OPTIMISATION (DESIGN AND CONSTRUCTION) AND TESTING OF IOT BASED NFT HYDRPONICS SYSTEM

A project report submitted for the partial fulfillment of the Bachelor of Technology Degree in Mechanical Engineering under Maulana Abul Kalam Azad University of Technology

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CERTIFICATE

TO WHOM IT MAY CONCERN

This is to certify that the project report entitled "**[OPTIMISATION (DESIGN AND CONSTRUCTION) AND TESTING OF IOT BASED NFT HYDRPONICS SYSTEM]**", submitted by

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Students of **INSTITUTE OF ENGINEERING & MANAGEMENT,** in partial fulfilment of requirements for the award of the degree of **Bachelor of Technology in ME,** is a bonafide work carried out under the supervision and guidance of **Prof. Rimjhim Majumdar and Prof. (Dr.) Rahul Baidya** during the third year of the academic session of 2018-2022.The content of this report has not been submitted to any other University or Institute for the award of any other degree. It is further certified that work is entirely original and its performance has been found to be quite satisfactory.

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*This foregoing (***OPTIMISATION (DESIGN AND CONSTRUCTION) AND TESTING OF IOT BASED NFT HYDRPONICS SYSTEM***) 3rd Year Project is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made, opinion expressed or conclusion drawn therein but approve the 3rd Year Project only for the purpose for which it is submitted.*

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FOR EVALUATION	______________________________________
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We should like to take this opportunity to extend our gratitude to the following revered persons without whose immense support, completion of this project wouldn’t have been possible.

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Last but not the least, we would like to extend our warm regards to our families and peers who have kept supporting us and always had faith in our work.

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EXECUTIVE SUMMARY

Even though agriculture has been the source of nutrition since a very a long time, in the past few decades its quality(of nutriton) has been degraded with accusations of depleting natural resources. As the world's population is expected to be about 9.8 billion people by 2050, it stares at increasing food production by at least 70 per cent.

Soil salinity (I.e the degradation of the quality) is one of the most devastating environmental stresses which causes major reductions in cultivated land area, crop productivity and quality. The salinity issue has led to grow plants in solution as an alternative method, such as Nutrient Film Technique (NFT). This paper is focusing on hydroponic system in which a variety of vegatables can be grown but for the time being we are focused on one type of crop i.e LETTUCE .Here we can also are monitor and control two important parameters in plant growth which are EC and pH parameters. To execute this process we uses a few sensors (like PH sensors,EC sensors.etc) . This project development is designed to provide automatics control of two main parameters for leafy greens growth. The parameters will be monitored using Liquid Crystal Display (LCD) and IoT platform. Using ESP32 microcontroller board, this project will be able to manages and maintain an optimum condition for nutrient consumed by the plant. EC and pH value can be controlled using smartphones via Blynk application, which provides real time changes.

This offers advantage for the user to monitor and control the system with less effort and requires no presence at the farmed area. The developed system is proven to provide a sufficient nutrient for plant growth with hassle free built in automatic control and monitoring system.

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1. INTRODUCTION

1.1. MOTIVATION

Even though agriculture has been the source of nutrition since a very along time, in the past few decades its quality(of nutriton) has been degraded with accusations of depleting natural resources. As the world's population is expected to be about 9.8 billion people by 2050, it stares at increasing food production by at least 70 per cent.

Globally, owing to unsustainable agriculture practices, more than 70 per cent of the water available on earth is used for agricultural production. About 38 % of earth’s land, except for the frozen parts (i.e the Arctic part mostly) , is used for growing food and by 2050, an estimated 594 million hectares of land(approx), double the size of the land of India, will be needed to meet the required calorie needs of the world's population. Therefore, it is feared that many ecosystems may disappear and manmade disasters such as deforestation and climate emergency may happen. In result , the pursuit for food may end up threatening food security, especially in water-stressed countries like India. Considerations like these are the driving force behind emergence water-smart technologies such as hydroponics where all the needs can be met.

1.2. OBJECTIVE

Soil salinity(I.e the degradation of the quality) is one of the most devastating environmental stresses which causes major reductions in cultivated land area, crop productivity and quality. The salinity issue has led to grow plants in solution as an alternative method, such as Nutrient Film Technique (NFT). This paper is focusing on hydroponic system in which a variety of vegatables can be grown but for the time being we are focused on one type of crop i.e LETTUCE .Here we can also are monitor and control two important parameters in plant growth which are EC and pH parameters. To execute this process we uses a few sensors(like PH sensors,EC sensors.etc) . This project development is designed to provide automatics control of two main parameters for leafy greens growth. The parameters will be monitored using Liquid Crystal Display (LCD) and IoT platform. Using ESP32 microcontroller board, this project will be able to manages and maintain an optimum condition for nutrient consumed by the plant. EC and pH value can be controlled using smartphones via Blynk application , which provides real time change. This offers advantage for the user to monitor and control the system with less effort and requires no presence at the farmed area. The developed system is proven to provide a sufficient nutrient for plant growth with hassle free built in automatic control and monitoring system.

2. LITERATURE REVIEW

Hydroponics is the technique of growing plants using only water, nutrients, and a growing medium. The word hydroponics stand as “hydro”, meaning water, and “ponos”, meaning labor.This method of gardening does not use soil. The earliest examples of hydroponics are the Hanging Gardens of Babylon and the Floating Gardens of China. Humans has used these techniques for thousands years. The general theory behind hydroponics remains the same as it is, modern technology has enabled us to grow plants faster, stronger, and healthier.

Ahaidayu et al, (2017) “plant cultivation using Nutrient Film Technique (NFT) hydroponic system. It is stated that plants in this system need nutrient solution to grow well. TDS, pH and temperature of the nutrient solution must be checked to ensure plant gets sufficient nutrients. This particular previous work had developed monitoring system of NFT hydroponic where farmers are able to monitor pH, TMDS and temperature online. Farmer can easily decide which plant is suitable to be cultivated and time to boost growth.

Eridani et al., (2018) “prototype scaled Nutrient Film Technique (NFT) hydroponics for nutrition feeding by using an automation system. The system is designed by a control which uses the Arduino UNO R3 board. The GP2Y0A21 proximity sensor is used as water level detector, while the TDS sensor as a detector of electrical conductivity of the nutrient solution. The system used a servo motor that has an opening device of the faucet in the nutrient container. The outcome of the system proposed is successful to control water delivery automatically when the water level is less than the minimum level and be able to add the nutrients automatically when the nutrient solution.

