lux Sensor	2638	
Others	App development cost, Transportation cost, Steel cutting cost, Safety cost, 3D printing	10534.8	

Design Flowchart

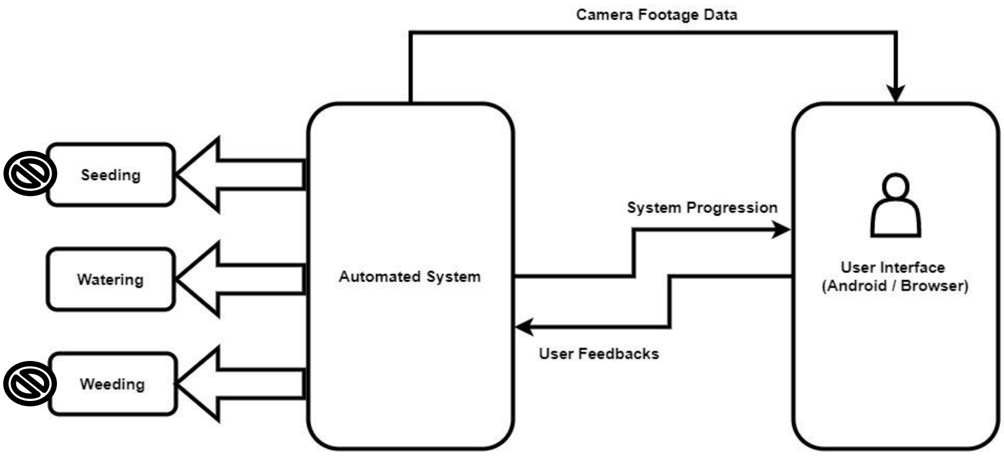

Figure 20: Design Flowchart for IoT Based Approach

2.5 Conclusion

This section shows the analysis of the four selected design approaches to solve the problem. Throughout the selection process it is carefully noticed that all the objectives are fulfilled according to the specification and functionality. The constraints that every approach faces are also being considered. The work breakdown structure has been shown to observe the functionality of each approach. Moreover, the power consumption analysis is done for the approaches for the mechanical and sensor part of each system.

Chapter 3: Use of Modern Engineering and IT Tool

3.1 Introduction

This section describes all the software and the coding language used to simulate all the working functionalities of the system. This is done to build the architecture of the circuit diagram along with available libraries and components in the software to check whether the system is functioning properly. For all the validation of the prototype the tools have been divided into different categories such as Simulation, 3D modeling, website design. First of all, the popular software is taken into consideration for each task to be performed and the optimal one has been selected for the prototype. For instance, Simulation software Proteus has been selected over Eagle as it has simulation facilities along with design. An Analysis has also been shown among the software about their performance criteria that signifies why to choose between those software. Apart from that, all the sensors have been listed according to their cost analysis and availability.

3.2 Select appropriate engineering and IT tools

There is multiple software available in the market to work with. From those similar form factors, a number of software has been listed down to under consideration according to their availability and working procedure to fulfill our requirements.

Software Name	**Portability**	**Library Resources**	**Components Availability**	**Import Facilities**	**Graph Generate**	**User Complexity**	**User Popularity**
Circuit Simulation							
Eagle	Yes	Moderate	Moderate	Yes	Yes	Moderate	Low
Proteus	Yes	High	High	Yes	Yes	Low	High
MATLAB	Yes	Moderate	Moderate	Yes	Yes	High	High
3D Modeling and Visualization							
Fusion360	Yes	High	High	Yes	No	Moderate	High
Blender	Yes	High	Moderate	Yes	No	low	High
Maya	Yes	High	Moderate	Yes	No	High	Moderate

Tinker CAD	Yes	Low	Low	Yes	No	low	Moderate
Website Design							
HTML CSS	Yes	High	High	Yes	Yes	Moderate	High
Django	Yes	Moderate	High	Yes	Yes	High	Very High
Laravel	Yes	High	High	Yes	Yes	Moderate	High

3.3 Use of modern engineering and IT tools

3.3.1 Proteus

Circuit Designing and simulation software

For the Circuit simulation, Proteus is used due to the multipurpose facilities it provides. Mainly it is used for the intelligent principal layout, hybrid circuit simulation and accurate analysis, single-chip software debugging, single-chip and peripheral circuit co-simulation, PCB automatic layout and wiring. On the contrary, Eagle does not have the facility to simulate any software that is built in it. Thus, proteus is chosen to build the circuit along with simulation.

3.3.2 Fusion360

3D modeling and simulation Software

Design of the 3D model is built with the software Fusion360 as it is user friendly and enriched with tons of components compared to the other software like blender which is an advanced and optimized software but has a complexity using it as it offers a lot of different features.

3.3.3 Visual Studio

Microsoft created Visual Studio, an Integrated Development Environment (IDE), to create GUI (Graphical User Interface), console, Web, web, mobile, cloud, and other services. One can produce both managed and native code with the aid of this IDE. It makes advantage of Microsoft's many software development platforms among others. It is not a language-specific IDE because you can use it to write code in many different languages, including C#, C++, VB (Visual Basic), Python, and JavaScript.

3.3.4 Arduino IDE

Integrated Development Environment for embedded systems.

Arduino IDE has been used to compile the codes written for Arduino and convert to machine readable language. So that the data obtained from the sensors can be processed and used for further work progressions.

3.3.5 HTML

The coding that organizes a web page's content is called HTML (HyperText Markup Language). Content may be organized using paragraphs, a list of bulleted points, graphics, and data tables, among other options. The website that is developed is using HTML to manage the content of our designed system.

3.3.6 Laravel

Laravel is a reliable and simple to use open-source PHP framework. It adheres to the model-view-controller pattern of design. Laravel makes use of pre-existing parts from other frameworks to build online applications. The resulting web application is more organized and practical.
Incorporating the fundamental components of PHP frameworks like CodeIgniter and Yii as well as other programming languages like Ruby on Rails, Laravel provides a wide range of functionalities. The extensive feature set of Laravel will accelerate web development.

3.3.7 Hardware tools

For the hardware parts, all the mechanical and sensor parts have been assembled together to verify the functionality of the project. The Arduino Mega is used to control all the Nema-17 motors(17HS8401). To connect the motors with Arduino Mega, RAMPS 1.6 control board is used and motor driver is attached, where 4 motors are wired for operation. These motors are used to drive the alloy mount according to the axis and position selection of the system. A direct power supply is given to power the motors. Along with this, Lm-2596 HVS buck converter is used to step down the voltage for 6v Air pump as base power supply is 12v. For monitoring, the soil moisture sensor, Air quality measurement sensor MQ-135 and humidity & temperature sensor are used, which are mounted with the Raspberry Pi. Besides, the sg90 Servo motor is used beside the center vertical probe to mount the soil moisture sensor to take the measurement of the soil in different time scenarios. Moreover, all the data measured through the sensors are directly uploaded through the ESP-32 module.

3.4 Conclusion

After the analysis and selection, the information of selecting the IT tools both in software and hardware have been listed down that are used for building the prototype. All the tasks for simulation, validation and design, the tools have been considered through comparative analysis. The constraints in each case have also been discussed for the software and hardware requirements. Manuals and online materials have been gone through to get a clear visualization of the functionalities.

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

4.1 Introduction

In this chapter, the optimal solution for the project has been selected from the multiple designs discussed earlier. All the specifications, requirements and standards have been considered for each design. As multiple solutions have different components and models associated with it, some factors have been taken under consideration such as usability, cost analysis and manufacturability to figure out the optimal system among four designs. After that, the validation is checked with the selected software and performance criteria has been checked with analysis of the simulation readings. Moreover, power consumption is shown for the sensor parts and motors. A concept scoring matrix is created based on the performance that each design is offering.

4.2 Optimization of multiple design approach

As multiple design approaches have been selected, it is now the task to validate the designs through performances measured by the software selected for the system. The proteus is being used for the simulations of the 4 designs that have been selected in the previous section. Proper code has been generated to check the performance and functionality according to the objectives set for the systems. The approximate cost has been calculated and compared among the designs. Rather than that, user flexibility is also measured for selecting the optimal solution. Thus, these criteria are being checked for every design for the optimal solution.

4.2.1 Weight Distribution

<u>For an 18*36 square inch bed size</u>

Table 12: Weight Distribution Comparison

Approaches	Product Weight (Estimated)	Weight	Distribution of weight	Performance in Lifting Weight
Approach 1	10-15 Kg	More than 5 Kg	Even	Very good
Approach 2	8-10 Kg	About 5 Kg	Uneven	Good
Approach 3	10-12 Kg	About 0.5 Kg	Uneven	Poor
Approach 4	5-8 Kg	-	-	N/A

4.2.2 Survey from Stack Holders

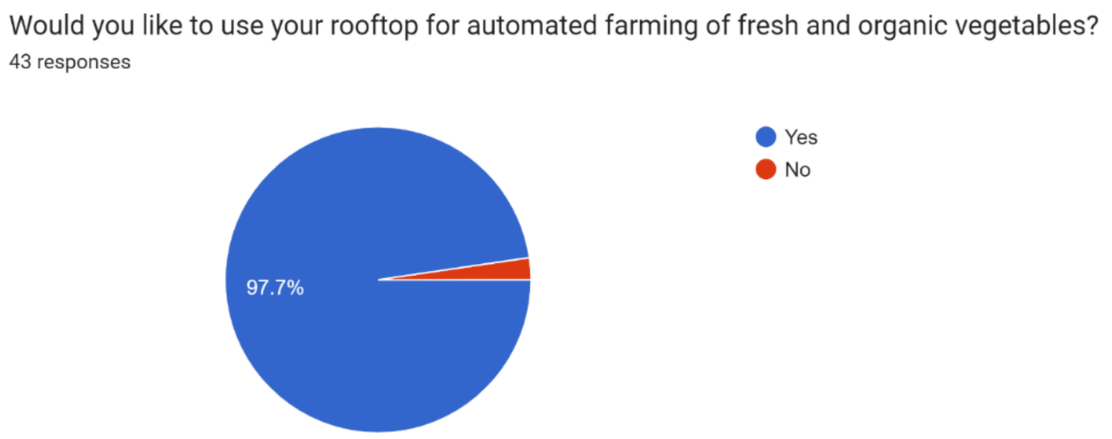

Figure 21: Survey about rooftop availability

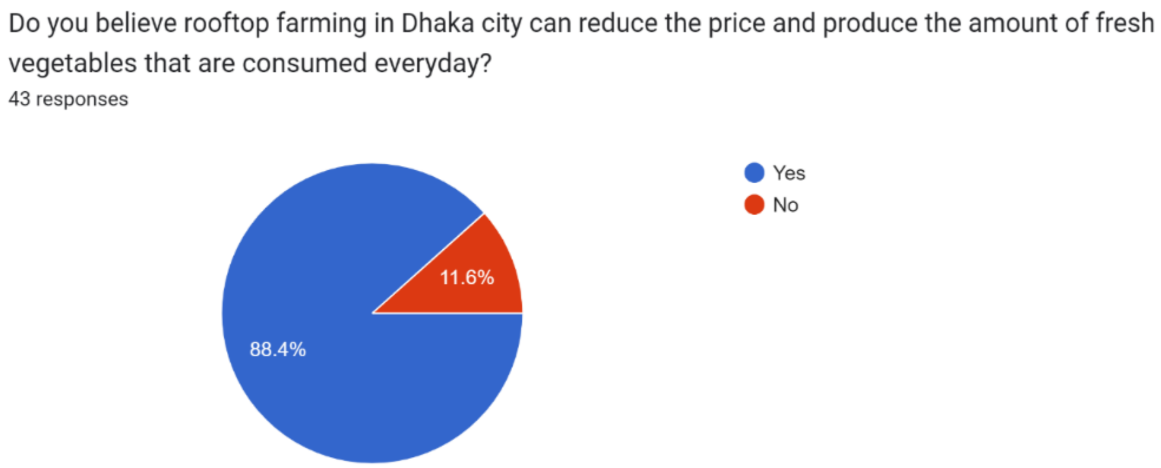

Figure 22: Survey about product efficiency

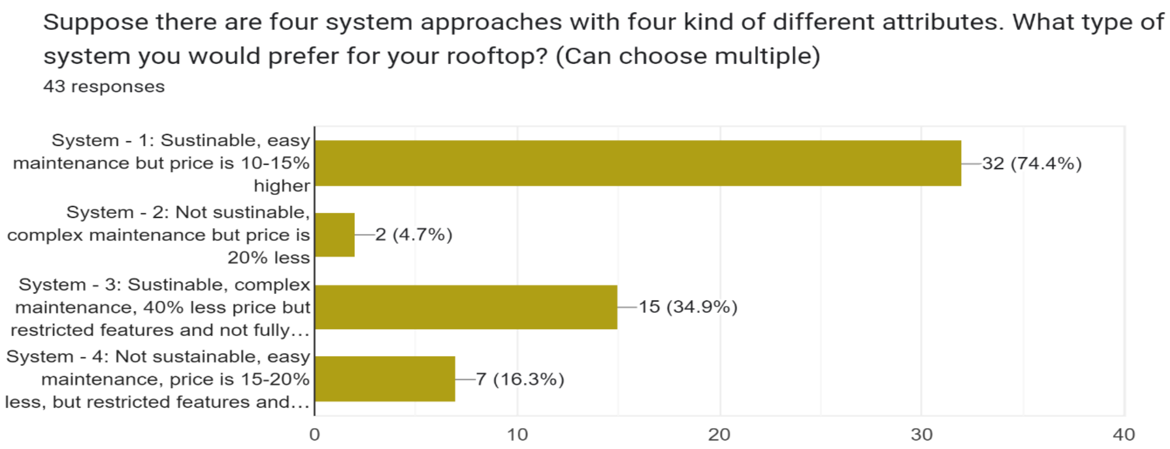

Figure 23: Survey about preferable system

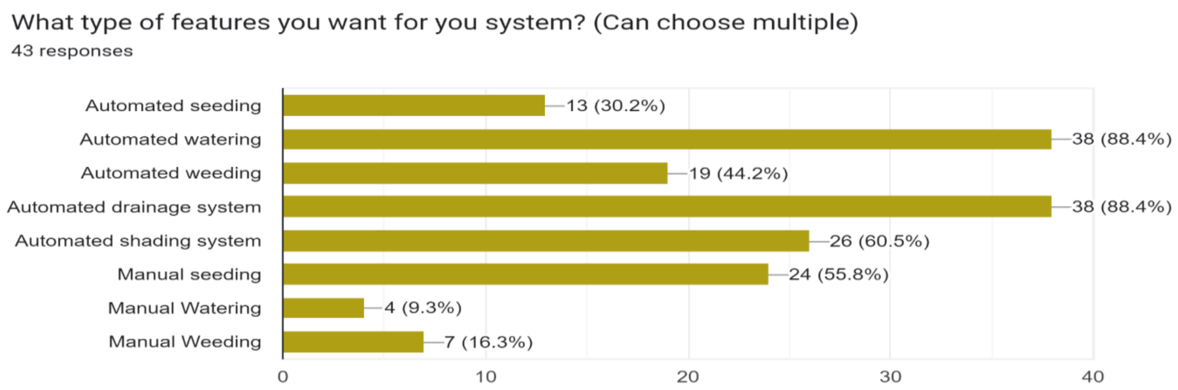

Figure 24: Survey about preferable features

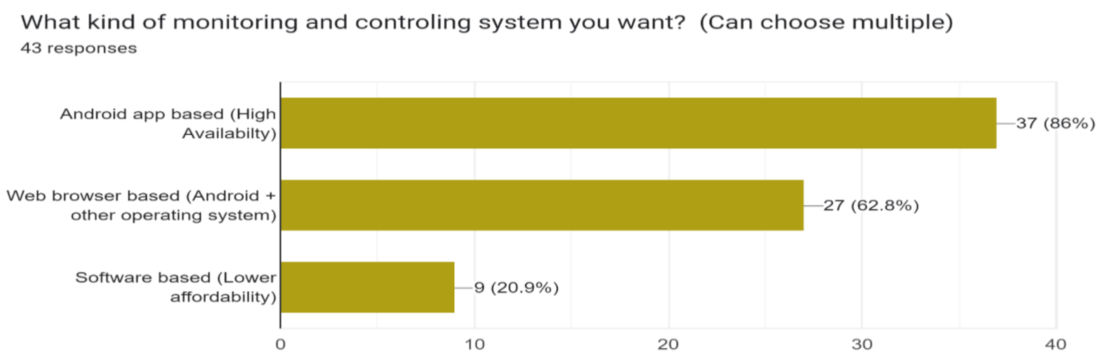

Figure 25: Survey about preferable monitoring and controlling system

4.2.3 Design Comparison

Table 13: Design Comparison

Properties	Design 1	Design 2	Design 3	Design 4
Seeding	✓	✓	✓	X
Weeding	✓	✓	X	X
Watering	✓	✓	X	✓
Manufacturing Complexity	Moderate	High	Very High	Low
User Complexity	Low	High	High	Low
Precision	High	High	Low	N/A
Cost/Budget	Moderate	Moderate	Moderate	Low
Maintenance	Low	High	Moderate	Low
Power usage	Moderate	High	Very High	Low
Size	High	Moderate	High	Moderate
Sustainability	High	Low	Very Low	Very High

4.2.4 Concept Scoring Matrix Structure

Table 14: Concept Scoring Matrix Structure

	Concepts						
Selection Criteria	**First Design**		**Second Design**		**Third Design**		**Weights**
	R	**Score**	**R**	**Score**	**R**	**Score**	
Handling ease	5	1.25	4	1.0	3	0.75	25%
Ease of use	4	0.60	5	0.75	3	0.45	15%
Readability of settings	4	0.40	3	0.30	3	0.30	10%
Metering accuracy	5	1.0	4	0.80	4	0.80	20%
Durability	4	0.40	3	0.30	2	0.20	10%
Ease of Manufacture	4	0.40	3	0.30	3	0.30	10%
Portability	3	0.30	3	0.30	3	0.30	10%
Total Score	4.35		3.65		3.1		
Rank	1		2		3		
Continue?	Develop		No		No		

4.3 Identify optimal design approach

4.3.1 Optimal Design

Circuit Simulation

From the above circuit simulation part in section 6, there are in total 4 approaches, but the simulation for approach 1 and approach 2 is almost identical. In approach 3 and 4, you can see the differences in the circuit part.
For instance, circuit 1 and 2 uses Nema17 Stepper motors, approach 3 uses BLDC motors and approach 4 uses DC motors.

Stepper Motor: Stepper motors are proportionate to the input pulse, and their maximum torque is available at rest. In general, stepper motors provide precise positioning, great speed control, and repeatable movement.
Since the motor has no contact brushes, stepper motors are also very dependable. This increases the motor's operational lifespan and minimizes mechanical failure. Due to the fact that the rotational speed is related to the frequency of pulse inputs, these motors can be used in a variety of situations.

Stepper motors are diverse in their uses, but some of the most common include:

- 3D printing equipment
- Textile machines
- Printing presses
- Gaming machines
- Medical imaging machinery
- Small robotics
- CNC milling machines
- Welding equipment

BLDC Motor: A Brushless DC Electric Motor (BLDC) is an electric motor powered by a direct current voltage supply and commutated electronically instead of by brushes like in conventional DC motors. BLDC motors are more popular than the conventional DC motors.

Advantages –

- High efficiency.
- Higher speed ranges.
- Reduced Size
- High torque to weight ratio.
- Brushless DC motor does not have any carbon brushes, which reduces the frequent replacement requirement of brushes and maintenance costs.
- Brushless DC motor is available in small compact sizes.

Disadvantages –

- The cost of a brushless DC motor is comparatively higher as compared to a brushed DC motor.
- When the Brushless DC motor is operated at low-speed slight vibrations occur during low-speed rotation.
- Brushless DC motor the wiring and operation of the motor is not that simple due to the involvement of electronic control and its link to all electromagnets.
- Less precision as it is unable to know its position unlike stepper motor.
- ESC (Electronic Speed Controller) controls BLDCs movement and speed by activating MOSFET which is driven by 3 PWM sine waves. This helps the motor to rotate faster and this creates less precision.

As tasks like seeding, watering and weeding is required in the field, the precision is the first priority. And Approach 1 and 2 are more precise than the others like approach 3 and 4.

4.3.2 Mechanical Approach

From the shown weight distribution, it is seen that the weight of the approach 1 is higher than others which indicates a stronger base. Also, the weight distribution is even and performance is good at any point of the bed area.

4.3.3 Power Consumption

Power consumed by the first approach in a day is moderate and comparatively lower from approach 2 and 3. The approach 4 has lowest of all as it has only sensor parts to consume power.

4.3.4 Budget

Approach 1 requires a moderate budget compare to the 4th one. Approach 1 and 2 also requires high budget. Approach 4 has the lowest budget among all.

