A PRELIMENERY REPORT ON

IOT BASED HYDROPONIC SYSTEM

SUBMITTED TO THE SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE
IN THE PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE

OF

BACHELOR OF ENGINEERING (COMPUTER ENGINEERING)

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2020-21

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CERTIFICATE

This is to certify that the project report entitles

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ACKNOWLEDGEMENT

We take this opportunity to express our sincere thanks and gratitude to all those who helped us to complete the project successfully. At the outset, we are greatly indebted to our guide, **Prof. P. R. Patil**, Department of Computer Engineering, for her advice, creative guidance, valuable suggestions, support and encouragement throughout the project. We would like to thank **Prof. A. N. Adapanawar**, Head, Department of Computer Engineering for his support and guidance. Our sincere thanks to **Dr. K. P. Patil**, Principal, Sinhgad Academy of Engineering, Pune, for his encouragement and constant support. We would like to thank our project coordinators **Prof. S. N. Shelke**, Department of Computer Engineering for his support and guidance. We thank all our Department Teaching and Non-Teaching staff who helped us to complete this work.

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ABSTRACT

The blast in human population has left scientists scrambling for arrangements on how to take care of the world. Moreover, provincial metropolitan movement i.e. rural-urban immigration has from one perspective left the farms in the rustic regions without farmers and then again has left the metropolitan regions over-populated. Hydroponic is a type of horticulture where yields are developed without soil. This method permits the homesteads to follow the ranchers to the metropolitan region. Also, the truth that no dirt is required, permits Hydroponic framework to be stacked upward (otherwise called vertical cultivating) to save space. The last outskirts in tank-farming is mechanization or automation. It will permit one rancher to work more than one work and develop more than one homestead at the same time. This project gives an exhaustive view on brilliant Hydroponic framework created to date.

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LIST OF ABBREVATIONS

ABBREVIATION	ILLUSTRATION
NFT	Nutrient Film Technique
DFT	Deep Flow Technique
PVC	Polyvinyl Chloride
N	Nitrogen
P	Phosphorous
K	Potassium
pH	Potential of Hydrogen
Ca	Calcium
Mg	Magnesium

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1. Introduction

The dirt is a significant part of agribusiness: it gives support for the plants, it additionally give supplement to the plants and the soil give a home to a portion of the microbial living being that frames a beneficial interaction relationship with the plants. Be that as it may, this multitude of fixings can be given hydroponics. Hydroponics is the interaction of developing plants without soil. Proof of hydroponics was found in the Egyptian divider painting. There are many advantages to hydroponics: 1) it doesn't need soil, 2) it is quicker than conventional cultivating, 3) it requires less space and can be filled in any area, 4) it is unaffected via occasional change, 5) practically no pesticides and herbicides are required 6) Plants get total reach of supplements they need at the amount they need it, 7) Plants are secured against infections and irritations, 8) It can be utilized to seclude crops during tests .

The term Hydroponics was derived from the Greek words hydro - which means water and ponos which implies work. It is a technique for developing plants utilizing mineral supplement arrangements, without soil .Hydroponics is the procedure of developing plants in soil-less condition with their foundations inundated in supplement arrangement. This framework assists with confronting the difficulties of environmental change and likewise helps underway framework the executives for effective usage of normal assets and alleviating lack of healthy sustenance First there is a requirement for an area or developing region where the framework is going to be introduced since hydroponics require just water any space could be utilized for it. The repository is a holder that stores the supplement arrangement utilized by the framework.

Supplements in a decent hydroponic framework should contain the ideal degree of; oxygenation, saltiness, pH, and conductivity of nutrient solution. The hydroponics fertilizers contain six essential nutrients: N, P, S, K, Ca and Mg, which are fed to the plants in form of mutual ratio of anions: NO−3 , H2PO−4 and SO2−4 , and the mutual ratio of cations K+ ,Ca2+ and Mg2+ [20]. Light is vital for photosynthesis, right up different sources of light are utilized to give lighting in lieu of the sun. Different variables that might be considered are; surrounding temperature, nutrient solution temperature, photoperiod, and humidity of air.

1.1 Motivation

Motivation is to have a Mobile & Dynamic setup and to design efficient systems in terms of water usage, and a higher crop yield. It helps to reduce inefficient and Destructive farming and increase awareness relating to the benefits of Hydroponics.

1.2 Problem Definition

Every plant grown using open agriculture farming, ties up a certain amount of land for a long duration (usually through the growing season). Also the conventional agriculture uses lots of water and Agriculture farming takes lot of time to produce outputs. That’s why we need an efficient solution.

CHAPTER 2
LITERATURE SURVEY

Various researchers have conducted research on this topic and authored journals, those research reviews are considered in this study.