Adhau et al., (2018), “self-controlled automated hydroponics system where the data in real time is use to control the counteractive steps. The aims of this project are to construct a smart and intelligent system with an optimization used of present technology. The real time data will be imported from a low cost AVR microcontroller board. The NI LabVIEW monitors all the data and send this data to a network based IoT system. The traditional PID controller is implementing for tuning control and the system has been tested and verifiedsuccessfully.

Sisyanto et al., (2018) “Cyber Physical Social System (CPSS), and hydroponic farmers. The new ideas are development of hydroponic smart farming system that can be monitored online via Telegram Messenger. The significant parameter in the hydroponics system, such as light intensity, room temperature, humidity, pH, nutrient temperature, and Electrical Conductivity (EC) can be monitored based on that design. The prototype in the system proposed has Raspberry Pi 3 that connects directly with sensors DHT11 module, LDR, pH sensor module, and EC sensor. An AI is designed to allow the sensor be monitored online. With the help of the Physical System such as Raspberry Pi and other sensors connected online via internet, the hydroponic system monitoring becomes more flexible.

Palande et al., (2018) “challenge of plant growing in remote areas such as deserts and north andsouth pole due to an unpredictable weather. The paper presented a system that can grow common plant and vegetables without depending on the weather by introducing the hydroponic system. The system is automated controlled by using the microcontroller and sensor with minimum guided. In order to improved reliability and control automated, the system was applied with Internet of Thing (IoT) network. The Titan Smart-phonics project is developed with automated control and human interface are unnecessarily once the germinated plant done into the system.

Siregar et al., (2018) “monitoring system embedded with PH sensor, Electro Conductivity Sensor, water temperature sensor, air temperature, Light Sensor, GSM / GPRS, Open Garden Shield, Open Hydroponic, and Arduino Uno as microcontroller. The result shows that the number of leaves and plant height for lettuce and red spinach is changed after two-week testing indicated that the sensor and system working properly. The system proposed uses “Arduino” to monitor the changes of pH, nutrition, water temperature, air temperature and light intensity in the hydroponic plantation.

Patil et al., (2016) “automation in hydroponic system. Hydroponic concept is the method of growing plants in water without using soil. The nutrient and fertilizers are supplied directly through the water. In order to control the plants growth, an Automated Monitoring and controlling environment like temperature, humidity, light intensity etc. is proposed. All the parameter will response to the respective sensors. If the values exceed or decrease their corresponding set points, the system starts the taking action and set back to its normal value.

Ramasamy Rajesh Kumar et al., (2014), “Reuse of hydroponic waste solution” review addresses the problems associated with the release of hydroponic waste solution into the environment and possible reuse of hydroponic waste solution as an alternative. Recharge and reuse of HWS may be valuable as economic, control environmental pollution and could contribute to reduce the consumption of irrigation water.

Agung Putra P et al., (2015), “Soilless Culture System to Support Water Use Efficiency and Product Quality” concluded that Soilless culture can be the effective tool to increase the crop yield and closed irrigation systems are adopted that could increase the water-use efficiency reducing the environmental impact of greenhouses and nurseries. Author concerns in determining the soilless cultivation system is an understanding of its benefits, which is a flexible growing method that lets the grower have full control over the growing environment, including the active root zone. The system can increase the efficiency of water-usage while maintaining its quality and is implemented in any scale to support eco-agriculture.

Guilherme Lages Barbosa et al., (2015), “Comparison of Land, Water and Energy Requirements of Lettuce Grown Using Hydroponic vs. Conventional Agricultural Methods”. The land, water and energy requirements for hydroponics were compared with the conventional agriculture and crop production considered was lettuce in Yuma, Arizona and USA. In this research the data considered were crop budgets, agricultural statistics given by government and compared with theoretical data obtained by experimental hydroponic system by generating engineering equations populated with literature values.

Ashwini Patwardhan et al., (2016) “Design of Flood and Drain Vertical Hydroponic System” by, concluded that highest germination of 96% was achieved with hydroponic system, which was 26% more than germination percentage quoted by the manufacturing company of seeds. Here Pak-choi crop in hydroponic system was cultivated which was twice than the yield obtained from field conditions. Therefore, the Flood and Drain Vertical Hydroponic System designed gave 66% more cropping area than the open field.

Shakrani S A et al., (2012) “The Effects of Secondary Treated Wastewater on Brassica Campestris

Sp. Parachinensis Growth Using Soil and Hydroponic Cultivation” , discusses the effects of secondary treated wastewater irrigation on mustard greens vegetable (Brassica Campestris Sp. Parachinensis) growth with soil and hydroponics cultivation. The study involves the assessment of nutrients such (NO3 - , NO2 - , PO4 3- and K) and heavy metals such (Cr, Co, Cu, Fe, Mn, Ni, and Zn) inwastewater.

Valenzano V et al., (2008), “Effect of Growing System and Cultivar on Yield and Water-Use Efficiency of Greenhouse_Grown Tomato”. The motive of the research was to compare the cultivation of tomato (Solanum lycopersicum L.) plants in soil with two hydroponic systems: the Nutrient Film Technique (NFT; closed cycle) and rock wool (open cycle), in terms of yield and water-use efficiency (WUE). In these research in total two trials were carried out, one in Winter-Spring (WS) and the other in Autumn- Winter (AW).

Jocelyn Amihan Gonzales et al., (2010), “Uptake Ability of Tomato Plants (Solanum Lycopersicum L.) Grown Using Nutrient Film Technique (NFT) by Ascending Nutrient Concentration Method” which concluded that tomato plants can uptake nutrients even from extremely low nutrient concentrations. These results suggest that cultivation with low nutrient concentration could be applicable if each nutrient element was stably supplied and balanced with the absorption. In the further studies should be conducted on the uptake ability from low nutrient solution concentration and evaluate at different growth stages of the plant of a specific variety at a givenseason.

T Reshma et al., (2017) “Standardization of Growing Media for the Hydroponic Cultivation of Tomato” , revealed that the plants grown in coco peat medium performs the best with relevance to yield per plant (1.67 kg), average fruit weight (45.86g), plant height (69.36 cm), crop duration (85.73 days) etc. followed by pebbles. The coco peat medium similarly has high amount of potassium (0.36 %) and also possessed high water holding capacity. As the result, the performance of plants grown in expanded clay pellets was very poor. Fruit quality in terms of total soluble solid content and tithable acidity was not significantly affected by the treatments.

Mahdi et al., (2020) “A Survey of Smart Hydroponic Systems” , the researchers have done a lot of work in the monitoring of hydroponic systems and the automation of nutrient supply. The automation of nutrient supply is mainly controlled by proportional controllers, who are notorious for oscillations. The few AI-based research carried out have shown that AI is a good technique for controlling the hydroponic system.