4.3.5 Available Features (Survey from Stack Holders)

Approach 1 and 2 qualifies for the features that the stack holders want in their system. They want automatic seeding, automatic watering, weeding, drainage system and controlling system. The other two approach is missing some of the features because of their weight distribution and physical appearance.

4.3.6 Sustainability

Strengths

- ✓ Automatic Seeding
- ✓ Automatic Watering
- ✓ Automatic Weeding
- ✓ High Sustainability
- ✓ Low Maintenance

Weakness

- ✓ High Budget
- ✓ Moderate Complexity

Opportunities

- ✓ Job opportunities
- ✓ Economic Growth
- ✓ Tech Teams

Threats

- ✓ People resisting to use rooftop as a farming bed

4.3.7 Optimal Design Selection

According to the SWOT analysis CNC based approach which is approach 1, has the most sustainable design as it has the capability to perform all the automatic functions such as the seeding, weeding, watering and application-based control system. A number of job opportunities can be established which can participate to the economic growth of the country. Although it has some adverse effects like the implementation cost is quite high which may lead people not to implement such system to the rooftop but the organic vegetable that the system is going to produce can help them to maintain a more efficient and healthy life.

4.4 Performance evaluation of developed solution

To determine the performance of the optimal solution, there are two things that is needed to be separated. One is the electrical part and another one is the mechanical part. In the electrical parts, there are DC motors, sensors, NEMA motors and microcontrollers. And in the mechanical parts, there are wheels, t-slots and the other materials.

4.4.1 Electrical Part

Firstly, the simulation has been done in the proteus circuit simulation software, where all the sensors have been tested and all the sensors were connected to Arduino Mega. From where the sensor data has been collected. The DC motors and the NEMA motors were also working fine.

To replicate this in real life, ESP32 has been used instead of Arduino Mega. All the sensors' data has been tested using the Arduino IDE.

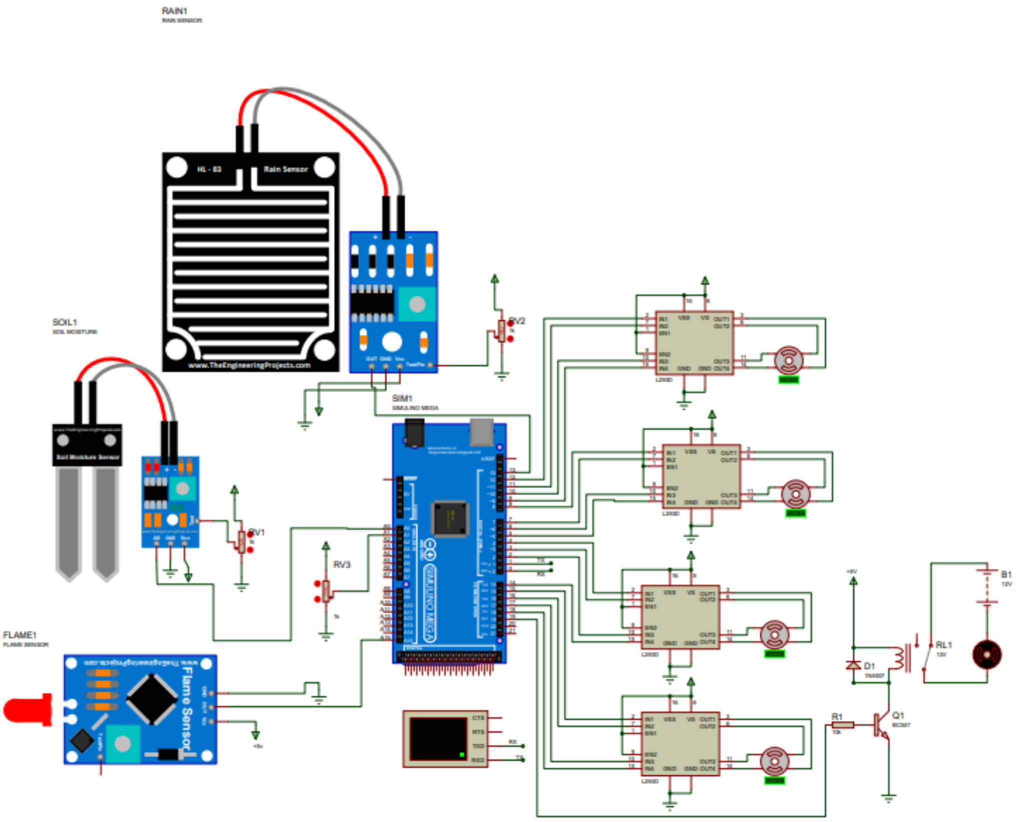

Figure 26: Circuit Simulation in Proteus

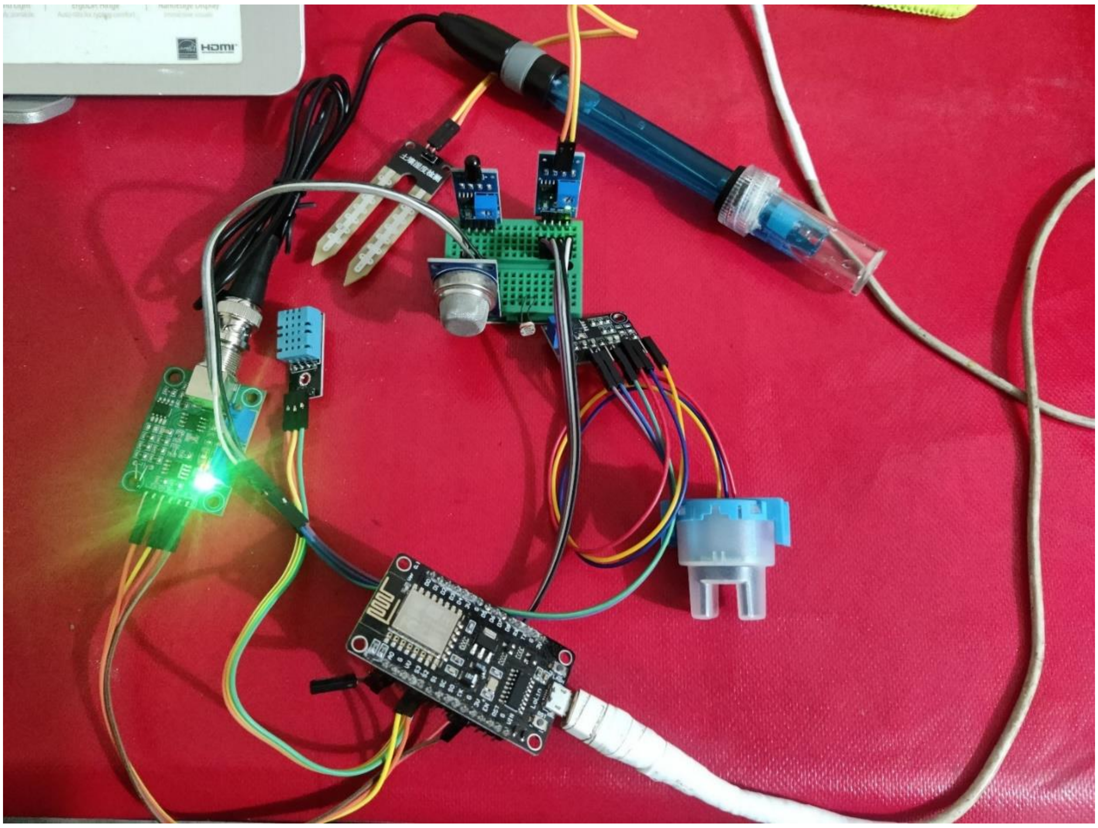

Figure 27: Sensors Connected to the ESP32

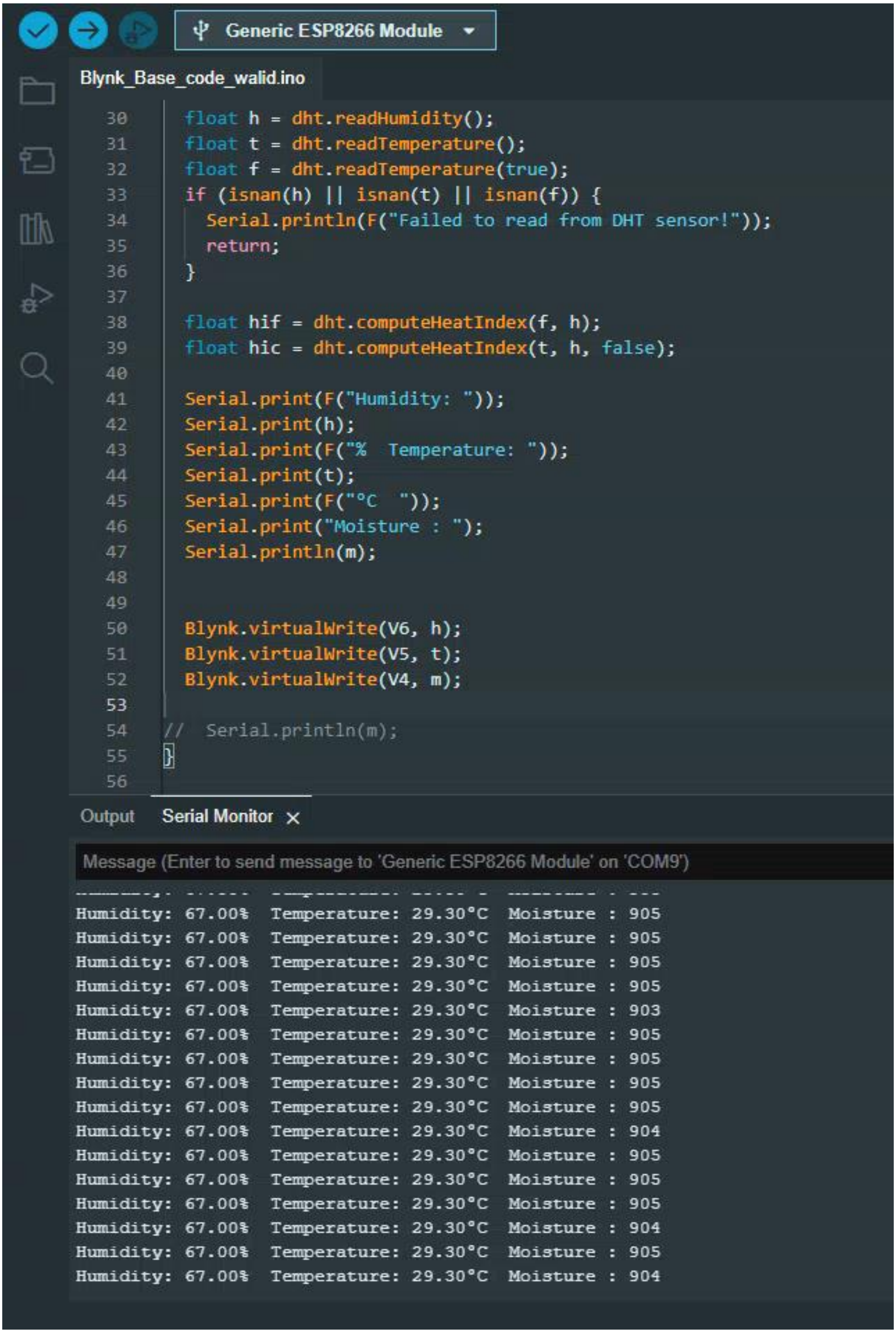

Figure 28: Sensors Data Collection

4.4.2 Mechanical Part

The simulation of the mechanical part has been completed in the fusion 360.

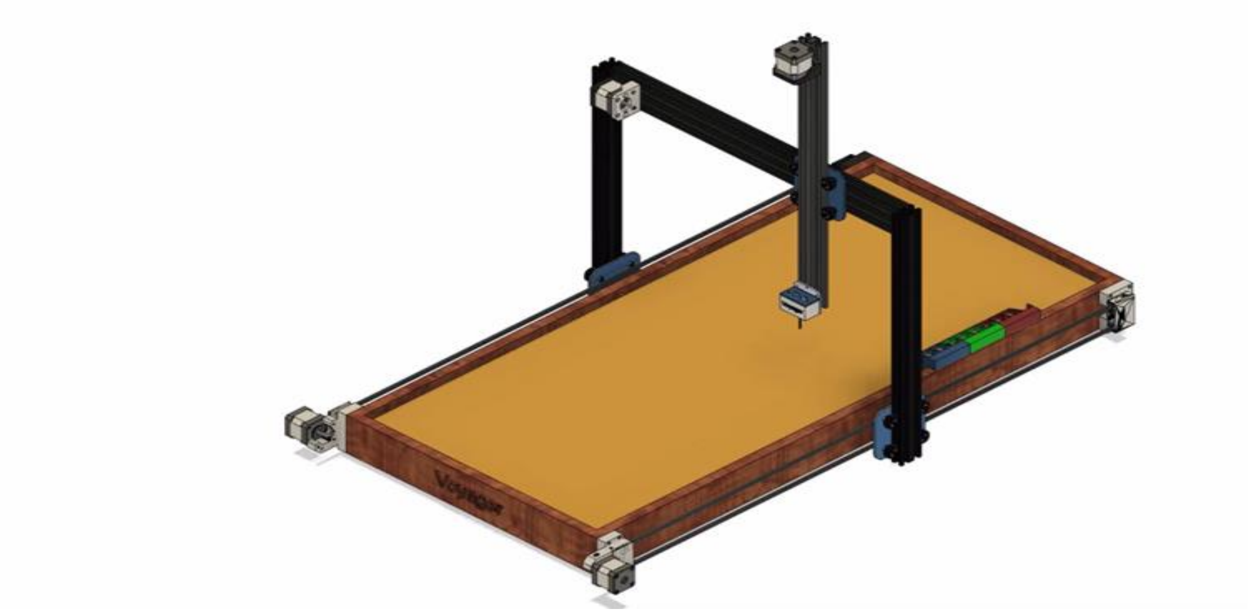

Figure 29: Simulation on Fusion 360

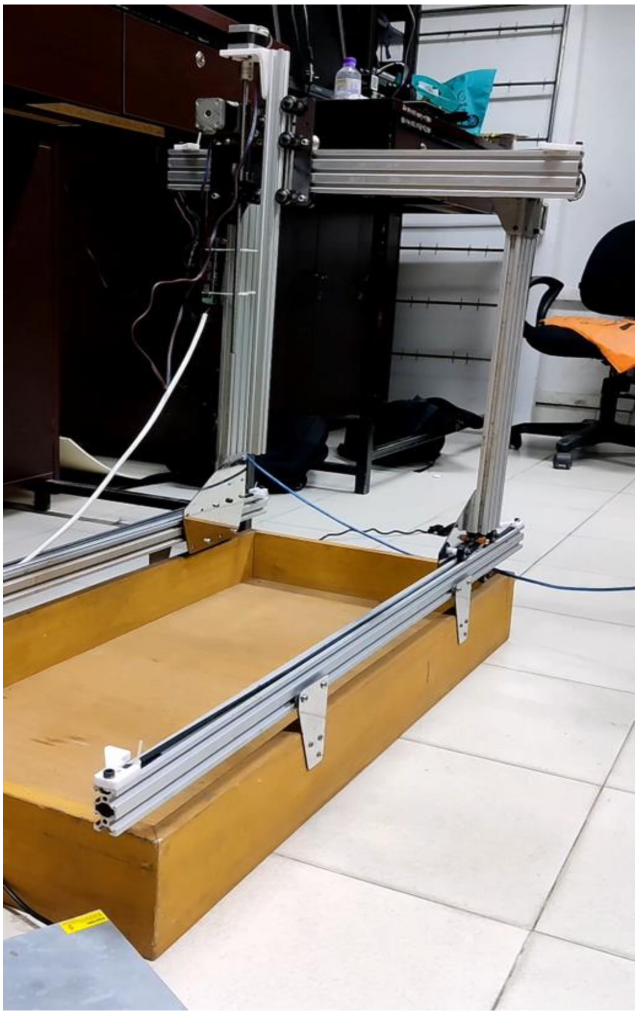

Figure 30: Actual Mechanical Part

4.4.3 Performance of the system

Both the electrical and the mechanical parts are fully functional and working properly. All the sensors and the other electrical parts has been mounted on the mechanical body. It is capable of moving throughout the bed, seed and collect sensor data from the soil and other environmental element.

4.5 Conclusion

To conclude, all the sensors has been working properly along with the mechanical part. The challenge was to mount all the sensors in such a way that it will be able to take data from the soil and do not resist the movement of the mechanical part. Though, there is a lot of risk involved as it is not a finished product. The wire connections of the prototype are handled.

Chapter 5: Completion of Final Design and Validation

5.1 Introduction

After finding the optimal solution, building the final prototype is the next task. All the components are gathered according to the specification given for the optimal design. Though there came a slightly change in the components available in the marketplace and description selected to build the project. For that reason, the orientation shown in the 3D modeling design slightly differs to the actual prototype. Even some functional verifications are modified in the actual design. On account of that, the verifications made in the simulations are cross checked with the actual built prototype for the functional verification of fulfilling the objectives.

5.2 Completion of final design

The system that was needed to be designed is the Automated Farming and monitoring system. The CNC Formfactor approach was the best optimal solution among the four alternative approaches that were considered. This CNC Formfactor approach was chosen over other options because it was deemed to be the most efficient, effective and cost-effective solution for automating and monitoring farming tasks.

5.2.1 Sensor Data

The objective is to create an automated system for planting seeds and watering a bed area using various sensors to gather data from the bed. The sensors being utilized include a soil moisture sensor, flame sensor, air quality sensor, temperature sensor, and humidity sensor.

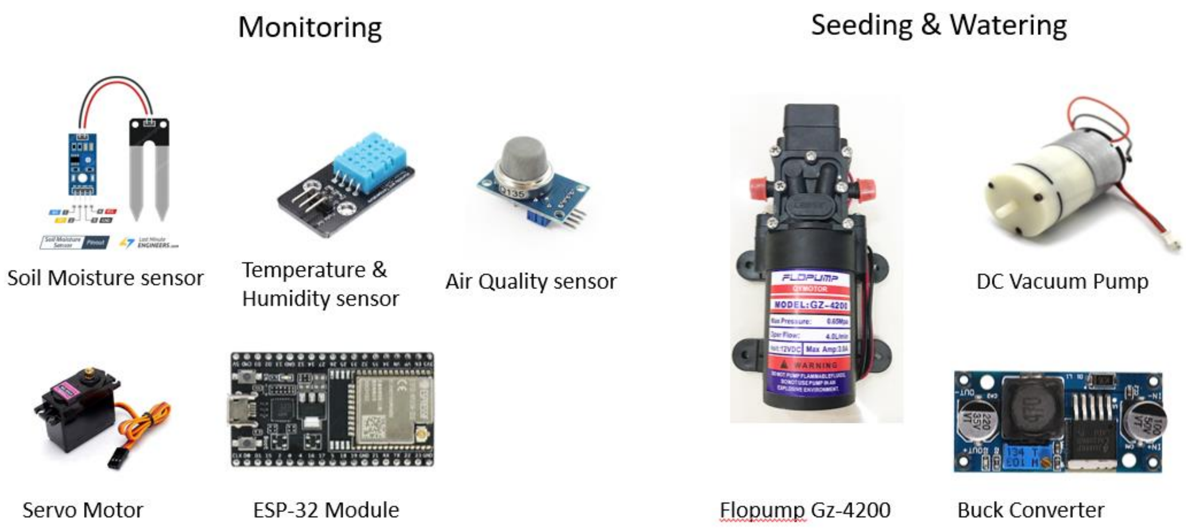

Figure 31: All Electronic Components

These sensor data are important for the system to detect the moisture level and automate the watering and seeding process.

The soil moisture sensor is mounted at the gantry and it is movable to the whole area. So, it can cover the whole bed size and can detect the moisture level of any place inside the area.

The other sensors are connected at the z axis of the system as these values do not varies much corresponding of the little space.

5.2.2 Gantry

The gantry is the most important part for seeding and watering process. It moves everywhere inside the bed area this gantry was used to mount the necessary tools. There is a nozzle that can suck the seed from the seed box and implement it into the soil. A servo motor was also mounted behind 2020 v-slot that is used to rotate the soil moisture sensor to 90 degrees vertically. The reason behind this is to fold it back when it does not require and saving from any damage, also it can be rotated to make the seeding easier. A water streaming mechanism is also connected with the gantry to water the whole bed area.

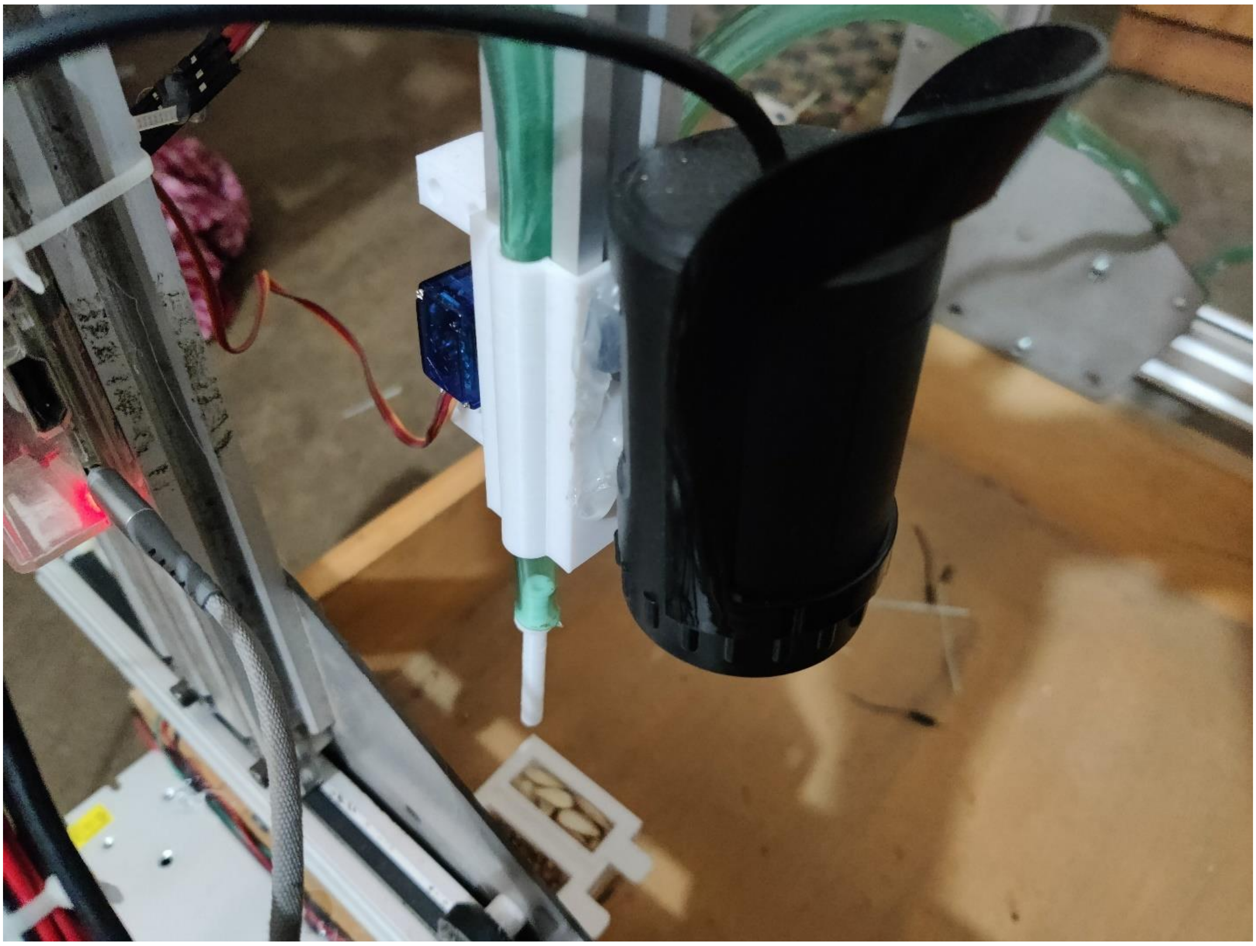

Figure 32: Gantry with the nozzle and camera attached to it

5.2.3 NEMA Motors

Nema-17 motors has been used to drive the mechanical body of the system. There are 4 Nema-17 motors in total to move the system towards x, y and z axis. The motors are used to control the movement of farming bot as it plants seeds, waters plants. Nema-17 motors are relatively small and compact, making them well-suited for this application. A thread coupler is used to connect the Nema-17 motor's shaft to a lead screw, which is a type of linear actuator that can be used to convert rotary motion into linear motion.

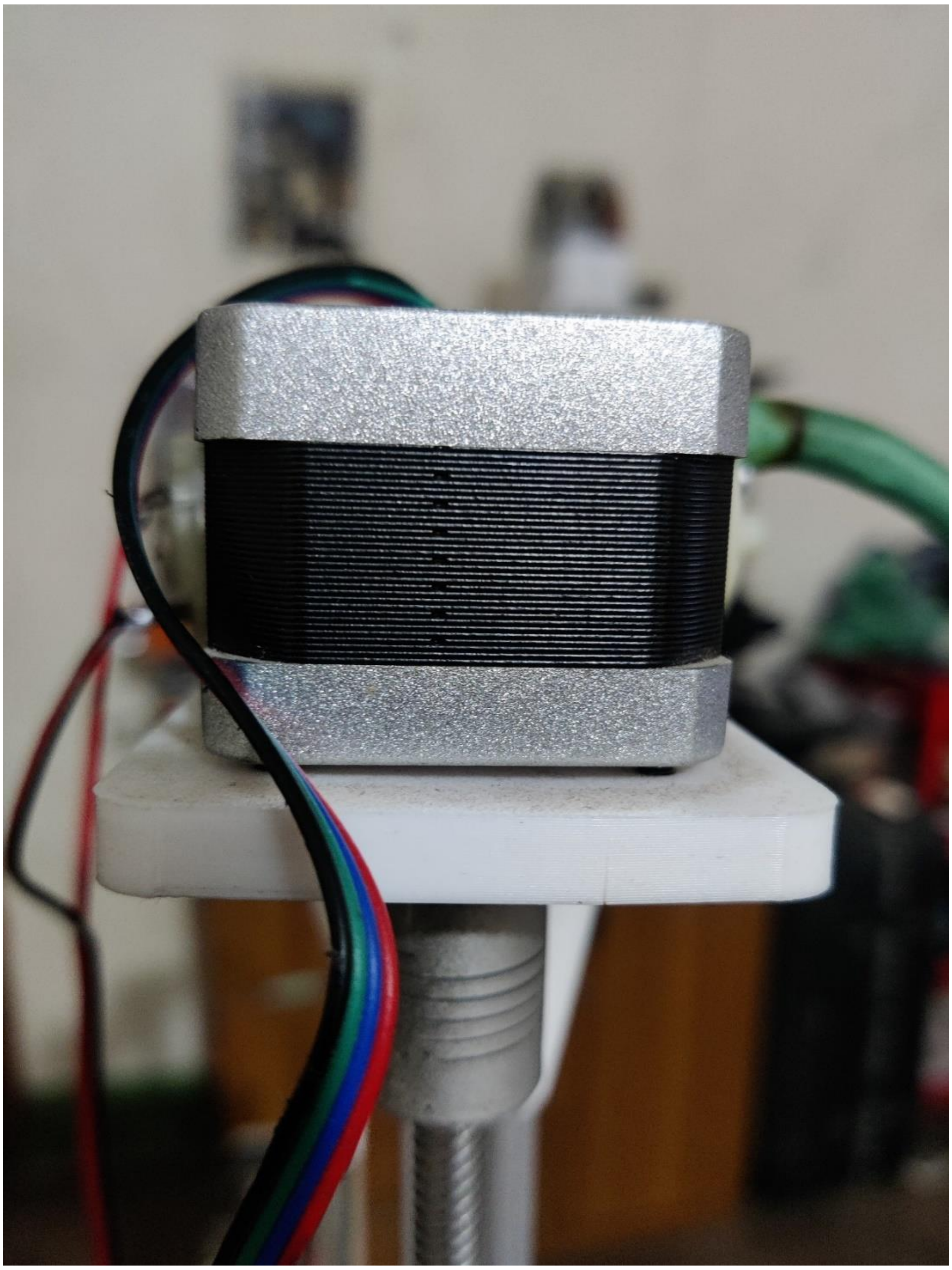

Figure 33: NEAM-17 motor

GT2 belt is used to connect the motor's shaft to other components in the system, such as gears, pulleys. The GT2 belt is driven by the NEMA 17 motors, and can transmit the rotary motion of the motor to other components in the system, allowing them to move in a controlled, precise manner. Compared to lead screw, GT-2 belt can move the components very fast and swiftly.

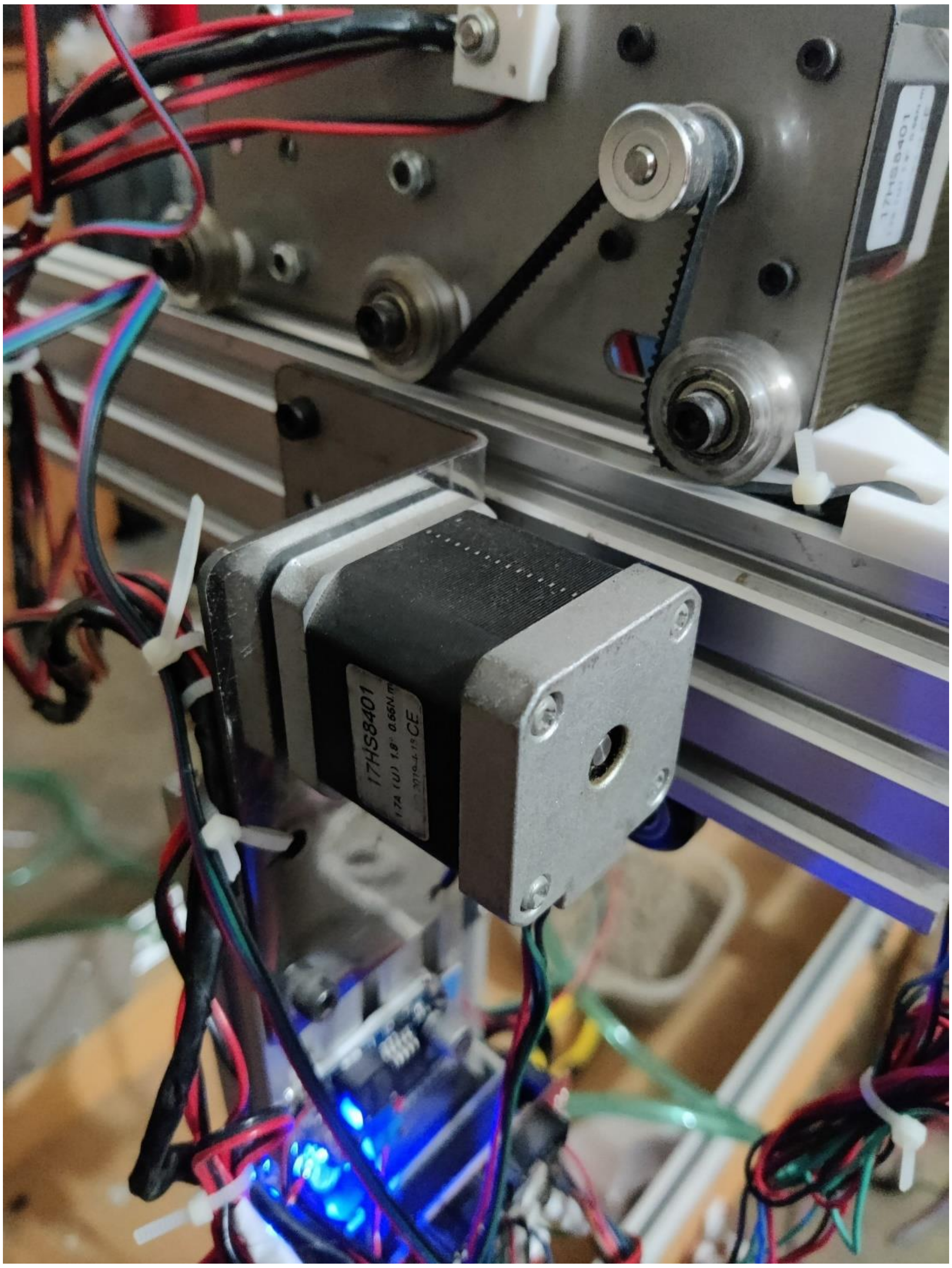

Figure 34: NEAM-17 motors

5.2.4 Microcontrollers

To drive and control the system, a combination of hardware and software components has been used, including the Arduino Mega microcontroller, the RAMPS (RepRap Arduino Mega Pololu Shield) board, the ESP32 microcontroller, and the Raspberry Pi computer. Arduino Mega and RAMPS board work together to control the mechanical movement of the system, while the ESP32 and Raspberry Pi handle communication and data processing tasks. The system is able to perform mechanical movements and control functions automatically using these microcontrollers. Arduino mega is also connected to a number of other components, such sensors, servo motors, Water and air pump.

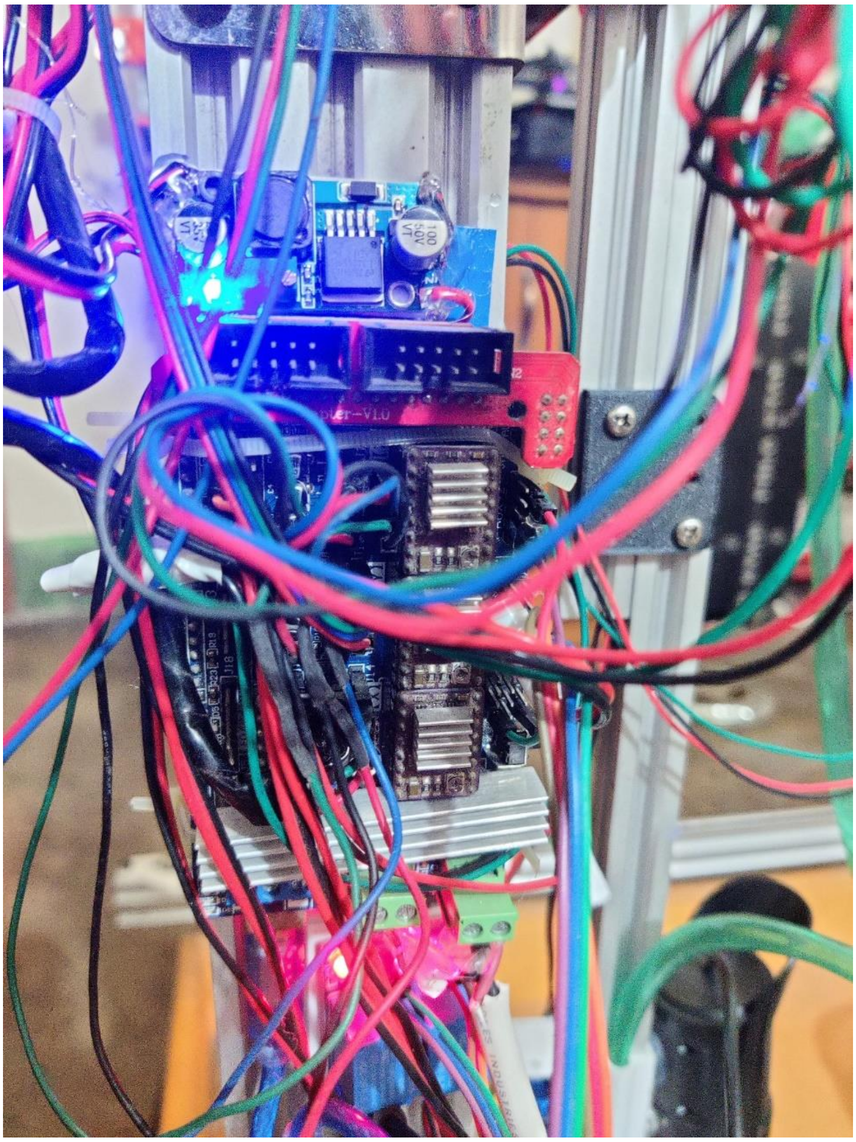

Figure 35: Arduino Mega mounted on Ramps

Moreover, Arduino Mega is programmed to control the water and air pumps by sending digital signals to the relays. When a digital signal is sent from the Arduino Mega to a relay, it activates the relay which controls the 12v water pump and 6v air pump.

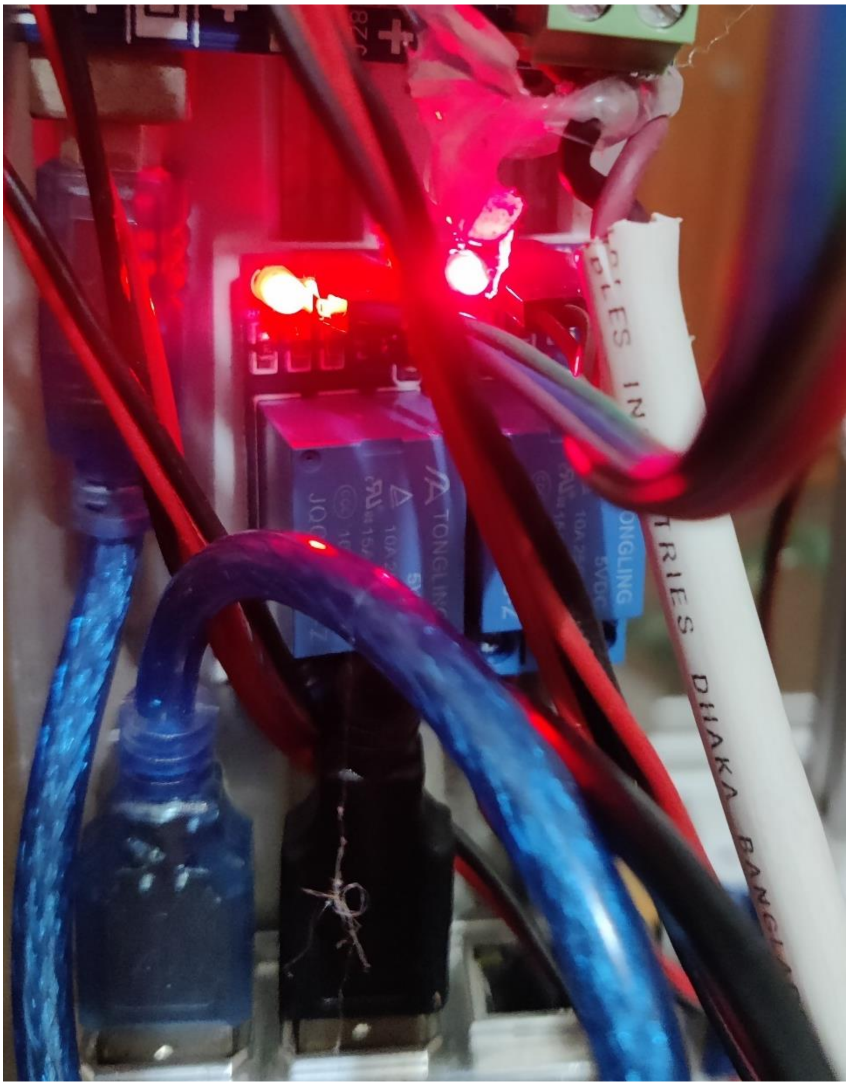

Figure 36: Relay to automate the seeding and watering

The Raspberry Pi is running a Laravel server, Laravel server is responsible for handling communication and monitoring tasks for the system. It might be used to send and receive data between the system and other devices, such as sensors, motors, and other components, as well as to process and store data for later use. The Laravel server is also used to provide a web-based interface for interacting with the system, allowing users to control and monitor the system remotely.