T. Namgyel et al. (2019). “IoT based hydroponic system with supplementary LED light for smart home farming of lettuce”. Different technologies were used for farming practices to adapt and build resilience against irregular microclimate shifts. Farming system like hydroponic culture technique and integration of smart artificial light and IoT system are promising solution. In the research they developed a smart hydroponic system with LED lighting technology controlled by IoT system. Plants were grown hydroponically under various conditions and morphological parameters were recorded and characterized. The plants were exposed to blue supplementary LED light resulted in greater accumulation of biomass, leaf density, leaf area and pigment content. IoT devices and software applications were imposed to monitor and display of system information.
The system was successfully archived real time data for end user access.

KRYZEN biotech PVT. LTD conducted a basic comparison between tradition agriculture and Hydroponic farm. This compassion is done with 50kg of basil pant produced every day. Given bellow is the table of comparison. [18]

	HYDROPONIC FARM	**TRADITIONAL FARM**	**DIFFERENCES**
AREA	5000sqft	43560sqft	8.7 times less area
WATER	12000 litters/month	3,00,000 litters/month	24 times less water
FERTILIZER	35kg (3200 INR)	240kg (21,000 INR)	6.8 times less fertilizer
WORKERS	1 worker for harvest	3 workers	1/3 man power cost
LAND PERPARATION COST	0	12,000 INR	Nil cost
PRODUCTION	All year	Seasonal	
NUTRIENT VALUE	High	Low	
AUTOMATION	Possible	Difficult	
LOCATION	Farm as well as urban	Only farmland	
CLIMATE DEPENDECY	Zero	Very high	
QUALITY	Constant	Varies	
PEST CONTROL	None	Highly required	
PRICING	Premium	Market price	
MAINTAINACE	Low	High	
ECOLOGIACL EFFECT	Low	High	
PULLUCTION EFFECT	Zero	High	Water pollution by runoff

Table 1

2.PROPOSED STRATEGY

NFT technique used in this project is applied to recirculate the nutrient flow in order to supply all required nutrients for plant growth . Basically there are two type of NFT based hydroponic systems i.e (1) **Horizontal N.F.T Sysytem**

(2) Vertical N.F.T System

Horizontal NFT systems are best used for larger spaces and for maximizing the growth of the plants. This should be preferred if there is enough amount of space availibility.
Vertical NFT systems are best suited for smaller spaces and faster yields[19] ,hence in our proposed design we have used the Vertical NFT sysytem .

There are several type of plants that can grown in vertical NFT system (approx. 2500). The most common and successful grown crops in India through Hydroponics are Tomatoes, Lettuce,Radish,and Spinach etc. In this project we are considering (focousing)only one type of plant(favorable to the climatic condition) i.e Lettuce.[30]

In any hydroponic system, there are several parameters that should be maintained within certain range, such as pH, electric conductivity (EC), the temperature of the surroundings, water flow rate and water level of
the container .

The designed system is capable of maintaining healthy growing parameters for the plants with minimal input from the user. The functionality of the overall system was confirmed by evaluating the response from individual system components and monitoring them
in the IoT platform.

The system can be divided into two main parts. The first part is an automatically control system used to continuously regulate two important elements in the nutrient solution of a hydroponic system. Those two elements are pH value and the nutrient concentration (EC). The values are continuously being sensed by their respective sensor to maintain the nutrient solution in the right condition for lettuce growth.

The second part of the system is where the technology of IoT is practiced. With the special features of ESP32 microcontroller, the data from four sensors (pH, EC, temperature and flow rate) can always be transferred into web hosting and database server.

What We Can Grow?

Spinach

A nutritious leafy vegetable, spinach helps to prevent premature ageing, prevents vision loss, boosts immunity and has inflammatory properties. It also protects the body from a number of diseases and maintains the brain functions and the nervous system especially in patients of advanced age.

- **Sowing Season** - All year round except Dec-Feb
- **Soil Type and Prep** - well-drained soil rich in organic matter such as compost or composted manure; pH of 6.5 to 7.
- **Germination Temperature** -10°C - 22°C.
- **Sunlight** - Sun to partial shade.
- **Water** - Since spinach grows best in cold weather, avoid over-watering. [37]

Lettuce

It ranges in color from yellow to dark green but may also have reddish hues. While it’s grown worldwide, China produces the greatest volume — upwards of 66% of the global supply. Lettuce is not only a major ingredient in salads but also often added to various dishes, such as wraps, soups, and sandwiches.

- **Season -** February-April; September-November
- **Germination Temperature -** 7°C - 27°C
- **Sunlight -** First 2 weeks - 5-6 hours;
- After 3 weeks - 8 hours;
- Winters - 6-7 hours
- **Types of Containers -** Clay, wood, terracotta, wheelbarrows, discarded barrels, window boxes
- **Soil -** Loamy, well-drained loose soil
- **Water -** Summer - Twice a day; Winter - When needed [38]

Cabbage

Cabbage is a popular crop that's grown all over India for its delicious greens. An excellent source of Calcium, Iron, Magnesium, Phosphorus, Potassium, Dietary Fiber, Vitamin C, K, B6, & Manganese, cabbage is usually consumed for its naturally peppery flavor.

Sowing Season - Mid Feb - Mid Apr; Aug - Oct
Soil Type - Sandy to heavy soil rich in organic matter with a pH level of 6.5 to 7.5
Height - 3.3 ft to 6.6 ft
Width - 10” to 14”
Germination Temperature - 15°C - 21°C
Flowering Season - 4 to 5 months after planting**.**
Sunlight - Full Sun; 6 to 8 hours of direct sunlight daily.
Water - Regular watering intervals; Ensure that the soil is moist yet well-drained [39]

Design of Algorithm

1. Introduction to fussy control

Nutrient Film Technique (NFT) is the method of hydroponic system which use a circulated water containing nutrient as a growing media of plant. The important parameters that affect the plant growth are electrical conductivity (EC) and pH that should be maintain in proper range that depend on types of plants. In the experiment, we implement the fuzzy logic to control the EC and pH condition of the NFT-based hydroponic system in Internet of Things (IoT) system environment. By using IoT consist of wireless sensor network, data logger, machine-to-machine and actuator (pump), we can remotely control and monitoring all parameters through internet network, that can be applied to scattered area. The experiment based on proportional small-scale process which consist of four controlled tanks (nutrient A, nutrient B, acid solution, and alkaline solution) and one mixing tank with adjustable flow pump by using 12 rules fuzzy logic. Parameter EC and pH are maintained in range defined according to the input range given. The required time to recover the EC and pH from outside range to within the defined range is about 15 minutes. [35]