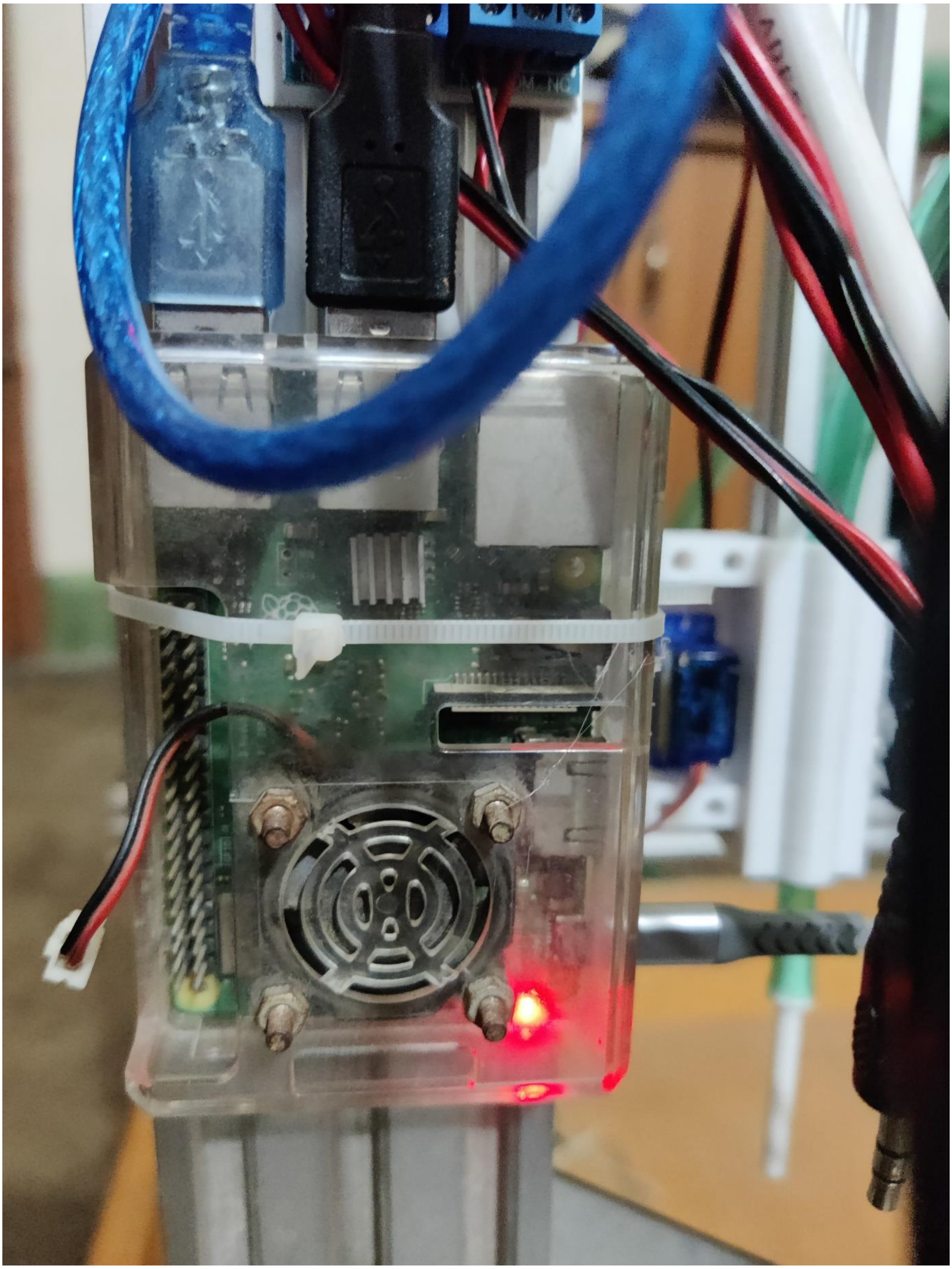

Figure 37: Raspberry Pi

5.2.5 Complete System

After mounting everything in place the system is tested by calibrating motors movements and settings its limits in order to safely operate in the specific area. The system is using 12v-30A power supply. The system is also tested under full load. This is important because it allows the system to be used to its full potential and helps to ensure that it will be reliable and effective under real-world conditions. After running all the tests, it is ready to begin the seeding and watering process.

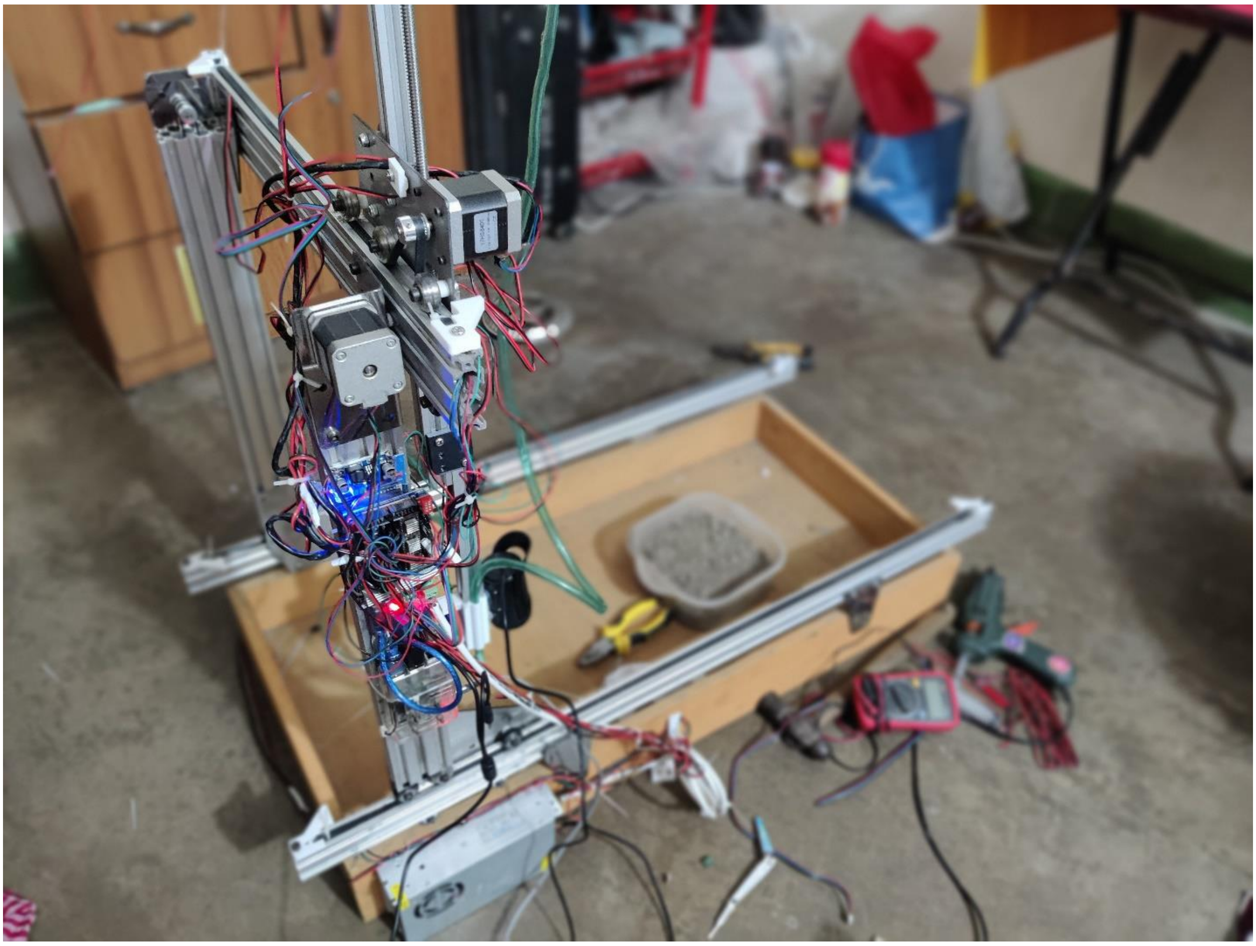

Figure 38: Complete System

5.3 Evaluate the solution to meet desired need

The system is able to achieve the desired results in terms of planting seeds, watering the plants, and monitoring their growth. The solution is able to perform these tasks accurately and consistently, without any issues with reliability or accuracy.

To achieve these results, the solution relies on the flawless and reliable use of mechanical components and sensors (such as soil moisture, air quality, temperature, and humidity) to perform smooth and precise movements, as well as gather data about the plants and the environment. This system is much efficient as Arduino mega and Raspberry Pi process the data from the sensors and control the movement of the mechanical components automatically which are programmed. Overall, the solution is able to effectively and accurately perform the tasks of seeding, watering, and monitoring, ensuring that the plants are provided with the necessary resources to grow and thrive.

Moreover, the system is designed in a way that is easy to understand and navigate, with clear instructions and straightforward controls. Thus, the is user-friendly and accessible, making it easy for users of all levels of expertise to get up and running quickly.

5.3.1 Evaluation of seeding part

The seeding part is working as it is capable of lifting the seed and place it into the soil. An air pump is used to suck the seed from the container (seed box) and place into the soil. By carefully controlling the flow and pressure of the air, the seeding part of the solution was able to accurately plant seeds at specific intervals and locations. To accomplish, precise seeding with an air pump, the system used the microcontroller (Arduino Mega) to process this data and control the air pump.

The process was done by this manner:

Calibrate position → Move to the nozzle to the seed box → Turns on Air pump → move to seeding area → Release the seed by turning of the air pump

As a whole, this perfect design and controls, makes it possible for a perfect solution of seeding plant in a precise and accurate manner.

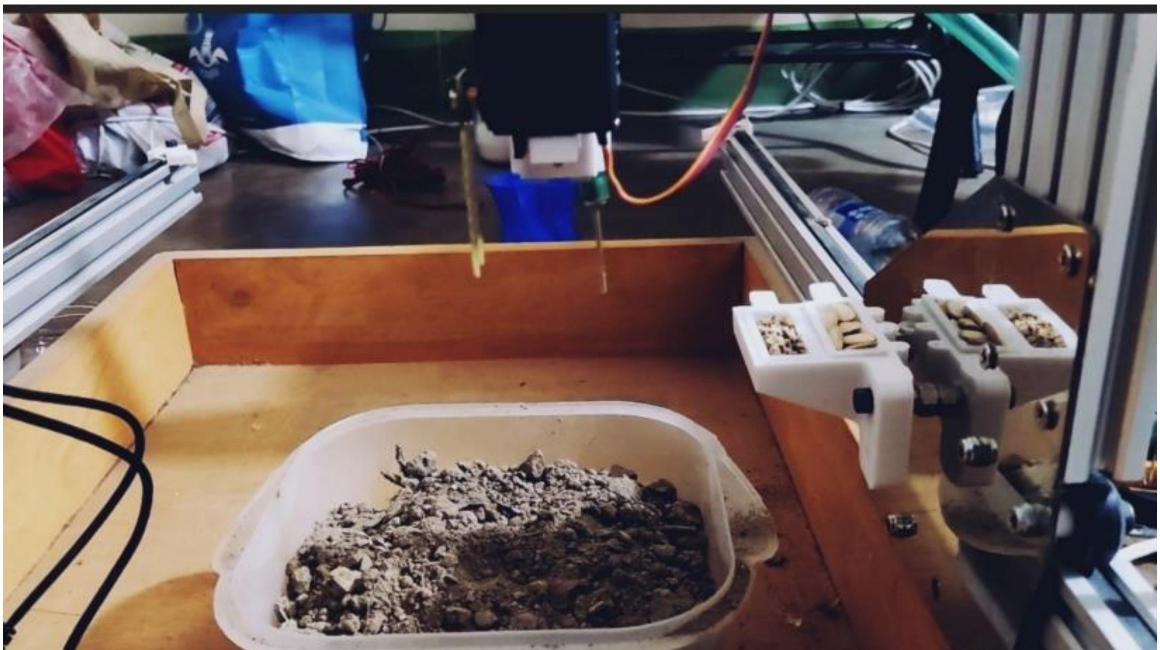

Figure 39: Nozzle Without Seed

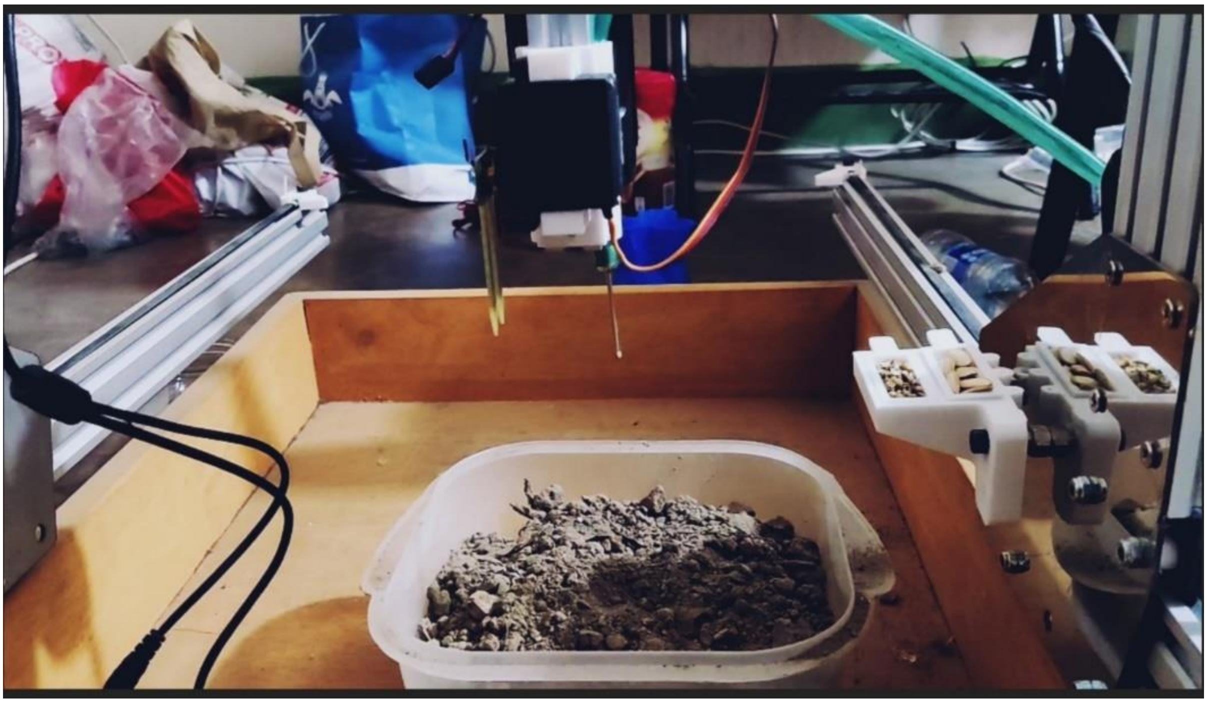

Figure 40: Nozzle with seed

5.3.2 Evaluation of sensors data

Real life Sensor data was collected and stored in excel sheet. Sensor's data can be monitored real time through website. Collected sensors data were very stable. The stability of the sensor data was essential for ensuring the accuracy and reliability of the system's performance. The collected data showed a high degree of consistency and precision, which contributed to the overall effectiveness of the system.

Time	12/13/2022 11:09	Temperature	26.86C	Humidity	nan%	AirQuality	10	Moisture	1430
Time	12/13/2022 11:09	Temperature	26.86C	Humidity	24.00%	AirQuality	10	Moisture	0
Time	12/13/2022 11:09	Temperature	26.86C	Humidity	28.00%	AirQuality	10	Moisture	24
Time	12/13/2022 11:10	Temperature	26.86C	Humidity	24.00%	AirQuality	10	Moisture	193
Time	12/13/2022 11:11	Temperature	26.86C	Humidity	24.00%	AirQuality	10	Moisture	0
Time	12/13/2022 11:13	Temperature	26.86C	Humidity	24.00%	AirQuality	10	Moisture	0
Time	12/13/2022 11:13	Temperature	26.86C	Humidity	24.00%	AirQuality	10	Moisture	0
Time	12/13/2022 11:13	Temperature	26.86C	Humidity	24.00%	AirQuality	230	Moisture	798
Time	12/13/2022 11:13	Temperature	26.86C	Humidity	24.00%	AirQuality	49	Moisture	1300
Time	12/13/2022 11:14	Temperature	26.86C	Humidity	24.00%	AirQuality	118	Moisture	425
Time	12/14/2022 11:14	Temperature	26.86C	Humidity	24.00%	AirQuality	118	Moisture	425
Time	12/15/2022 11:14	Temperature	26.86C	Humidity	24.00%	AirQuality	118	Moisture	425
Time	12/16/2022 11:14	Temperature	26.86C	Humidity	24.00%	AirQuality	118	Moisture	425
Time	12/17/2022 11:14	Temperature	26.86C	Humidity	24.00%	AirQuality	118	Moisture	425

Figure 41: Evaluation of sensors data

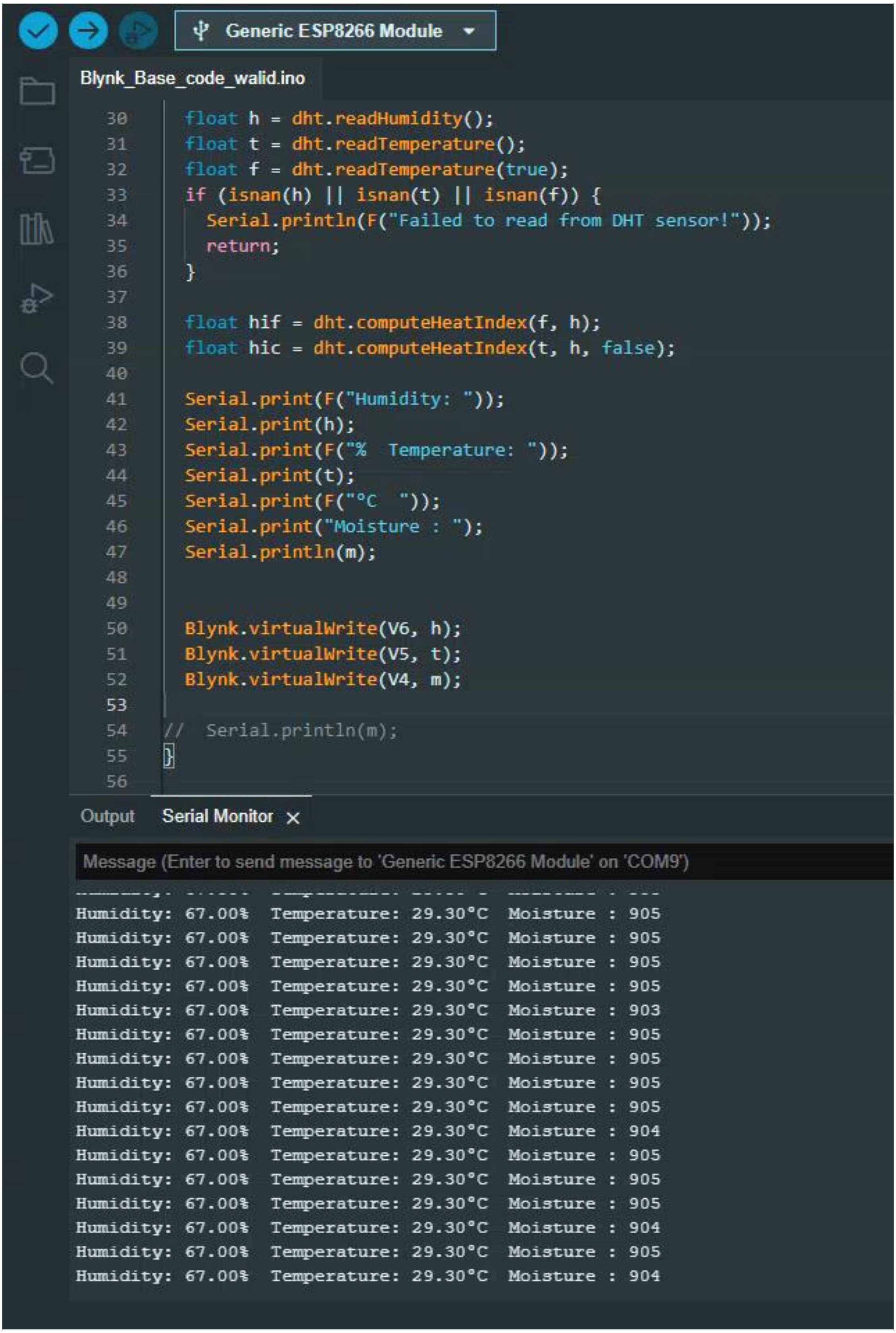

Figure 42: Raw Sensor Data

5.3.3 Control & Monitoring

For controlling and monitoring, a webcam is attached to the gantry to deliver 24*7 real time data and footage to the consumer. By viewing the webcam footage, users can remotely control and manage the system from a distance, making it possible to operate the system even when the user is not physically present. Mainly, a website is built for controlling the system.

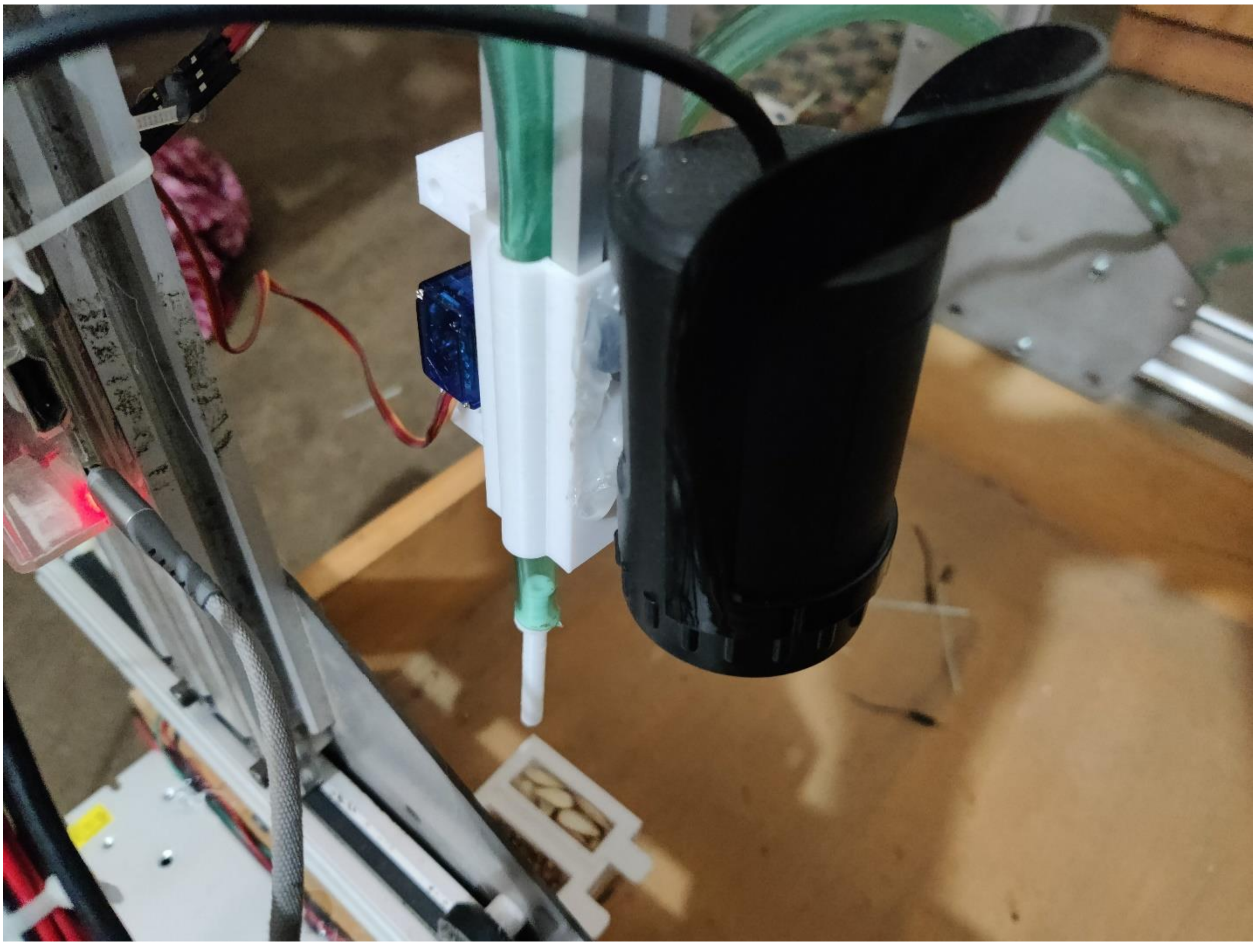

Figure 43: Webcam mounted on the Gantry

5.3.4 Controller Website

To control the whole system the website is designed. And it is fully functional. The website provides a user-friendly interface for controlling and managing the system, with clear and intuitive controls and features. Users can access the website from any device with an internet connection, allowing for convenient remote control and monitoring of the system.

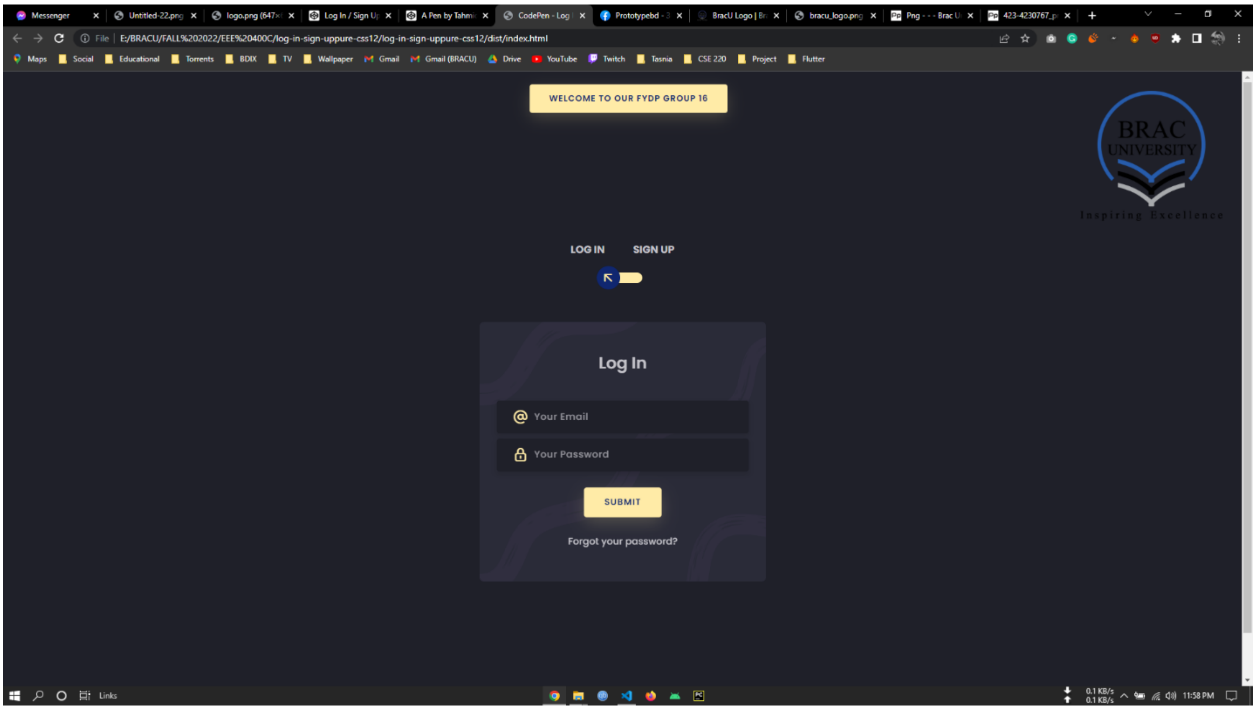

Figure 44: Login Page

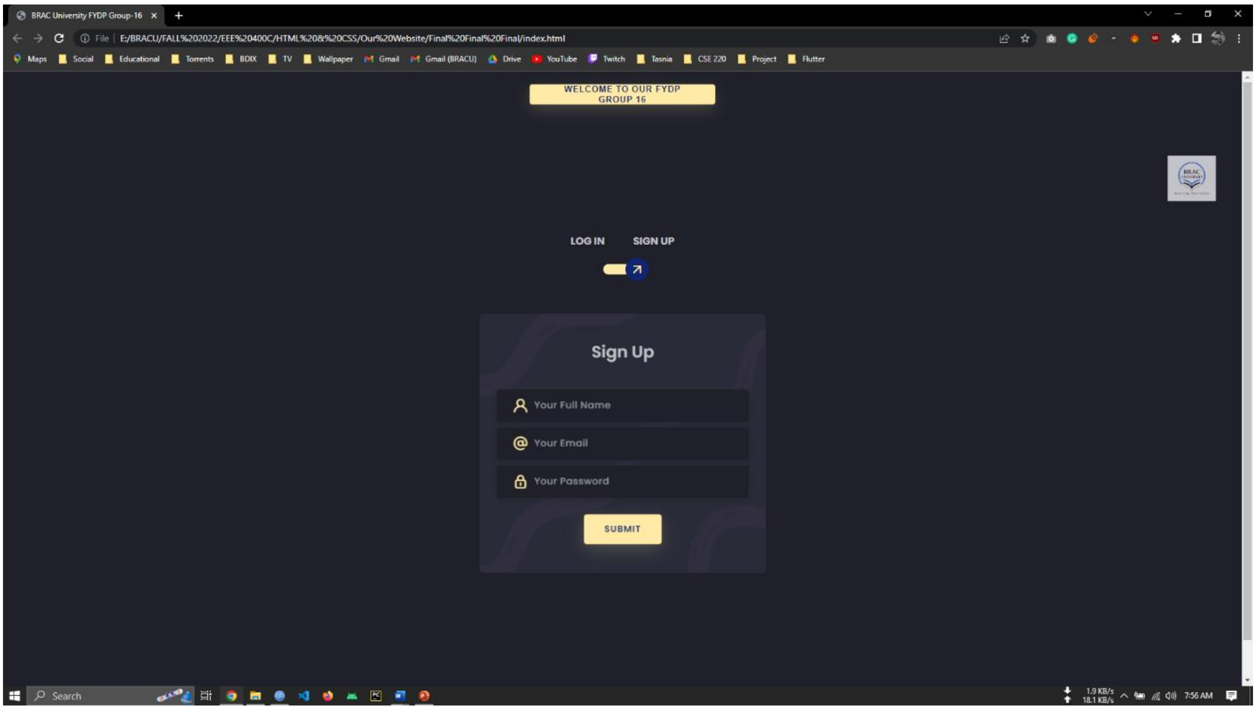

Figure 45: Sign Up Page

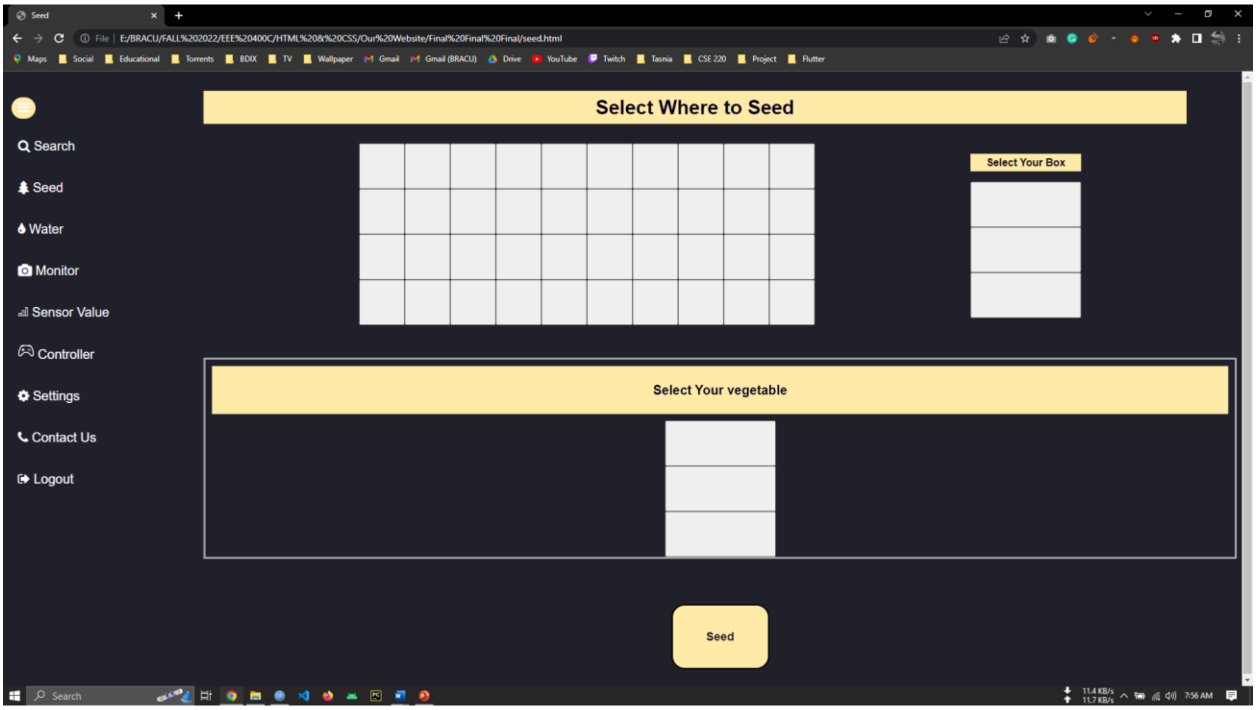

Figure 46: Seeding Page

The seeding page provides access to data about the seeding process, such as the number of seeds planted.

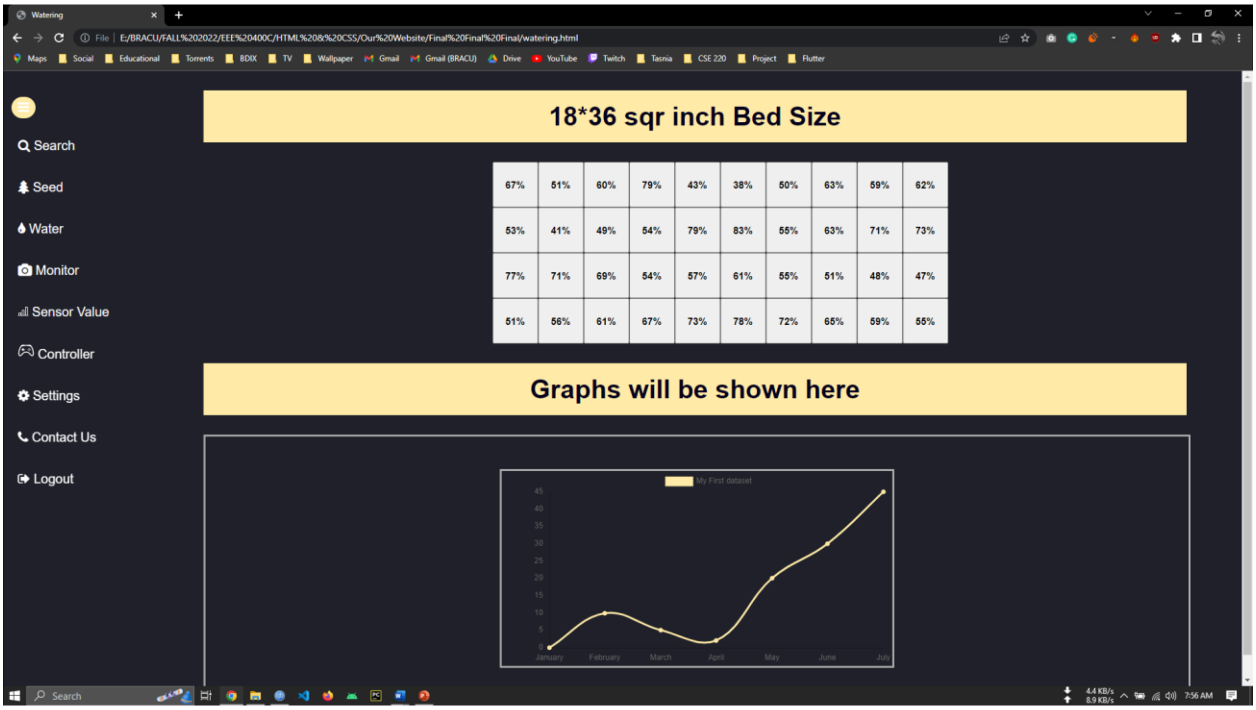

Figure 47: Watering Page

he watering page serves as a useful tool for monitoring and managing the watering process within the system, providing users with the information and controls they need to optimize and maintain optimal water levels for the plants.