1.1. Fuzzy Logic Control Method

Fuzzy system was first conceived in 1965 by Lutfi Zadeh, a professor at the California University, Berkley. Fuzzy logic is a method has ability to process variable that ambiguous or cannot be described in exact or definitely. Basic of fuzzy logic is fuzzy set theory. Fuzzy logic control is a methodology to presented and implement human knowledge or intelligence about how to control a system. In this research, fuzzy logic control used to control the EC and pH condition on the providing of plant nutrition. PH value and EC value as input and pump activation time (actuator) as output. The design of fuzzy logic control in this research. [32]

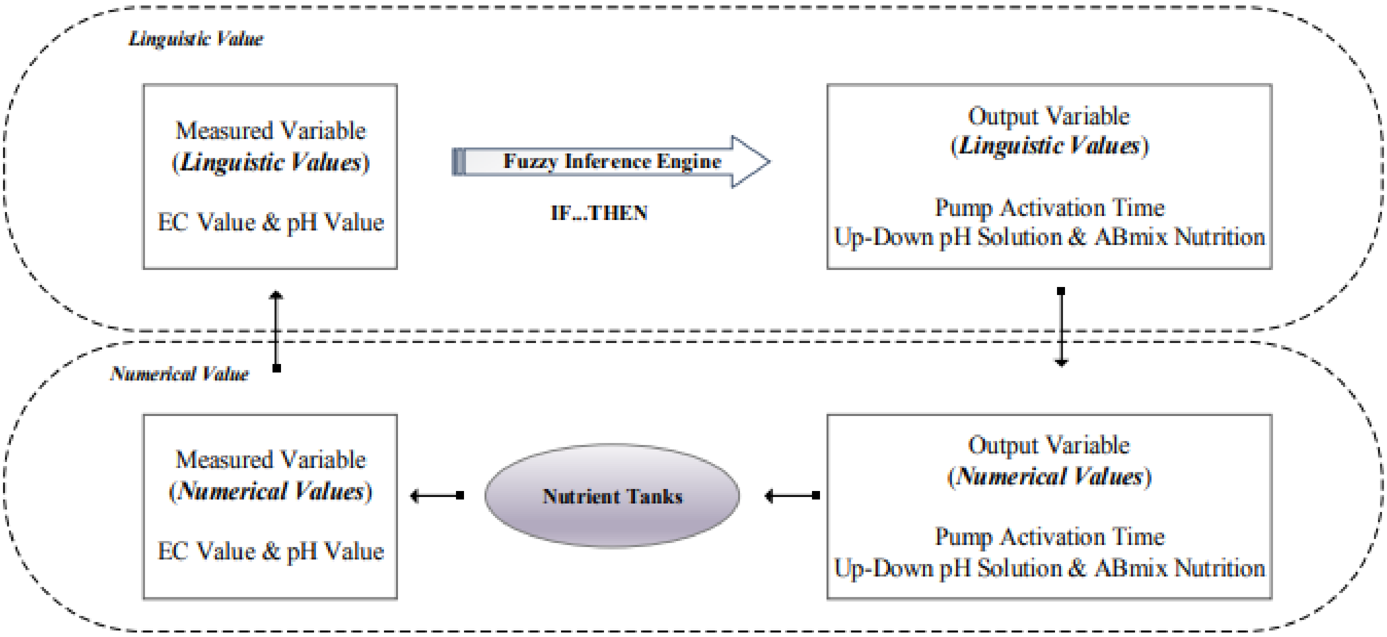


Fig.1.1 Design of fuzzy logic control method

1.2. **Steps the application of fuzzy logic control consist of: -**

- **The first step** is defined variable involve in process that will be determined and according to fuzzification functions. In this case, there is six variables that will be modeled, namely: • Input variable: pH and EC • Output variable: pump A, pump B, pump C and pump D.

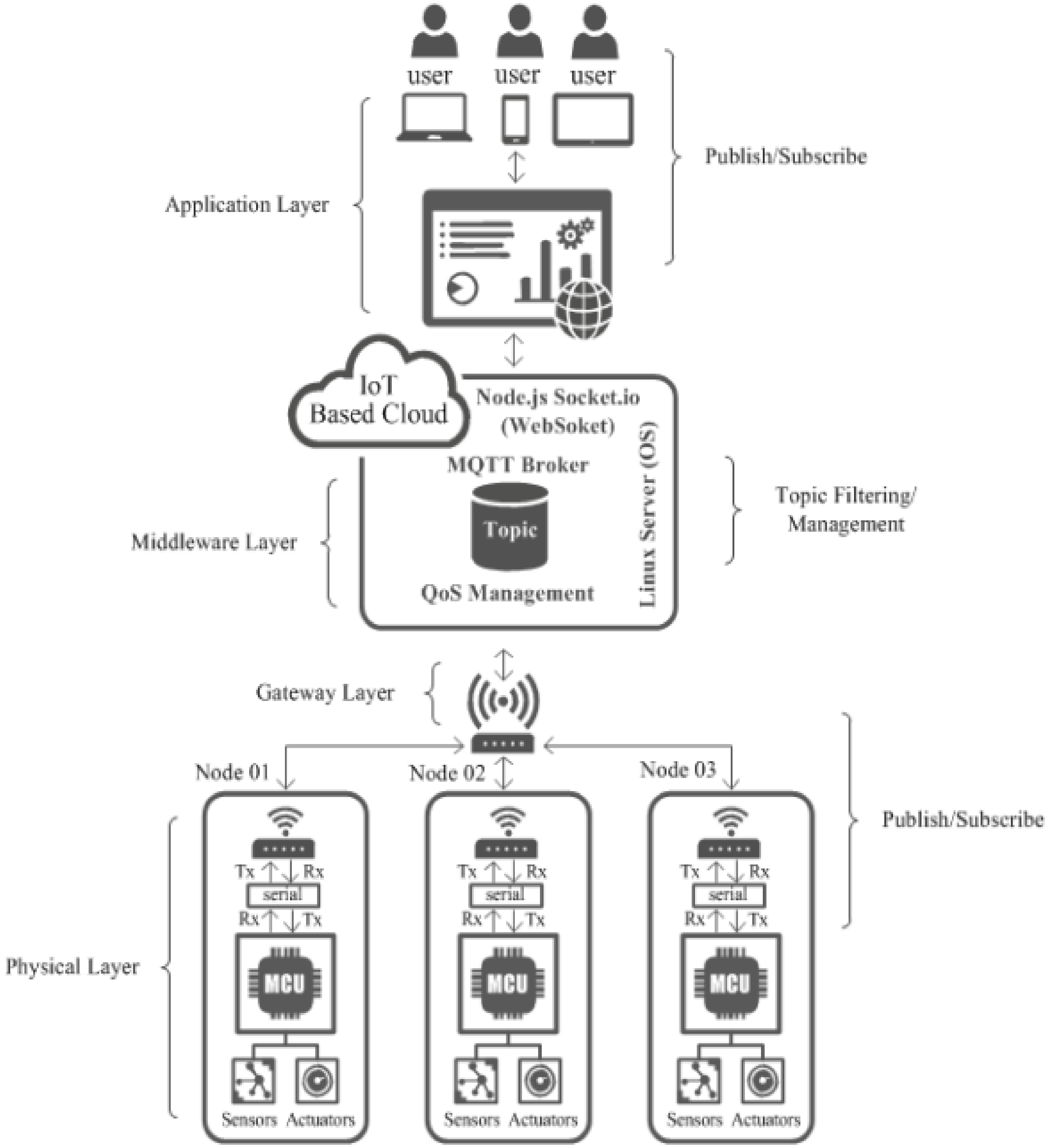
- **The second step** (Fuzzification) is step mapping input crisp into fuzzy sets that presented in form membership function. The purpose of fuzzification is get degree of membership. The following computation of value membership functions (μ) for each input variable and output variable.