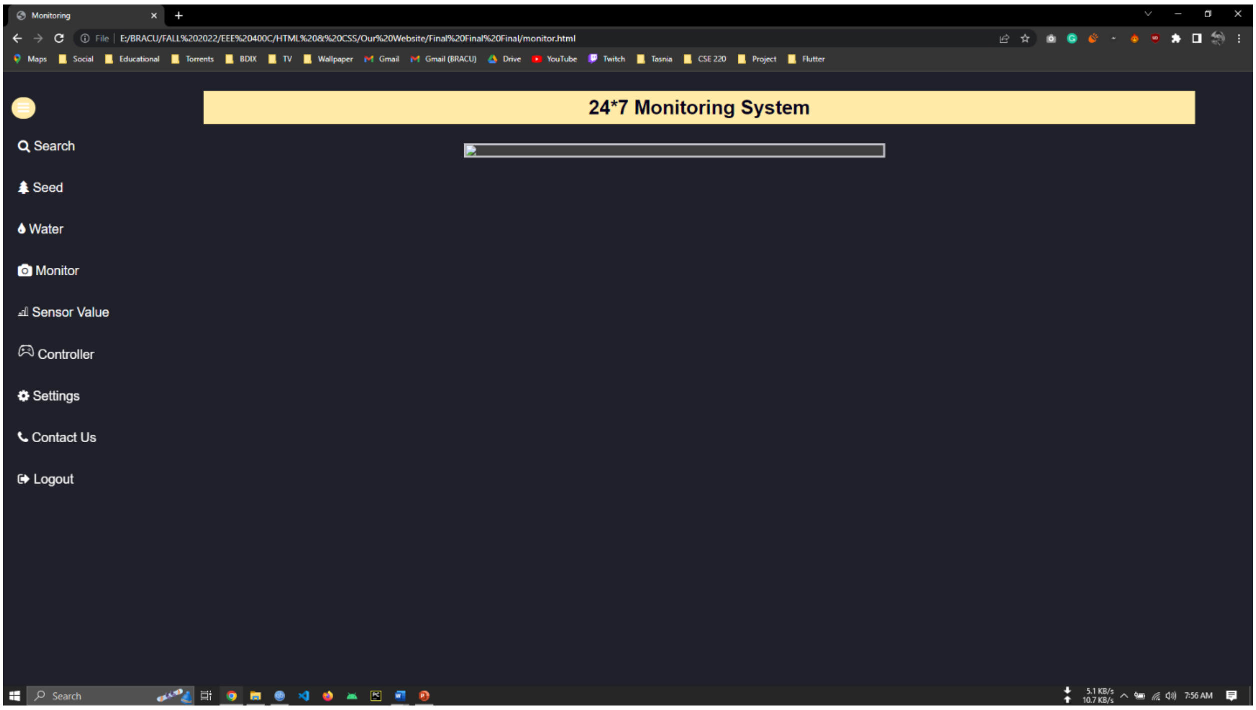

*Figure 48: 24*7 Monitoring Page*

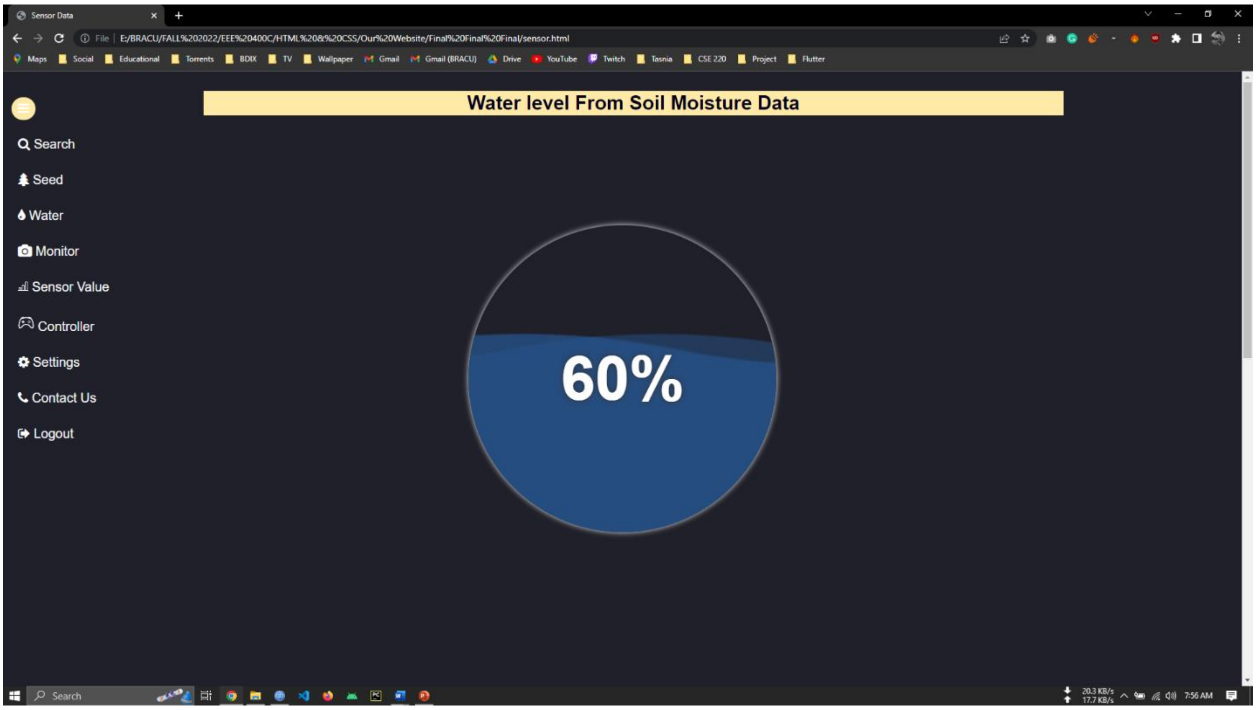

Figure 49: Water Level From Soil Moisture Data

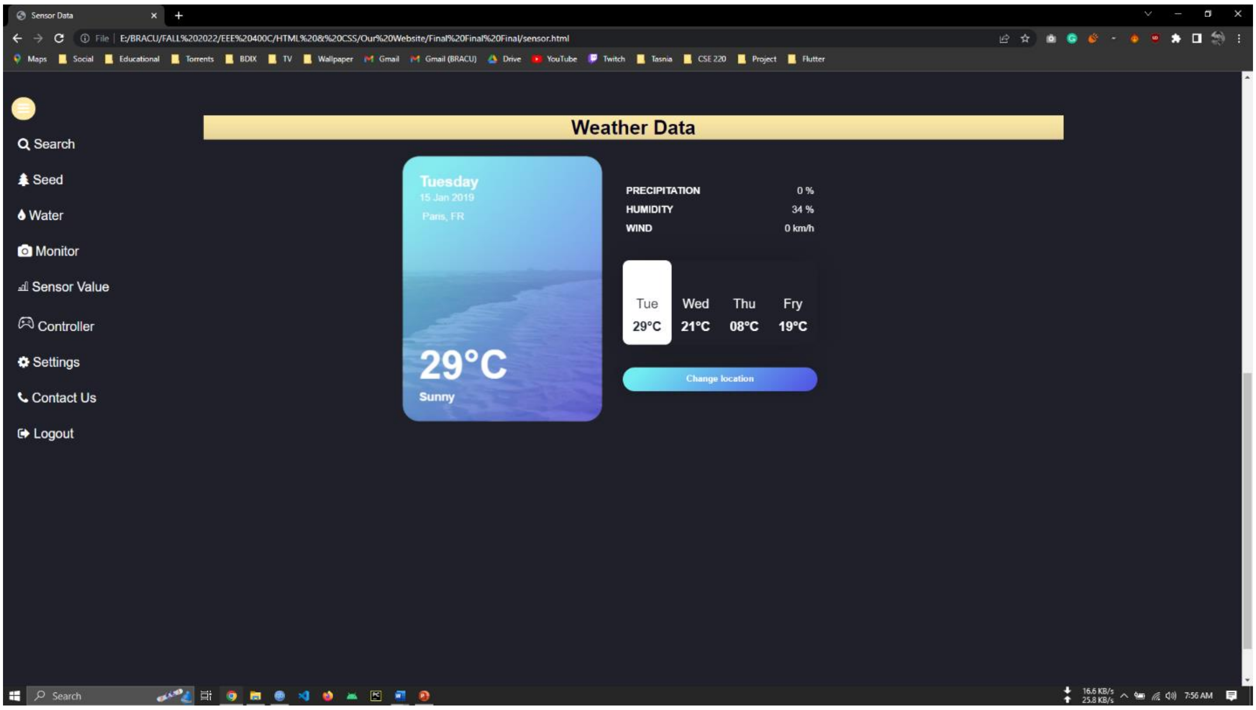

Figure 50: Weather Data

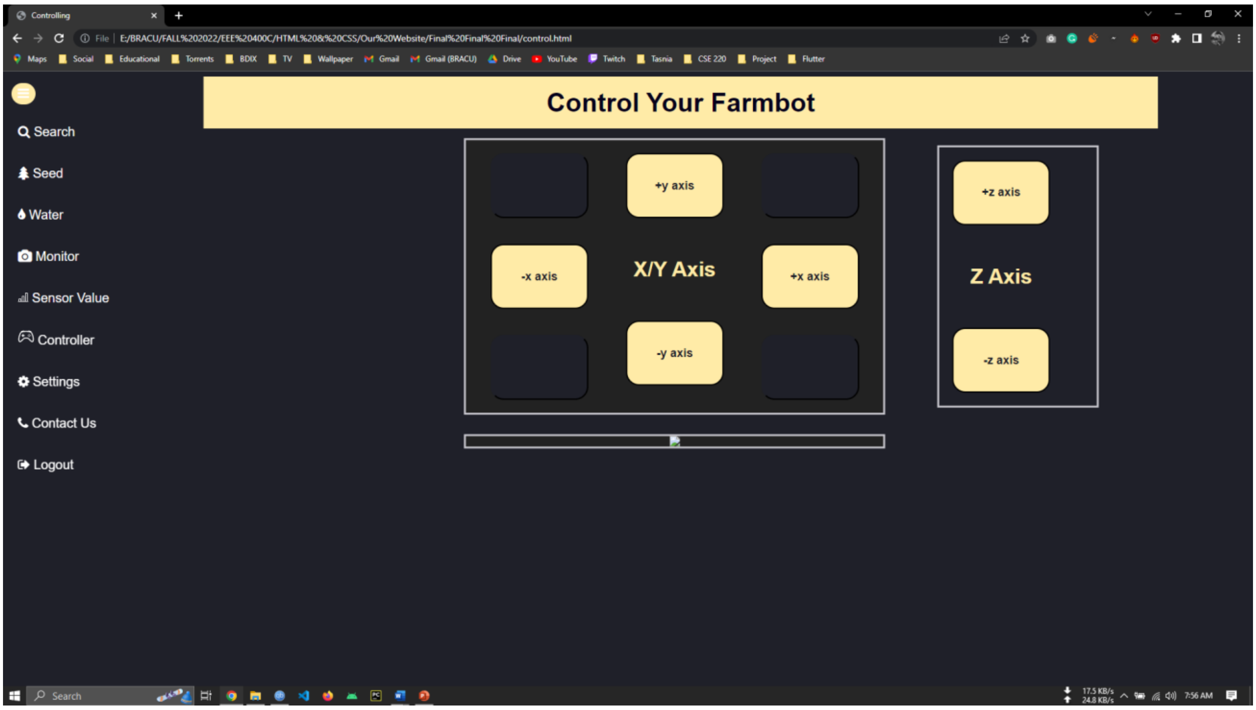

Figure 51: Control panel

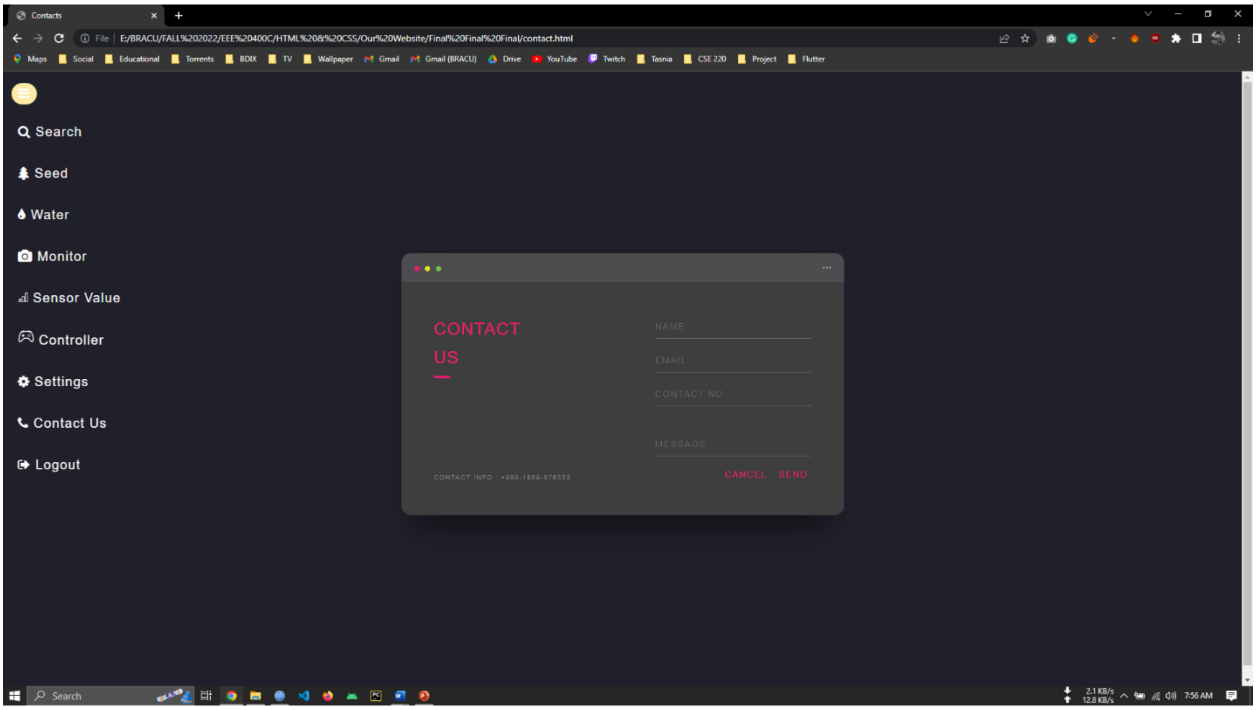

Figure 52: Contact Us Page

5.4 Conclusion

By using various microcontrollers and sensors, as well as a website and webcam for control and monitoring, the system was able to perform automated farming tasks accurately and consistently, ensuring the success of the plants and the overall effectiveness of the system. To control and monitor the system, a website was designed that provided a user-friendly interface for managing the system's tasks and settings. The website was fully functional and allowed users to access the system from any device with an internet connection. In addition to the website, a webcam was attached to the gantry of the system to provide real-time data and footage of the system's processes.

It is hard to use any video reference in the report. But more pictures can be added to validate the system properly. As this is a draft, there can be more changes before the final submission. But however, video reference is added on the slide to validate the process.

Chapter 6: Impact Analysis and Project Sustainability

6.1 Introduction

Impact analysis means considering the influence of the project on the environment and individual in different manners. There can be a number of factors associated with the project in a positive way or negative. In this section, these factors are briefly discussed in detail with proper research and authentic information. Besides, the sustainability is checked through the SWOT analysis to get a more comprehensive understanding of the project.

6.2 Assess the impact of solution

In the context of the current world, this needs no explanation that pollution of every kind is increasing day by day. So, any kind of product that has been introduced recently has at least one or two things in common. And those are the impact of it on the environment and the health of the consumers. There are many other important aspects of impacts but those differ between products. Some of the impacts are societal, safety, legal and cultural.

6.2.1 Environmental

In busy cities like Dhaka, pollution is one of the main concerns. According to IQAir, the air quality of Dhaka is very unhealthy for a sensitive group of people [22]. Also, recently the air of Dhaka became the most polluted among all the other countries in the world [23]. The environment of Dhaka city needs to be heeled in terms of leading a healthy life here. Again, Dhaka does not have enough space to plan trees for fresh air. And it is not feasible to create green areas around Dhaka city to provide that facility. The only way to turn cities like Dhaka into green cities is through rooftop gardening.

In countries like China, the population is increasing very quickly. And the space for both people and plants are very limited. Multi-steroid buildings may solve the problem of increment in population but to solve the environmental crisis, China has taken a great initiative to turn their cities into green cities. An appropriate example would be the city called Liuzhou which is also planned to turn into the Liuzhou Forest City [24]. Though this is a concept till now, proper execution of this plan can ease millions of lives.

Unlike China, Dhaka does not have any proper planning for its future infrastructures and how it is going to solve the problem of environmental pollution. Rooftop gardening or to be more specific, farming on rooftops of most of the buildings of Dhaka city can generate enough oxygen and consume carbon-di-oxide on a regular basis. Unlike other farming processes, this system will have proper planning and drainage systems that will never affect the environment badly. Furthermore, because of the minimal amount of usage of fertilizers, this system will not pollute any kind of organic beings or products that are heavily dependent on the environment.

6.2.2 Health

It has been mentioned multiple times that the automation system has been planned to minimize the issues that are harmful to the human body. As the transportation of vegetables will be cut off significantly, less formalin and other chemical products will be used. In this process, the vegetables will remain fresh and organic and ready for the consumers to be consumed. Another advantage is the vegetables that will be produced, can reach out to the nearby markets without any delay. This way, the consumers can have the vegetables that are just plucked out from the plants. Also, plants on the rooftop will keep the top floor comparatively cooler than the rooftops that do not have any of these facilities [25]. So, people will be less worried about the problems that occur on hot sunny days like pickles, rashes, and other skin problems. There are other benefits or impacts of health that are produced by the system like less human interaction for the users, foods for living pet animals in a form of plant remains, non-consumed parts of vegetables, and much more.

6.2.3 Societal

Every system that is available in the market and consumed by the users has some impact on society directly or indirectly. Some of them have strong and emotional bonds with the users, and some may just slowly affect society. The autonomous farming system will also have some societal impact that is highlighted below.

1. <u>Owner consumer relationship:</u>

It will create a strong bond between the house owners and the consumers that are dependent on them. The consumers may be the families of that apartment or can be some others from the society. Even it can be someone who will work as a middleman who will provide services to the consumers.

2. <u>Job opportunities:</u>

There are many organizations that provide different kinds of services to consumers. One of a kind is providing daily resources and raw food materials. This farming system can supply new products that can create a new working chain among the existing organizations or new organizations can enter the market with their services [26].

3. <u>Price reduction:</u>

When some products need distant transportation, the cost of that product increases significantly. With the autonomous system, the necessity of importing vegetables from other cities will reduce significantly. Consumers will have suppliers in their own backyards and the amount of money they will have to pay will reduce.

There are a few more societal impacts that can be highlighted like the trust between the consumers and suppliers, a healthier food chain for the consumers living in society, and moreover connecting people from different backgrounds together.

6.2.4 Economical

In the societal part, the price reduction issue has been mentioned about how this autonomous farming system will reduce the cost of the products or vegetables. This system will act significantly on the economy if it is used properly. People can have better products at comparatively lower prices. It will create job opportunities for thousands of people, and also connect people from different aspects [27].

6.3 Evaluate the sustainability

6.3.1 SWOT Analysis

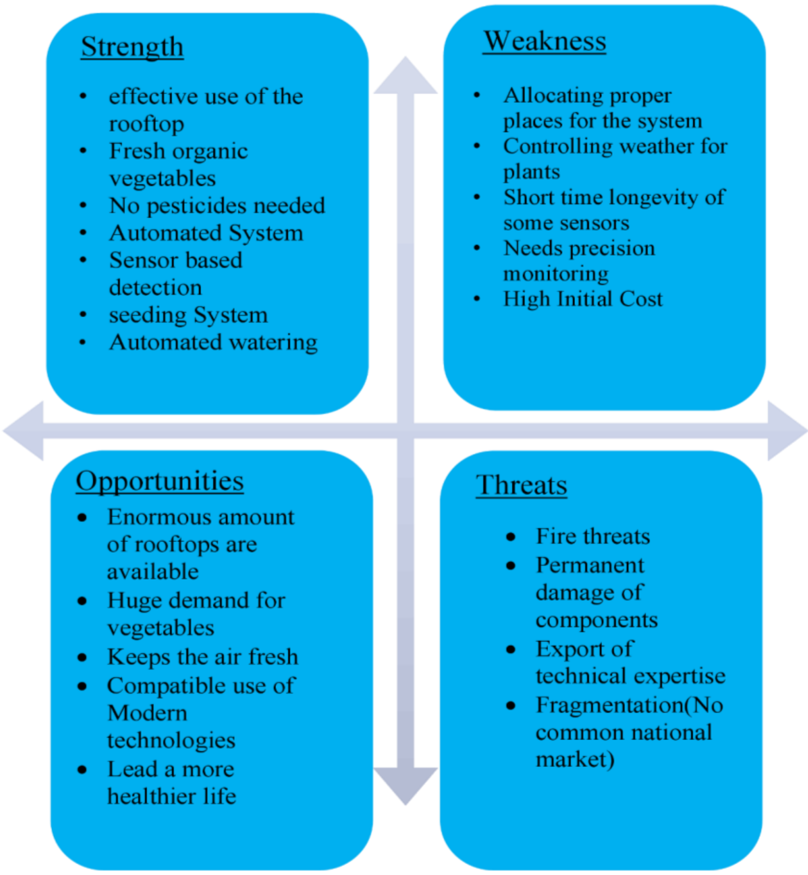

Figure 53: SWOT Analysis

As per our projection, this project will be highly beneficial and environmentally friendly for the urban areas as it can be visualized that there are seer opportunities for the rooftops. There are plenty of rooftops that are mostly empty and not in use for such structural purposes. So, this project will allow people to grow vegetables in a sustainable way with the use of modern technology. It is going to be a fully automated system that will mostly do the necessary work of farming and monitoring with different types of sensors and robotic components. The system will be very user-friendly so that the owner himself will be able to control it easily after installation.

Throughout this project, the whole urban community will be taken under consideration and will be connected through this urban farming system. For instance, the roofs of personal belongings to commercial spaces like offices, restaurants, etc. can use our system to create an eco-friendly system for themselves as well as others [28]. This farming system will take less supply of water rather it can use the rainwater directly and the rest of the water can be stored for future uses. Again, these green environments on rooftops will have significant values to keep the air fresh and reduce dust particles. Moreover, one can minimize the daily cost of buying vegetables and collect them freshly from the rooftop. Restaurants can also be benefited in different ways. So, all these possibilities will ensure humans a better lifestyle with the supply of higher quality of food, and a greener environment to live in.

Although this system has a very impactful and significant role to demonstrate, it has some drawbacks that might slow down the estimated outcome. People are still used to farming in an ordinary way. So, the target area we are focusing on may always not be provided by the owners. All corporate buildings may not have the tendency to provide space for the project. In Spite of having the advantage of rain for the plant, the other natural value needs to be added to the soil priorly to maximize the growth. For all the sensors and robotics components the initial cost will be a bit higher only during the installation process. A study on technological advancement used in urban agriculture following (CEA) seems to be an optimized process to apply in this agriculture field [29]. Tech implementation of the sensors surely adds facilities to precision monitoring but these sensors might get corrupted for unavailable reasons which may lead to a decrease in the effectiveness of the system. Things might get worse if the whole building is under some threat like catching fire or other unwanted calamities. So, maintenance protection will also be a challenge. Moreover, large-scale farming will require skilled IT personalities to operate which needs to be hired for different areas.

So, considering the technology, a novel era for the farming system of the urban areas, will bring positive impacts and will be adjusted to the environment very spontaneously along with a few drawbacks that have been discussed briefly.

6.4 Conclusion

After analyzing the facts correlative with the project, a number of impacts such as environmental, societal, health and economical are visible in this project. It is an important task to analyze this information to determine the long term effects the project will have on individuals and the community. As the project is selected for the overall betterment of the farming system and to make it more sustainable for the urban people, all the possible opportunities and features are explained. Besides, the failings that the project may face are also discussed to make sure of taking all the necessary steps afterwards. In the sustainability part, the whole summarization of the impacts is noted down to make a decision of the project about how much it is going to be suitable for the rooftop environment. Thus, this analysis represents the suitability of the project to be accustomed with the specific environments and individuals along with the technological advancement it provides and the overall issues that may occur during the implementation and daily use.

Chapter 7: Engineering Project Management

7.1 Introduction

In order to implement projects like this, one must have a proper time management quality and accommodation with the peer members apart from all the engineering knowledge and skills. So, it is always started by setting up specific goals which are to be fulfilled within a certain time frame. There is discussion among peers and all the work is broken down into a certain period that needs to be completed. Although uncertain situations can always occur and tackling those with proper direction is required then. This section briefly explains the management of the whole project starting from topic selection to design and implementation.

7.2 Define, plan and manage engineering project

Any project involving the building of new works, the alteration of existing works, or both that primarily involves engineering work and for the planning of which the client hires an engineer is referred to as an "engineering project." A target is set to be fulfilled according to the specifications of the project. In order to reach the target certain plans are made to meet the objectives properly in the end. The management of work and time is divided among the peers according to these activities.

This Project was divided into three major stages that are topic selection, design development and prototype implementation. These stages were assigned with three courses: EEE400P (Topic selection), EEE400D (Design development), EEE400C (Prototype Implementation). There were specific procedures of performing in every stage which have been represented through the Gantt Charts. These charts show how much time has been given in each stage for developing the project. Along with this, A log book is maintained whenever there is discussion among peers and discussion with the project coordinator. This helps to keep track of the progress in an organized manner. In case of uncertain issues, the plans were changed and the Gantt Chart was revised. For instance, the prediction made in EEE400P for the EEE400D was received while design selection. Again, the prediction made for EEE400C is also changed slightly in this ongoing implementation process as it is seen that the hardware assembling was a bit irregular as the components were not available in the local market all the time.

EEE 400p

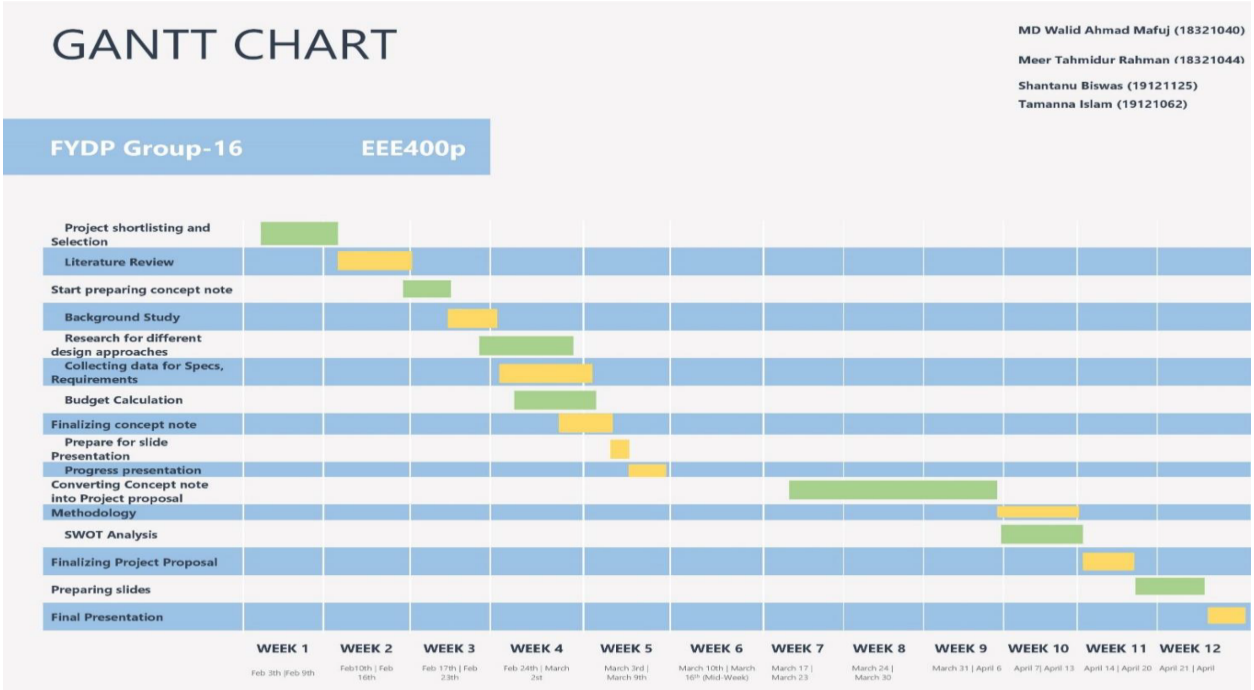

Figure 54: 400P Gantt Chart

EEE 400D

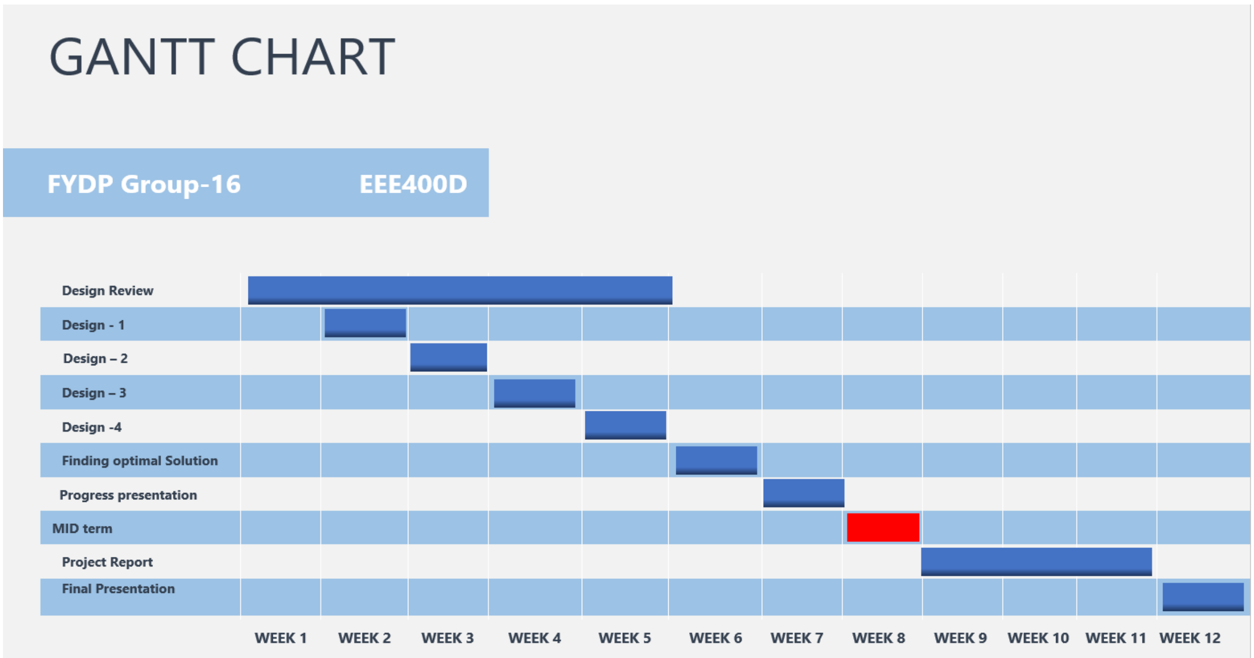

Figure 55: 400D Gantt Chart

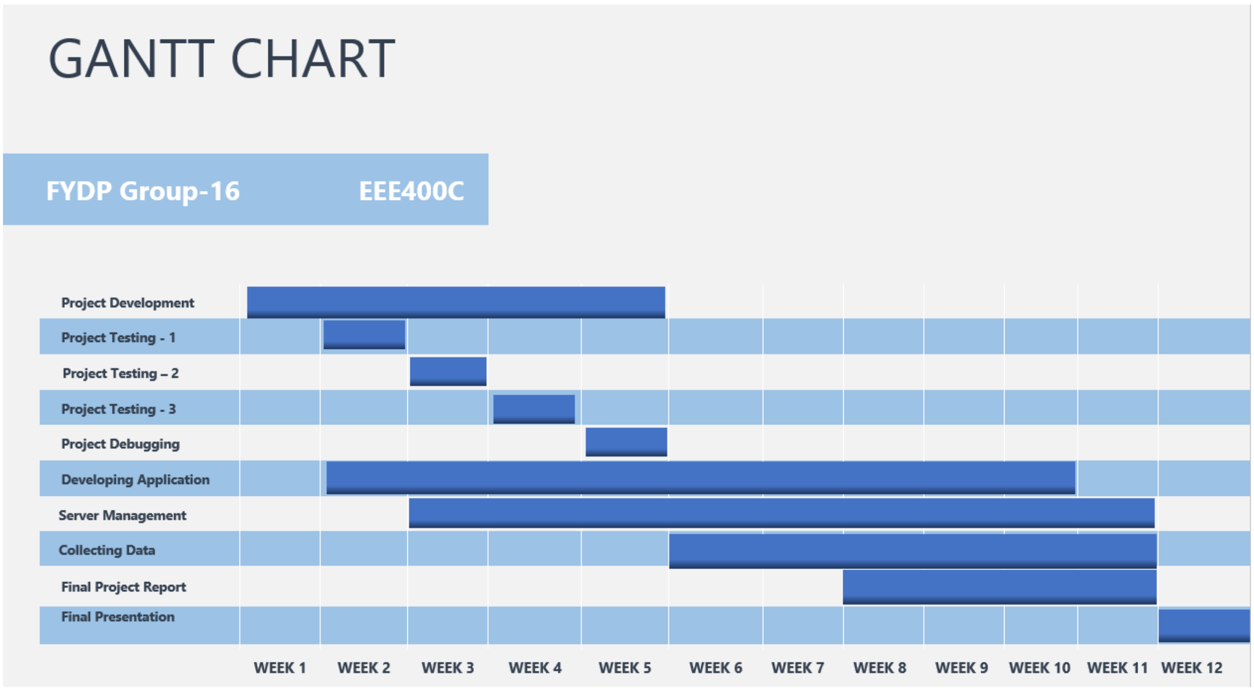

Figure 56: 400C Gantt Chart

7.3 Evaluate project progress

Evaluating this project requires the planning of all three semesters which has been demonstrated into the previous section. There are several distinctive stages that can be demonstrated for better understandings.

7.3.1 Design with alternate approaches

Firstly, the problem has been identified which is taken into consideration. The main objective is to solve the food adulteration problem by creating a sustainable environment in the rooftop. To solve this problem, an engineering design has been planned. After that, three other alternative solution has been proposed. The four approaches are –

- CNC Formfactor
- 6-dof Robotic Arm
- Cable Driven Parallel Robot
- IoT Based Solution

7.3.2 Finding Optimal Design Solution

To find the optimal solution, simulation has been done for all four designs. Other aspects have also been into consideration. For example, budget, power consumption, stakeholder's opinion, weight distribution and sustainability.

7.3.3 Work Breakdown for the Optimal Solution

After selecting the optimal design solution, the rest of the work has been broken down into several parts to assign it according to the expertise of the members.

- Web Development
- Sensor Simulation
- Prototype Design Optimization
- Prototype Completion
- Report Writing
- Presentation

7.4 Conclusion

In order to reach the expected outcome, all the members of the group have participated equally to complete the project. Most of the works were completed within the time frame. All the information is noted down to the log book to track our progress in time. Thus, project management procedures help a lot to organize things within a time frame and keep the members active.

Chapter 8: Economical Analysis

8.1 Introduction

The most important part of any project after it to analyze the economic impact and the economic aspects of it so that that it can be determined whether the project is sustainable enough for the users or not. There are many aspects of the economy to look at. There is economic analysis, cost benefit analysis and evaluation of economic and financial aspects.
However, this analysis requires strong market support and knowledge of economic growth and analytical skills.

8.2 Economic analysis

As the project work is nearly to an end, it is possible to compare the outcomes that we have expected and how they can impact economic growth and other indirect economic relativities.

Economic analysis is the both direct and indirect costs and benefits that are attached to this system. There are many economic aspects of this system that will be directly connected to the people of the society. The societal effects have already been discussed in the impact section. To directly connect this system to the people and their economic prosperity, it can be divided into some sections to make it more understandable.

8.2.1 Health and Economy

The impact of this system on health has already been come in front in previous sections. As this system is in development with the objective to produce fresh organic vegetables, this can reduce thousands of diseases that are in existence due to vast use of pesticides and chemicals in the vegetables. It can totally have direct impact on the medical expenses that people of the society are bearing. Also, this system can reduce the growing threats of cancer due to chemical consumption in the body and reduce huge amount of danger and economic hassle.

8.2.2 Transportation

Since, producing fresh vegetables is not possible due to shortage of space in big cities, a huge number of vegetables is transported from rural areas outside the city. This forces the providers to use chemicals that can keep the vegetables fresh for long 24-36 hours. This has been discussed in the health section but another problem arrives that the transportation cost is also comes like an add-on with the price of the products. This system can produce vegetables on the rooftops of its own place and can meet the necessity of the consumers and also others.

8.2.3 Waste Reduction

Transporting a product from one place to another requires high efficiency and good packaging. But in cities like Dhaka, vegetables are coming in with poor maintenance and that causes a huge amount of waste of products. Some get rotten inside the transport and some loses their productivity and shapes. This system can prevent that and directly have an impact on the price of the price.

8.2.4 Other Economic Aspects

This system has other economic benefits for example creating job opportunities, motivating entrepreneurs and also a different line of source of income for people who want opportunities.

8.3 Cost benefit analysis

The cost benefit analysis is to ensure the productivity by calculating the total expenses and the benefits that are available in the system or product. Firstly, the expenses of the product should be calculated and then the economic and financial benefits should be there to compare the productivity.

8.3.1 Individual Costs

<u>Direct Costs</u>

Here, the direct costs are the costs of the materials that are used to build the whole system and directly attached to it. The direct cost for this system is –

Table 15: Direct Cost of the System

Section	Components	Unit Price	Total Price
Hardware	**Ramps, drv8825, Nema17, Linear Rod, Bearing (Lm8uu), GT2 belt, Pulley, Idler pulley, Power Socket, Limit Switch, Frame, Screw, Thread, Coupler, lead screw nut, Gantry, Power Supply, Arduino Mega, Water Pump**	**32700**	**38750**
Sensors	**Moisture sensor, UV, Lux Sensor**	**1550**	
Others	**Server cost, App development cost, Transportation cost, Steel cutting cost, Safety cost, 3D printing**	**4500**	

Indirect costs

These are typically fixed expenses, such as utilities and rent, that contribute to the overhead of conducting business. As this system is implanted on the rooftop, the rent expense is not there.

Intangible costs

These are any current and future costs that are difficult to measure and quantify. Examples may include decreases in productivity levels while a new business process is rolled out, or reduced customer satisfaction after a change in customer service processes that leads to fewer repeat buys.

Opportunity costs

This refers to lost benefits, or opportunities, that arise when a business pursues one product or strategy over another. As the system is still prototype, there is hardly any chance to quantify the opportunity without any estimation.

8.3.2 Benefits

Direct

In the direct cost section, the total cost of the system has been demonstrated. Now, to determine the direct benefits, the sales amount of the products and the financial benefit should be on count.

Now, the main financial benefit will come from the vegetables that will be produced by the system. There are some factors that should be taken into consideration.

For example, the area of the bed where this system will be implemented. The amount of production is proportional to the area of the bed size. But the budget will not increase linearly according to the area of the bed size. So, it can be said that the larger the area is, the beneficial the system is, in accordance to the production and the budget. As this system requires a moderate budget, it may seem that it will require time to achieve the financial benefit from the system. But as this system is designed for a societal cause, there are benefits that cannot be measured by countable assets.

Cost Reduction

Similar systems are in development throughout the years and there are some organizations who are trying to improve and develop the system day by day. But there is hardly any development of using this system in the rooftop environment to solve the problem of space in big cities. Though if the price of this system is compared to the ones that are already available, there is a huge gap in the cost of the finished product. The price of their product is almost 4500 US

Dollars which is very high comparing to this 400 US Dollar system. There are so many things yet to be developed but the cost is significantly reduced.

8.4 Evaluate economic and financial aspects

Before beginning a project, it is important to conduct a financial review to see whether it will be lucrative. Additionally, examine the project's cost, risk, and return is necessary. If there are numerous alternative projects, the decision is based on the best project's financial evaluation. To put it simply, utilizing the techniques below to assess a project's financial viability.

8.4.1 Evaluate Cost of Product

It is already been discussed in the previous sections that the direct cost of the product is almost 400 US Dollar which is 38700 BDT. To implement this system, there is also labor and other costs which should not be more than 5000 BDT.

8.4.2 Time Value of Investment in Money

For any project, it is important to measure the time value of the product. The product should have the benefits of saving time or money or other valuable assets like health. This system is an automated farming and monitoring system, it is there to save a huge amount of time for its consumers.

8.4.3 Payback period

Any system or product has a period of paying back the benefits or financial amount that has been expected. For this system, the payback period can be as long as a consumer wants to maintain the system. For example, the system can be last long if there is maintenance. There will be some costs that will be deducted from the benefit but the profits will be everlasting with continuous production of fresh vegetables.

8.4.4 Risk Evaluating

There are some risks that are attached with any system. In this case, the only risk is the maintenance that should be done within a period of 1/1.5 year if no exception happens. There are other risks associated which is not a matter of concern as these will be very rare to take place.

8.5 Conclusion

In this chapter, the economic and financial aspects of the system have been discussed. Most of the methodology of the measurement is there to compare the system to its potential. Though there are some aspects that in intangible and nearly impossible to measure using the tools that fits the process. But however, the discussion can demonstrate a clear picture of the economic benefits of the system.

Chapter 9: Ethics and Professional Responsibilities

9.1 Introduction

In any engineering project, ethics and professional responsibilities play a vital part. Ethics and professional responsibilities involve concerns about the choosing of products, processes, systems and solutions. Issues including user autonomy, safety, sustainability and privacy. Ethical considerations and professional responsibilities are maintained here in a good way. Matters related to copying writing from other writings, doing any tasks without taking permission from the rightful owner/person, violation of privacy of the people, are controlled very carefully in our project. Every kind of safety measure is taken, honesty is maintained while doing the work. Credits are given in a correct way by referencing them. All the risks are analyzed and levels are mentioned with their contingency plans in the later writings. Efficient materials and equipment which are long lasting are used. Facts about maintenance are also kept in mind. In short, all work is done in an ethical way without plagiarism.

9.2 Identify ethical issues and professional responsibility

Ethical Consideration

In research projects in any country, there are some ethical considerations for projects which should be followed. In this project, those ethical points are always considered. Here-

- In this research one of the important points of ethics that has been followed strictly is that none of the group members copied writing from other projects. In the project concept note and project proposal report, only 6% and 3% similarity respectively have been found after checking which is much less compared to the minimum rate allowed.
- Permission from the flat owners of the building to work on their rooftop before establishing this project plan will be taken as it is their individual property. Other informed-consent rules with proper information about risks and favor will be signed if needed. The procedure of making the project, the time taken to establish it, contact details of the constructors, and also other details will be provided. Here, it will be kept in mind that if the person is underage or has any disability, his/her person can give consent and that guardian will also be provided exact information before getting his/her signature.
- As a camera will be used in the project field, the people who are interested to apply this system on their rooftop will take consent from all the flat owners.
- The users will be informed about how the data or information is used.
- Besides consent, privacy and confidentiality of the data of the users will be maintained. The users will get a pass for viewing the live / recorded data. The data will be stored in a reliable place with limited access.

- Safety measures will be maintained regarding the electrical wire connection and water line. That is, it will be tried to reduce the risks and increase the safety of the users.
- If necessity arises about any ethical consideration, it will be discussed with the ethical consideration Committee (ECC) of the area.
- Honesty, fairness, and impartiality will be maintained i.e., the designs will be made keeping in mind the moral responsibilities of a human being.
- The project is not an exact copy of any other person's project. It has some changes and updates compared to other projects done on similar thoughts.
- If there is any information received about the change of the concept of research findings, the correction will be obviously met.
- The references of the papers, internet links, books, etc. used for the research of this project are noted at the end of the proposal report. That means the whole credit for research has not been taken by the authors.

9.3 Apply ethical issues and professional responsibility

9.3.1 Risk Management and Contingency Plan

For any project, there will be some risks related to the components and the process. Those problems with their solutions and preventions are given below-

Table 16: Risk Management and Contingency Plan

Risk Type	Analysis	Level	Contingency Plan	Responsible
Short Circuit	Due to physical damage	High	Fuse	Walid
Continuous Electricity Supply	Lack of power supply from national grid	Moderate	Solar Panel	Walid, Meer, Tamanna
Fire	Due to short circuit	High	Automatic Watering System and Alarm	Shantanu, Tamanna
Sensor Error	Long time usages	Moderate	Warning and physical replacement	Walid, Shantanu
Drainage Problem	Heavy Rainfall/waste	Moderate	Investigate and act	Shantanu, Stack Holder
Website Malfunction	Due to mismanagement	Low	Maintenance	Meer
Data Loss	Server Error, Connection Problem	Moderate	Maintenance	Meer, Walid

9.3.2 Continuous electricity supply

The project will need an electrical connection to ensure the proper functioning of the devices [30]. Here, the device will convert the electrical energy into mechanical energy to water the plants and move from one place to another to pick the vegetables [31]. Again, to have a live view of the rooftop garden camera needs to be placed in certain positions. The camera will also need electricity to run. Without electricity, the camera will not be able to give us a live view. Moreover, there will be the use of sensors in the project. The sensors will need a continuous electrical connection to detect the moisture level of the soil, the color of the vegetables, detect the change in height of the plants, etc. That means electricity is playing a vital role here [32]. To ensure the continuous supply of electricity, we will connect the whole system with the generator of the building or use a suitable size of battery so that even when there is a supply of electricity from the national grid, our system can work without any difficulties [33] [34].

9.3.3 Power connection and Fire

There will be a number of live wires used in this project to provide a continuous supply of electricity to the system [35]. The system might get different levels of electricity at some moments. Again, due to coming in touch with live wires, anyone may get electrocuted. So, the design of the system will be made in such a way that no one will easily get near the plug-in connections or the live wires. The plastic covers can be used from the local market above the connection lines so that the amount of distance between the wires and human beings is increased and thus even if there appears an open surface of the wires from its original insulation covering due to a long time there will be another layer of protection. Again, power connections can get interrupted or destroyed and problems may occur due to earthquakes. Sensitive analysis and proper connections should be made in this case keeping in mind about preventing excess electric power flow to the equipment [36]. Now, the supply of excess electricity or shortage of electricity might cause harm to the components of the devices and may cause permanent damage also [37]. At most, there can be fire accidents due to short circuits. So, to prevent these kinds of incidents we will use circuit breakers or fuses. These electrical parts will stop any excess flow of electricity. Thus, the components of the system will remain safe all time.

9.3.4 Data loss

We will need proper information about the plants to ensure their good health. In this case, data is an important part for all of the users. Loss of any data will not be good for anyone. Data Loss in wireless systems is a very common issue [38]. Whenever there will be a power cut, the devices will restart. After restarting the whole data or some of the data might get lost. To prevent this issue a data storage system can be used [39]. The data storage system will store data for about seven days or one month or six months. Here, with upgrades, the system can also have a backup of the data in online data storage. Data loss prevention software tools can also be used like MyDLP and Open DLP [40]. So, in this way, we will solve the problem of data loss by solid preventive ways.

9.3.5 The incapability of the components of devices to work in high voltage or low voltage

There will be a big amount of voltage supply to the system. Various types of materials are used in the system. Not all of them can work in the same condition [41]. To ensure efficiency we will need a sufficient amount of voltage supply. Low voltage supply might cause an interruption in the system functions, whereas high voltage might be harmful for some of the sensitive components [42]. In this case, firstly a subsystem can be used to step down the direct voltage received from the suppliers. Secondly, rectifiers can be used for ac (alternating current) connections. Thirdly, an inverter can be used to ensure continuous working of the devices used in the project. The inverter will ensure the non-stop functionality of the components by using a minimum amount of power to function perfectly [43]. Thus, by using different devices under different operating conditions, we can use the power supplied very efficiently.