- **The third step** (Fuzzy Inference Engine) is set rules fuzzy use Tsukamoto model, which is by counting value αpredicate for each rule with using implication system MIN function and value of z in pump variable value for each rule fuzzy.

- **The fourth step** (Defuzzification) is convert fuzzy sets into a firm number. The method used in defuzzification process in composition rule Tsukamoto that is weighted average. [33]

Internet of Things

- Internet of Things (IoT) is a network that connect things to internet network for communicate or exchange data or information via sensing devices with protocol that agreed. As for topology that used in this system can be seen in the fig bellow (fig 2).[34]



<u>Fig 2. Topology IoT system [36]</u>

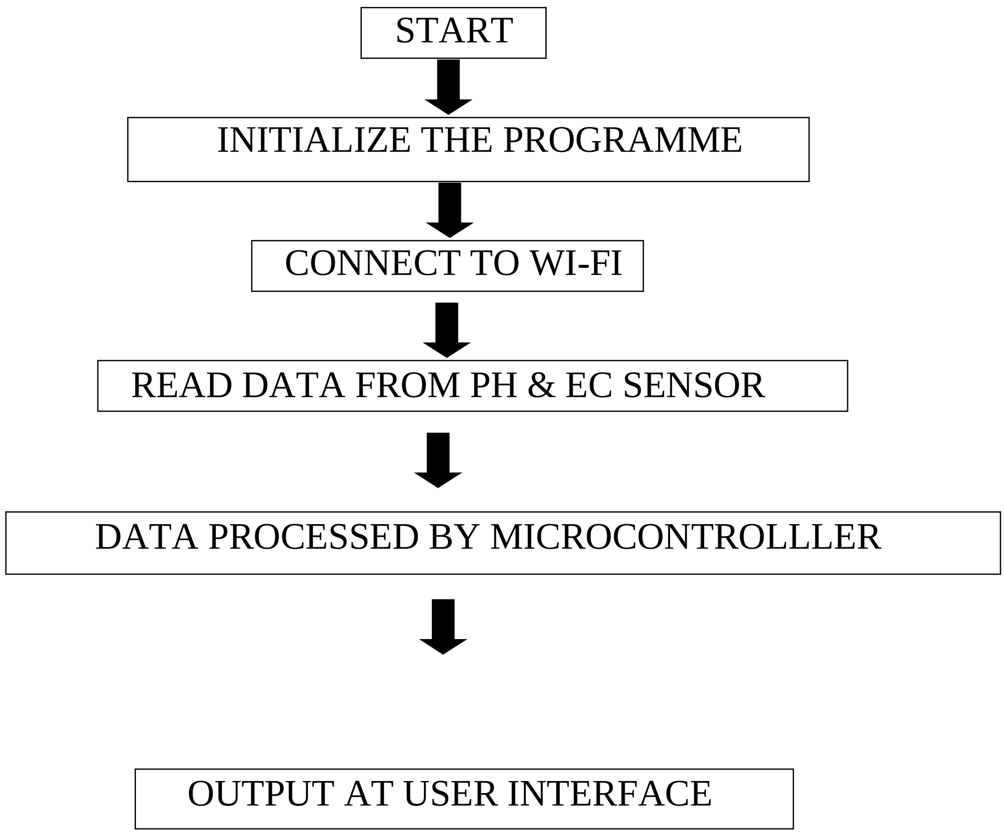


Fig 3.1 (Block Struct

ESP32 microcontroller

The ESP32 microcontroller plays the most important role in collecting all data from sensors, projecting it online, and use the data to successfully regulate the nutrients solution parameters. The microcontroller will process a decision-making statement by comparing the current EC and pH measurement with the reference value. [28]

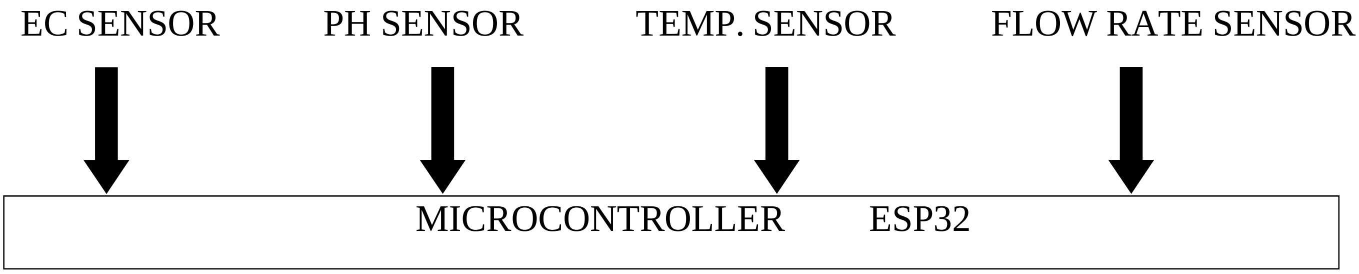


Fig 3.2 (Microcontroller workflow)

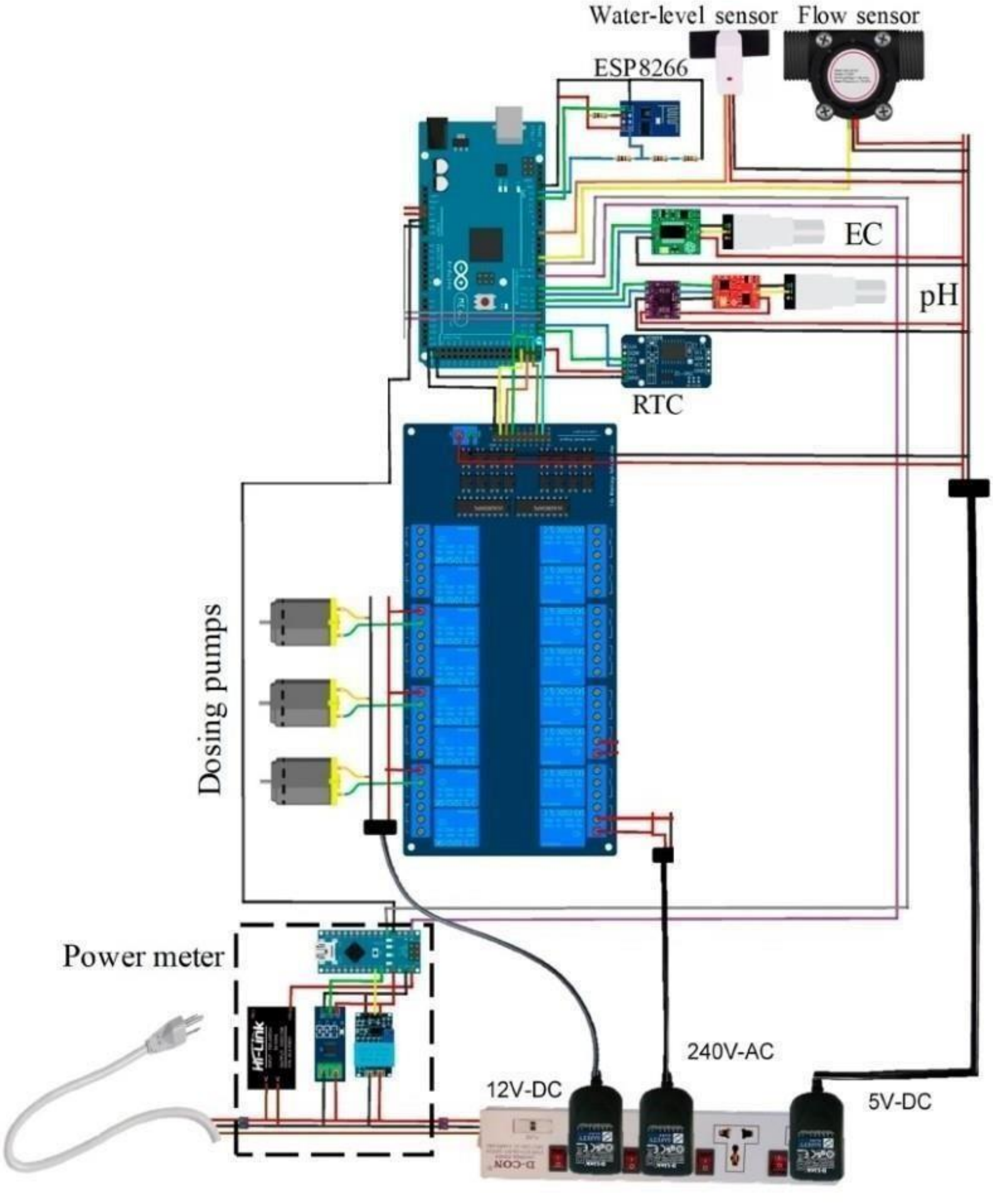


Fig.3.3 (Overall circuit diagram of the System) [29]

EC and PH Sensor

The EC and pH sensors can be tested and calibrated by connecting them to the ESP32 microcontroller. These sensors are expected to provide live mainstream of data through the ESP32 microcontroller, directly to the server by Wi-Fi internet protocol. Once the microcontroller is connected to the internet provider, it will simultaneously send all data and provides automatic regulation of the nutrient's EC and pH parameters. The domain of the data server is using **BLYNK** online server, once paired up with a smartphone, all data required would be displayed on the phone screen.

The EC sensor will continue monitoring the EC level to maintain the EC at the required level by adding water to decrease EC or adding nutrients by the dosing pump to deliver nutrients to keep it at the desired level. Furthermore, the pH is controlled by dosing pumps where pH up or down was added to the nutrient solution to keep the pH in the suitable range for the growing plant. [23]

Water Flow Sensors

The water flow sensor is connected to the microcontroller, as shown in the circuit diagram and it is calibrated to measure the flow rate, to provide the pumped nutrient solution to the system. Following mathematical equations can be used to calculate flow rate and total volume of water supply.

Sensor Frequency (Hz) = 7.5 * Q (L/min), where Q is flow rate in L/min Flow
Rate (L/h) = (Sensor frequency × 60 min)/7.5
Litres = Q × time elapsed (s)/60 (s/min)

Litres = (Frequency (Pulses/s)/7.5) × time elapsed (s)/60
Litres = Pulses/(7.5 × 60)
It is very important to ensure the correct volume of water to add to the system when necessary and also to measure the circulation of the total volume of water in the system. This will help to measure the volume circulation per day and on average in a month how much freshwater was refilled to maintain the water level correct in the system. [22]

Water level Sensor

A water level indicator sensor, also known as a probe sensor, is what tells the control panel that corrective action is needed. A combination of high and low sensors is used to tell the control panel when water levels are too high or too low. The control panel will then automatically turn the pump on or off depending on the corrective action needed.[24]

Dosing Pumps

The most obvious benefit of automatic dosing is that we won't have to spend time testing and adjusting your pH, temperature, and EC levels.

In the calibration stage, it can be tested that how many solutions the dosing pump can deliver per minute. This was done by pumping water from a bottle to another mL labeled bottle by continuously running the dosing pump for one minute.[25]

Power Meter Subsystem

During the calibration and testing phase, the power meter subsystem can be used to test the power consumption of each system component so that overall system power consumption can be calculated and verified with the power data provided in the system run-time.