9.3.6 Waterline and proper drainage system

There will be a number of plants on the rooftop. The plants will need water for making their food and their growth. To give water to the plants and to ensure the cleanliness of the surrounding, the need for water is unlimited. For water supply, there will be a number of pipelines on the rooftop. The pipelines will ensure proper water supply to the plants. Again, there will be a water line connection with the device also. The pipelines can get blocked or may burst [44]. To prevent these accidents from taking place, good quality pipes can be used and good placement of them is needed [45]. The pipes will have to be placed in a safe position so that the flow of water is smooth, they are not easily stepped on, and do not break. Again, to be sure of the fact that there is no blockage in the pipeline, filters on the drains can be used. The filter will prevent the dead leaves, soil, etc. from going through the water lines. The filters will also have to be cleaned regularly. Sewer operators can be called on scheduled time to check for maintenance [46]. Cleaning liquids for drainage systems can also be used on a routine basis to make sure removal of any possible blockage in pipes.

9.3.7 Safety Consideration

Every project needs to be built in such a way that it can be operated exceptionally in a smoother way and it should not bring extra trouble and damage to any person or society. So, throughout our consideration, while building up the idea for the project, safety measurements of the system have been taken with respect to the selection of technological equipment, manufacturing process and final outcome. Some prominent safety measurements have been explained thoroughly below.

- First of all, while developing the project, necessary protective measures will be taken and wear certain elements that will keep themselves away from the components that might have the possibility to break easily or getting contaminated with other elements [47]. Workers can wear flame-retardant garments that do not break open while in accidents for working in low voltage electrical items so that they suffer less during an accident. To make themselves adapt to the protection level of clothing to really get some protection, different levels of protecting garments can be used instead having only one fixed level of protection [48]. Personal protective equipment should be worn whenever required [49].

- Then the connections for electrical equipment will be made secure enough so that none get electrified by touching the wires from outside. Steps will be taken so that the risks can be combated at the source [50]. The wires will be covered with proper insulating material. Fuses and circuit breakers will be used so that there is no chance of overflow of electricity. The electrical system should be grounded properly via a wire. The mechanical design should be made keeping in mind the whole electrical connection so that the wires do not break easily and there is significant distance between the conductor wires and the ground [51].
- Moreover, as there will be the presence of water supply alongside electrical components, the project will be demonstrated in such a way that during the supply of water there is going to be no risk of short circuits in the path of the device [50]. Thus, anyone can walk around that path and touch things without any fear.
- The device will only perform the tasks that have been assigned by us. No harm would be caused to human beings or nature.
- As an agriculture-related project, a proper drainage system of the water will be implemented so that the excess water can easily be transferred to a certain appropriate location.
- There will be no exposure to chemical hazards through the use of the equipment or the machineries. Only reliable equipment and machineries will be used.
- The programming commands need to be specific and work properly so that the system performs smoothly, and confidentiality and privacy are maintained for every particular owner.
- It needs to be kept always in mind that the project does not hamper any natural elements of nature. The whole system will be made in such a way that it would not cause any sound pollution to nature or living beings. Besides, heat generation will also be controlled within the acceptable range.
- Scheduled maintenance will take place to avoid any kind of accidents [51].
- The users will be given system information and will be informed about the risks. The risks which can be avoided shall be tried to avoid. The risks which cannot be avoided will be reduced or protective measures will be taken by replacing the dangerous things with the non-dangerous things.
- There are a variety of options in case of selecting the materials. The overall combination of materials will be made in a constructive way so that it helps the system to get long-lasted.

9.4 Conclusion

From the above writings, we see that all kinds of ethical considerations are taken into account and professionally all the responsibilities are maintained by every group member. Laws and policies are strictly maintained. All the risks are analyzed. Steps to reduce overall risks and prevention of accidents are taken for human safety. Proper citation with attached IEEE references is used. Therefore, we can conclude that all the work is done responsibly keeping in mind about ethics and professional responsibilities.

IEEE Standards	**Name**
IEEE 802.11	Wireless Networking – “Wi-Fi”
IEEE 830 / IEEE 1233	Software requirements specification
IEEE 829	Software Test Documentation
IEEE 12207	Information Technology– Software life-cycle processes

Chapter 10: Conclusion and Future Work

10.1 Project summary/Conclusion

In today's world, humans have very much less access to pesticides-free healthy vegetables. To ensure a huge amount of organic pesticide free healthy vegetable production, an autonomous system is created to be installed on the rooftops of buildings. The users will get benefits by the project as there will be no unexpected dangerous amount of chemicals or products used for getting more crops or for keeping the food fresh for a long time. The food harvested will be hygienic and free from food-adulteration. The system will also help to reduce environmental pollution and also increase the number of trees in the cities in this way by using the free space at the top of the buildings. According to our chosen design, it is a CNC based monitoring system designed with various sensors and electronic parts to do the required tasks for producing organic vegetables. The total cost for the project will be around Tk. 70,000. A prototype has been made which has been successfully working according to the commands or programmed given to it. Per day the system will use less than 0.07 units of power for the components throughout the day. The system will be able to maintain soil moisture level by watering the system, draining it carefully as well as sense various changes in the crops. Automatic seeding, real-time IoT based monitoring features are also the features of it. The user will be able to control the programmed using any type of device staying at any location on earth via wireless internet system. Modern tools like Arduino IDE, Fusion360, Flutter, etc. have been used here. The other required components along their specifications are given. The areas of risk management and the contingency plans of it are also discussed in the written report. All the works are done with honesty and no work is a direct copy of others, updates have been made compared to the previous works done on this project. To conclude, the users of this system will be benefitted by many different ways and their work of gardening will be done in ease by the help of the autonomous project, they will be able to set the commands according to their own wish, the system will be able to take care of the vegetables and plants according to its own knowledge when the information is put inside it correctly; the overall environment pollution will reduce as the number of plants in urban areas will increase and air will be purified, the time and effort of the people will be saved and people will be able to eat organic vegetables in a very low price free from any use of harsh chemicals.

10.2 Future work

Rooftop farms are the urban farms of today's date. With appropriate future works, a perfectly highly efficient system can be created by using a small compact area using our project. For our autonomous system, now only the mobile software is created for the project. With later modifications, the system can be made economically efficient in future by using the latest technology building components as stated in [52]. With advanced system having later updates, storm water can also be saved for other various uses by filtering the storm water [53]. According to G.E. Barrett and Richard G. Allen improved soil design of upcoming days will help us to reduce the overall weight of the structure and help to retain less water and increase the plant's health and crop's status [54] [55]. Matthew H. Koski and Nicholas Ohi have suggested in their paper this project can also be used for saving the pollen of the flowers and fertilizing the seeds of the plants at later periods according to our free time or according to the appropriate season by updating a few components of the system and the software [56]. Future renovation of the system can include a soil nutrient recycle system so that the use of soil nutrients is lessened for better life of humans [57].

Chapter 11: Identification of Complex Engineering Problems and Activities.

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

Table 17: Identify the attribute of complex engineering problem (EP)

	Attributes	**Put tick (√) as appropriate**
P1	Depth of knowledge required	√
P2	Range of conflicting requirements	X
P3	Depth of analysis required	√
P4	Familiarity of issues	√
P5	Extent of applicable codes	√
P6	Extent of stakeholder involvement and needs	√
P7	Interdependence	√

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

11.2.1 Depth of knowledge required

This project consists of electrical circuits, different sensors, and position detection mechanisms that need to be implemented with proper knowledge and providing command through coding to operate the features that will be added to the system. So, without expertise in these softwires like python, MATLAB, and knowledge about the devices, and sensors, this project cannot be implemented.

11.2.2 Depth of analysis required

In order to implement this project, certain requirements have been taken into consideration that whether this project can be demonstrated in the urban environment with respect to the environmental, economic, and cultural perspectives. Research has been made comparing with the other developing countries which are practicing this technology for years and having a pretty good outcome. Hence, the design method along with the placement of sensors and power distribution needs to be calculated properly for a consistent outcome.

11.2.3 Familiarity of issues

Agriculture is one of the sectors in Bangladesh which consists of the highest opportunities to develop with modern technology. This project focuses on the purpose to elevate this sector in the urban areas so that people in cities can be benefited from fresh and organic vegetables and get touched with the technologies that would solve their issues of having less nutritious vegetables.

11.2.4 The extent of applicable codes

In this project, we are using different types of electrical devices, software, circuit systems and other necessary elements. The standard IEEE codes and the specific requirements from any organization or manufacturer will be followed and maintained throughout this project. So the authentic components will always be chosen to maintain the standard of the project and to avoid conflicts with the codes.

11.2.5 The extent of stakeholder involvement and needs

The ultimate purpose of this project will be to get the people used to it in the urban lifestyle. As a new system, people need to get used to it by adapting themselves and getting used to it along with the price taken into consideration. The more they involve themselves the easier and more popular the system will be for spreading all over the city.

11.3 Identify the attribute of complex engineering activities (EA)

Table 18: Identify the attribute of complex engineering activities (EA)

	Attributes	**Put tick (√) as appropriate**
A1	Range of resource	√
A2	Level of interaction	√
A3	Innovation	X
A4	Consequences for society and the environment	√
A5	Familiarity	√

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

11.4.1 Range of resource

Research has been done to obtain maximum ideas about this project and collect data which will help us to select the range of exact components we need to use and how we can make the project cost-efficient. Moreover, it has also widened our vision to think of different approaches to operate with and select the best one in terms of components, devices, and software.

11.4.2 Level of interaction

This part also plays a crucial role in terms of the usability of this system because when people are going to use it, they are going to know about its benefits. A lot of rooftops are needed to operate this project on a large scale. So, the benefits of the project need to be spread from person to person. This will motivate our target audience to implement this project in their nearest areas. Enthusiastic people would always get to know about new technologies like this.

11.4.3 Consequences for society and the environment

This project will allow the consumer to precision monitor the farming system. So, farming becomes easy and the output of the crops will be excellent. The green areas will have a positive impact on the environment in many ways by providing extra oxygen and fresh air. As vegetables are consumed by everyone, this can create bonding between neighbors and insist others to implement such technologies of their own. Thus, it has consequences for both society and the environment.

11.4.4 Familiarity

Agriculture is one of the areas in Bangladesh with the greatest potential for development with modern technologies. This initiative aims to raise this sector in urban areas so that people in cities can benefit from fresh, organic veggies and learn about technology that can help them overcome their problems with less nutritious foods. Thus, Urban areas are getting highly benefited from this project.

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Appendix

Related Links

Control system firmware for Arduino mega: https://marlinfw.org/

Raspberry pi Firmware: https://octoprint.org/

API for the website for pi: https://docs.octoprint.org/en/master/api/index.html

Frame and structure inspiration: https://reprap.org/wiki/RepRap_Options

Related code/theory

Firmware

The firmware codes can be found here -

Control system firmware for Arduino mega: https://marlinfw.org/

Raspberry pi Firmware: https://octoprint.org/

Website Codes

The website that has been built has several sections and done in VS code. Each section contains thousands of lines of code and will not be appropriate to add on report.

Arduino Codes

```
#include <WiFi.h>
#include <HTTPClient.h>
#include "DHT.h"
#define DHTPIN 4
#define DHTTYPE DHT11
int cnt = 0;
int swt = 0;
int httpCode = 0;
String graphs = "";
DHT dht(DHTPIN, DHTTYPE);
const char* ssid = "Wiredwife";
const char* password = "i12@ccess";

//Your Domain name with URL path or IP address with path
String serverName = "http://192.168.0.179:8000/api";
```

```
void setup() {
  Serial.begin(115200);
  dht.begin();
  WiFi.begin(ssid, password);
  Serial.println("Connecting");
  while(WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.print("Connected to WiFi network with IP Address: ");
  Serial.println(WiFi.localIP());

  Serial.println("Timer set to 5 seconds (timerDelay variable), it will
take 5 seconds before publishing the first reading.");
}

void loop() {

    if(WiFi.status()== WL_CONNECTED){
      HTTPClient http;

      //Prepare data
  String postData;

    int MQ135 = analogRead(34);
    int YL = analogRead(A0);
//     Serial.print("Air quality: ");
//     Serial.println(MQ135);
delay(1000);
     float h = dht.readHumidity();
     float t = dht.readTemperature();
     float f = dht.readTemperature(true);

      if (isnan(h) || isnan(t) || isnan(f)) {
       Serial.println(F("Failed to read from DHT sensor!"));

      }
      float hic = dht.computeHeatIndex(t, h, false);
if(cnt <5){
  if(cnt==0){graphs = "a=" + YL ;}
  if(cnt==1){graphs = graphs + "&b=" + YL;}
  if(cnt==2){graphs = graphs + "&c=" + YL;}
  if(cnt==3){graphs = graphs + "&d=" + YL;}
  if(cnt==4){graphs = graphs + "&e=" + YL;}
}
else{
  cnt = 0;
}
   //prepare request
  postData = "t=" + String(hic) + "&h=" + String(h) + "&AQ=" + MQ135+
"&YL=" + YL;
```

```
http.begin(serverName);
http.addHeader("Content-Type", "application/x-www-form-urlencoded");
if (swt == 0){
  int httpCode = http.POST(postData);
  swt = 1;
}
else{
  int httpCode = http.POST(graphs);
  swt = 0;
}

String payload = http.getString();
 Serial.println(postData);
   Serial.println(graphs);
Serial.println(httpCode);
Serial.println(payload);
http.end();

  }
  else {
    Serial.println("WiFi Disconnected");
  }
}
```

Related Videos

Related videos can be found here –

Seed Holding Strength

https://drive.google.com/file/d/1OGbbmCV4AASFIc18VRDU7LpQOZBeen2T/view?usp=share_link

Prototype

https://drive.google.com/file/d/1o3v93qQ79nCd0BIgD9WzT4hZWd4_WdVN/view?usp=share_link

Rotatable Moisture Sensor Using Stepper Motor

https://drive.google.com/file/d/12K6EoHSbDJuE3Qu_Dyk_YWJbo_hiBl64/view?usp=share_link

Watering

https://drive.google.com/file/d/1WhTBw436s8zRilKs8iPDrdhK2SAP9mcZ/view?usp=share_link

Seeding

https://drive.google.com/file/d/1wMHckq3mOrKhcUlAOLKyAQORbIRnoQKZ/view?usp=share_link

https://drive.google.com/file/d/166ppsss-hPpTL5YekTaA3kFKNDiNFE3o/view?usp=sharing

Logbook

Panel Details

	Final Year Design Project (C) FALL 2022		
	NAME & ID	**EMAIL ADDRESS**	**PHONE**
Student Details			
Member 1	Walid Ahmed Mafuj – 18321040	md.walid.ahmad.mafuj@g.bracu.ac.bd	019120553712
Member 2	Tamanna Islam – 19121062	tamanna.islam1@g.bracu.ac.bd	01782588738
Member 3	Shantanu Biswas - 19121125	shantanu.biswas@g.bracu.ac.bd	01914428117
Member 4	Meer Tahmidur Rahman - 18321044	meer.tahmidur.rahman@g.bracu.ac.bd	01969879353
---------------	-----------------------------------	--	---------------------
ATC Details			
ATC - 8			
Chair	Tasfin Mahmud	tasfin.mahmud@bracu.ac.bd	
Member 1	MD Mehedi Hasan Shawon	mehedi.shawon@bracu.ac.bd	
Member 2	MD Rakibul Hasan	rakibul.hasan@bracu.ac.bd	

FYDP P Log Book

Date/ Time/ Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
03/02/2022	All Members from Students None from ATC	Introduction and Plannings 1 hour	Member 4	N/A Just an Introductory Meeting
08/02/2022	All Members from Students None from ATC	Topic shortlisting 1 hour		
10/02/2022	All Members from Students Chair and Member-1 from ATC	Topic review and selection 1 hour 30 min	ATC Panel	More research, no need of expensive problems and complexity
15/02/2022	All Members from Students None from ATC	Literature Review 30 min	Member 3	
17/02/2022	All Members from Students None from ATC	Literature Review 1 hour		
24/02/2022	All Members from Students Chair and Member-1 from ATC	Topic review and selection 1 hour	ATC Panel	Compare topics based on background research
02/03/2022	All Members from Students None from ATC	Final Shortlisting 1 hour		
03/03/2022	All Members from Students Chair and Member-1 from ATC	Topic review and selection 1 hour 30 min	ATC Panel	Finalizing Topic
07/03/2022	All Members from Students None from ATC	Concept Note and Presentation Slide 2 hours		
08/03/2022	All Members from Students None from ATC	Presentation Slide and Script Writing 1 hour 30 min		
09/03/2022	All Members from Students None from ATC	Mock Presentation and Slide Finalization 1 hour 30 min		
11/03/2022	All Members from Students None from ATC	Concept Note and Log Book 2 hours		
16/03/2022	All Members from Students None from ATC	Concept Note 2 hours	Member 3	

17/3/2022	All Members from Students One ATC member-1	Concept Note Finalization and get feedback from ATC member 1 hour	Member 4	Understanding the writing method, methodology, system requirements, budget
17/3/2022	All Members from Students	Correction according to feedback		
31/4/2022	All Members from Students One ATC member-1	Discussion on progress of proposal note 1 hour		Reviewing Concept note and elaborating contents
07/4/2022	All Members from Students One ATC member-1	Discussion on progress of proposal note 1 hour		-
12/4/2022	All Members from Students One ATC member-1	Discussion on progress of proposal note 1 hour		-
13/4/2022	All Members from Students	Progress on proposal note 30 minutes		
16/4/2022	2 members from the students Member-1 Member-2	Progress on proposal note		
17/4/2022	2 members from the students Member-3 member-4	Progress on proposal note 2 hours	Member-2	
18/4/2022	1 member from the students	Progress on proposal note		
19/4/2022	All Members from Students	Completion of proposal notes 4 Hours	Member-3	
21/04/2022	All Members from Students One ATC member-1	Draft checking	Weekly ATC meeting	Completion of Project plan, Expected outcome. Overall performance.

FYDP D Log Book

Date/ Time/Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
08/06/2022	All members from Students One ATC member-1	Meeting time fix, feedbacks from proposal report	ATC member-1	
15/06/2022	All members from Students One ATC member-1	Feedbacks on design approaches	ATC member-1	
22/06/2022	All members from Students One ATC member-1	Simulation process and demonstration	ATC member-1	
26/06/2022	All Members from Students	A common Application Development for all the designs 1 hour 30 min	Member 2	
28/06/2022	All Members from Students	Presentation Slide and Script Writing 1 hour 30 min	Member 3 & 4	
29/06/2022	All Members from Students	Final design of the Application & Presentation Slide 2 hours	Member 4	
19/07/2022	All Members from Students	Form Fill up of 30 minutes	Member 3	
4/08/2022	All Members from Students One ATC member-1	Discussion on progress of proposal note & feedback from ATC member 1 hour	ATC Panel	
11/08/2022	All Members from Students	1 hour 30 minutes	Member 3	
12/08/2022	All Members from Students One ATC member-1	Feedback from ATC member 1 hour	ATC Panel	

18/08/2022	All Members from Students	Form creation for survey & Progress on design report 2 hour 30 minutes	Member 1	
19/08/2022	All Members from Students	Progress on design report	Member 3	
28/08/2022	All Members from Students	Discussion & Progress on Design report 1 hour 30 minutes	Member 4	
30/08/2022	All Members from Students	Slide preparation 2 hour 30 minutes	Member 2	
31/08/2022	All Members from Students	Slides & Finalization of Design Report 2 hours	Member 3 & 4	
31/08/2022	All Members from Students One ATC member-1	Feedback from ATC member 30 minutes	ATC Panel	

FYDP C Log Book

Date/ Time/Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
04/10/2022	All members from Students ATC Chair	Meeting time fix, feedbacks from FYDP D	ATC Chair	
11/10/2022	All members from Students ATC Chair	Feedbacks on optimal solution	ATC Chair	
18/10/2022	All members from Students ATC Chair	Simulation process and work distribution	Member 4	
25/10/2022	All Members from Students ATC Chair	Website Development 1 hours	Member 1 & 4	
01/11/2022	All Members from Students ATC Chair	Presentation Slide and progress on prototype 2 hours	Member 3 & 4	
15/11/2022	All Members from Students ATC Chair	Prototype and website Development	Member 4	
22/07/2022	All Members from Students ATC Chair	Prototype and website Development	Member 3	
29/08/2022	All Members from Students ATC Chair	Prototype and website Development	ATC Panel	
06/08/2022	All Members from Students ATC Chair	Prototype and website Development	Member 1	
08/08/2022	All Members from Students	Prototype and website Development	ATC Panel	
12/08/2022	All Members from Students ATC Chair	Prototype and website Development	Member 4	