1.EXPERIMENTAL SETUP

1.3. DESIGN AND CONSTRUCTION

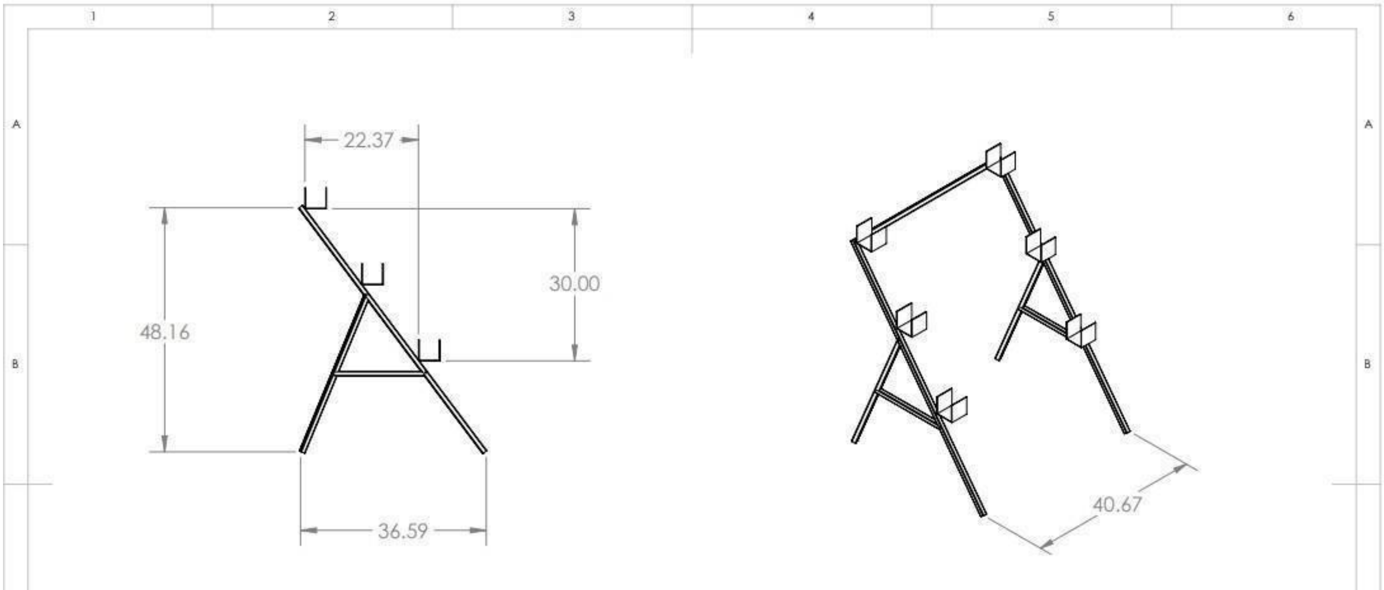


Fig 4.1 (Vertical NFT system)

The tower is planned to be constructed using 1” square mild steel tube and 3mm mild steel plates. Using a 3D based software (i.e Solidworks) we designed our hydroponics system i.e shown in the figure(fig 4.1). After the completion of the base framework the horizontal supports were put on for the 4”x4” PVC square pipes to rest on.

Fig 4.2 (Cad Model of NFT based Hydroponic system)

The slope of our hydroponic system (i.e recommended slope) is basically between 1:30 to 1:40 ratio which means for every 30 to 40 inches of length(horizontal),there is a drop of 1 inch (vertical) ,which is the recommended slope. We choose 1:40 ratio while designing the construction of the system, which is necessary for the flow of the water in the tubes.[20]

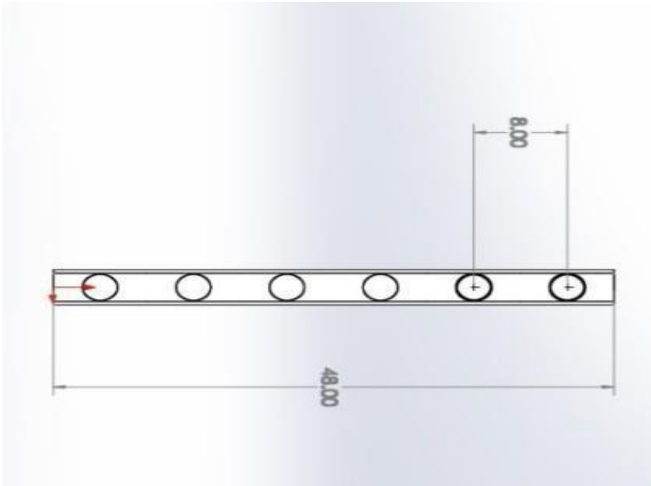


Fig 4.3 (PVC Irrigation pipe)

The next step while constructing the system is to determine the plant spacing. Usually it is recommend 8 inch spacing on center for lettuce and leafy greens, which means that each plant site in a single channel should be located 8 inches away from one another, so while designing our system we have taken 8 inches spacing as shown in the figure (Fig 4.3) [21]

1.4. COMPONENTS USED IN OUR SYSTEM

The components used while constructing our system is shown in the figure below :-

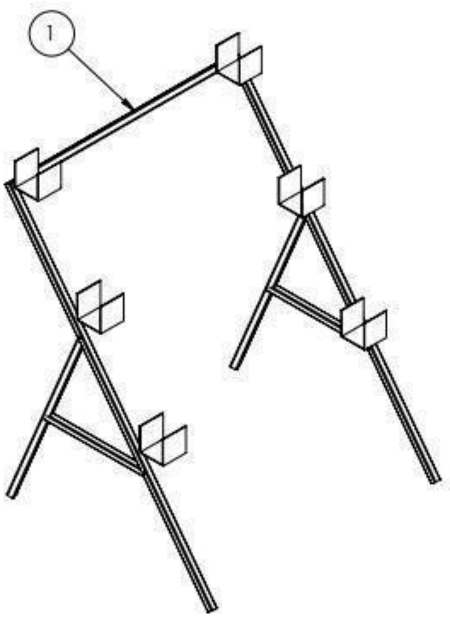


Fig 4.4 (Components used for the system)

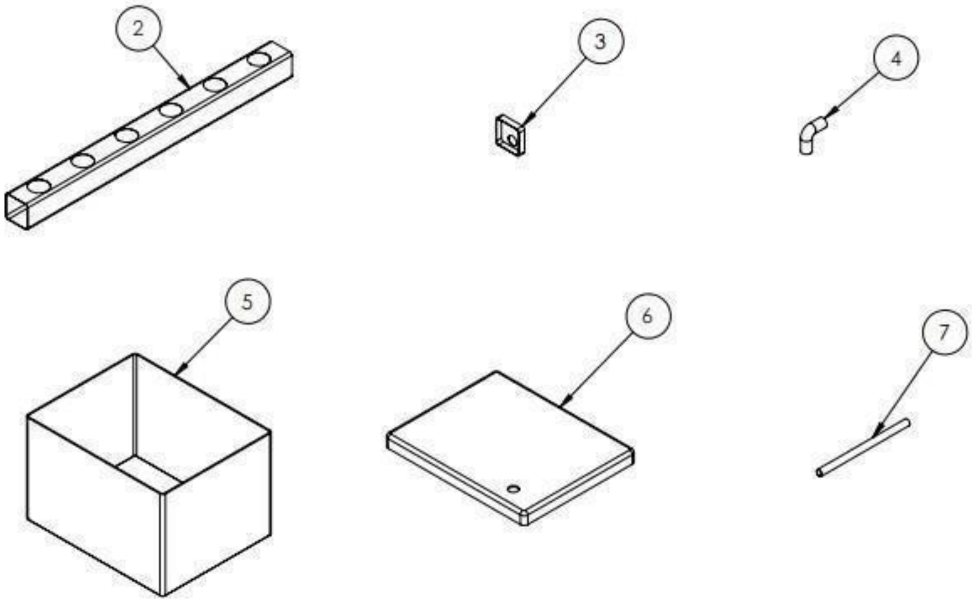


Fig 4.5 (Components used for the system)

1- Hydroponic Tower (Frame).

2- 4”x4”- PVC Square Tube.

3- PVC Side Cap.

4- PVC Two Way L Shaped Water Pipe Tube Joint Connector.

5- Water Reservoir Tank (Nutrient solution & Pump).

6- Water Reservoir Tank Cap.

7- PVC Circular Water Tube..

2. COST ESTIMATION

SL No.	REQUIRED COMPONENTS	QUANTITY	MARKET PRICE(INR)
01.	4”x4”- PVC Square Tube.	12ft.	400
02.	PVC Side Cap	6 pieces	60
03.	8- PVC Two Way L Shaped Water Pipe Tube Joint Connector.	7 pieces	50
04.	Water Reservoir Tank	2	400
05.	PVC Circular Water Tube	10 ft.	170
06.	1”x1” mild steel tube	22ft.	960
07.	3mm mild steel plate	1.4 - sq. Feet.	80
08.	Water pump	1	500
09.	ESP32-Microcontroller (wifi, bluetooth)	1	500
10.	PH- Sensor	1	1000
11.	EC-sensor	1	700
12.	Water flow sensor	1	250
13	Water lever sensor	1	40
14.	Dosing pumps	3	555
15.	Relay	1	140
		TOTAL	5,805

Table 2

3. RESULT AND DISCUSSION

As we have designed hydroponic system as per our need and it was found that the system worked successfully as per the design. Since drought is major problem while yielding crops, hydroponic system will be more helpful as it uses less amount of water and gives more yield in less time interval.

In terms of yield per area, the hydroponic production of lettuce in Kolkata, West Bengal was found to be 11 ± 1.7 times greater than that of its conventional equivalent. Specifically, hydroponic lettuce production was calculated to result in a yield of 41 ± 6.1 kg/m2 /y, while conventional lettuce production was projected to yield 3.9 ± 0.21 kg/m2 /y.

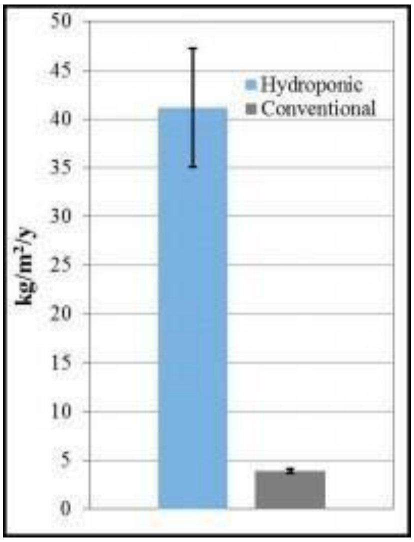


Fig 6.1 (Conventional Vs Hydroponics Yield/ area Graph)

Water consumption between the hydroponic and conventional production of lettuce was 13 ± 2.7 times less water demand in hydroponic production compared to conventional production. Specifically, hydroponic lettuce production had an estimated water demand of 20 ± 3.8 L/kg/y, while conventional lettuce production had an estimated water demand of 250 ± 25 L/kg/y.

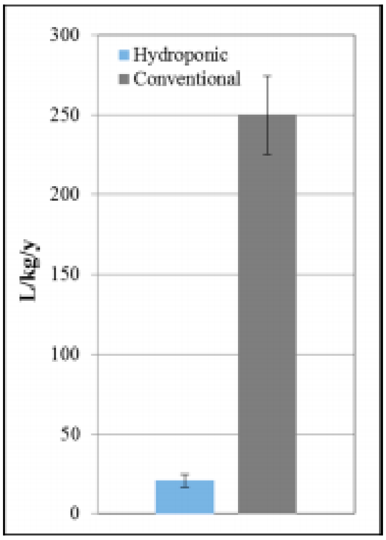


Fig 6.2 (Conventional Vs Hydroponic water consumption Graph)

According to the results presented, while the hydroponic production of lettuce results in higher yields and more efficient water use. So, our proposed system works efficiently and is productive.

The better yield performance was due to the greater and continuous availability of water in this hydroponic system. The vegetative and reproductive behavior of NFT-grown plants needs to be monitored through careful management of the NS, aimed, for instance, at increasing salinity levels to limit productive vigor.

4. Conclusion:

In this report, the crops are grown without the soil, instead the nutrients from the soil are directly given to the crops by the nutrients dissolved in water. The adequate nutrients that are required by the plants are measured and added to the water reservoir so that the crops get enough nutrients from the water as equal as from the soil. By using IoT this whole hydroponic system can be automated. All the data from the hydroponic system are sent to the cloud data for the automation purpose. A mobile application will be developed for the user to get notified all the nutrients required for the growth of a particular crop. The user also gets information about the hydroponic system with the help of the mobile application. The health condition of the crops is continuously monitored with the help of data that are collected by the sensors. Thus, this hydroponic system can be adopted in any environmental conditions and it is a fully automated setup that will be operated through a mobile application.

Scope For Future work:

- To feed the plants the hydroponic system needs all the time expensive nutrients and also on a regular basis a waste disposal issue appears by flushing the systems. Working On waste management would be required.

- Aquaponic Systems came as the magical solve for the down sides of both aquaculture and hydroponics in the best way, thinking about re-circulating both systems together we will find that the negative aspects of aquaculture “getting the excess nutrients out of the system” is the best solve for the negative aspect of hydroponics “the hydroponic system is in need all the time for expensive nutrients” and no more waste water cause of the periodic flushing of the systems that means no more lost money.

- By working on aquaponic aspect of hydroponic system, we will have fresh fish, vegetables and fruits all the time in the in the cheapest and cleanest way.

- In a controlled environment (such as Green House and others) of hydroponic system crop yielding aspect can be achieved with high accuracy and can yield crops without any outside factors effecting the yield.

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