Sr. No	Topic	Author	Year	Major Findings
1	iPONICS: IoT Monitoring and Control for Hydroponics	K. Tatas, A. Al-Zoubi Antoniou D. Zolotareva	2021	The system is composed of a specialized Wireless Sensor Network for monitoring the essential parameters for Hydroponics and control for the pump. It provides the user with a user friendly web-based tool to monitor his crops as well as being appraised by appropriate alarms and warnings. This greatly facilitates the observation of multiple hydroponics greenhouses with minimal effort and need for intervention.
2	Hydroponics System for Soilless Farming Integrated with Android Application by Internet of Things and MQTT Broker	Navneet K. Bharti Mohit D. Dongargaonkar Isha B. Kudkar Siuli Das Malay Kenia	2019	In this work monitoring several parameters is involved, which is achieved with basic sensors and one single micro-controller. Monitoring these parameters not only helps to keep a watch on the system but also data is used for further evaluation of the quality of the harvest for future scientific data analysis. Internet of Things is used to accumulate the data and store it on servers. An Android application can fetch this data, creating a more personalized setup and data. Many people are not aware of this kind of farming; Android application is a better platform to spread the knowledge than any other media

3	Automated Irrigation System Using a Wireless Sensor Network and GPRS Module - IEEE Transaction	Joaquín Gutiérrez, Juan Francisco Villa-Medina, Alejandra Nieto-Garibay, and Miguel Ángel Porta-Gándara	2014	The automated irrigation system hereby reported, consisted of two components wireless sensor units (WSUs) and a wireless information unit (WIU), linked by radio transceivers that allowed the transfer of soil moisture and temperature data, implementing a WSN that uses ZigBee technology. The WIU has also a GPRS module to transmit the data to a web Configuration of the automated irrigation system. WSUs and a WIU, based on microcontroller, ZigBee, and GPRS technologies.. The information can be remotely monitored online through a graphical application through Internet access devices
4	IoT Based Automated Hydroponic Cultivation System	Dr. Ponmurugan Sudharsan, Vargunan, Vignesh Raj , Selvanayagan	2019	In this study, the crops are grown without the use of soil, instead the nutrients from the soil are directly given to the crops by water reservoir. 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 the intervention of 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. The health condition of the crops is continuously monitored with the help of data that are collected by the sensors and actuators.

2.1 Types of Hydroponics

Mamta D Sardare et al., (2013), has conducted a research on “A Review on Plant without Soil – Hydroponics”. In 1960 with 3 billion population over the World, per capita land was 0.5 ha but presently, with 6 billion people it is only 0.25 ha and by 2050, it will reach at 0.16 ha. Due to rapid urbanization and industrialization as well as melting of icebergs (as an obvious impact of global warming), arable land under cultivation is further going to decrease. Again, soil fertility status has attained a saturation level and productivity is not increasing further with increased level of fertilizer application. Besides, poor soil fertility in some of the cultivable areas, less chance of natural soil fertility build-up by microbes due to continuous cultivation, frequent drought conditions and unpredictability of climate and weather patterns, rise in temperature, river pollution, poor water management and wastage of huge amount of water, decline in ground water level, etc. are threatening food production under conventional soil-based agriculture. Under such circumstances, in near future it will become impossible to feed the entire population using open field system of agricultural production only. Naturally, soil-less culture is becoming more relevant in the present scenario, to cope-up with these challenges. The author concluded that country like India, where urban concrete conglomerate is growing each day; there is no option but adopting soil-less culture to help improve the yield and quality of the produce so that we can ensure food security of our country. However, Government intervention and Research Institute interest can propel the use of the present technology.

Hydroponics is a technology for growing plants in nutrient solutions with or without the use of artificial medium to provide mechanical support. Major problems for hydroponic cultivation are higher operational cost and the causing of pollution due to discharge of waste nutrient solution. The nutrient effluent released into the environment can have negative impacts on the surrounding ecosystems as well as the potential to contaminate the groundwater utilized by humans for drinking purposes. The reuse of non-recycled, nutrient-rich hydroponic waste solution (HWS) for growing plants in greenhouses is the possible way to control environmental pollution. Many researchers have successfully grown several plant species in hydroponic waste solution with high yield. Hence in the present paper "Reuse of hydroponic waste solution" by Ramasamy Rajesh Kumar et al., (2014), 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. The driving force of future agricultural industry is to provide sufficient yield that satisfy the needs of consumers and meet their interests in terms of quality. Soilless cultivation is intensively used in protected agriculture to improve control over the growing environment and to avoid uncertainties in the water and nutrient status of the soil. Recently the type of soilless culture transformed from open to close-loop system is known for better result in water use efficiency, while maintaining the quality of the yield.

In the present study "Soilless Culture System to Support Water Use Efficiency and Product Quality: a Review" by Agung Putra P et al., (2015), concluded that Soilless culture can be the effective tool to increase the crop yield and, if closed irrigation systems are adopted could increase the water-use efficiency, also reduce 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. These systems, which can increase the efficiency of water-usage while maintaining its quality, should be more intensively implemented in any scale to support eco-agriculture.

Guilherme Lages Barbosa et al., (2015), has conducted a research on "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. Yields of lettuce per greenhouse unit (815 m2) of 41 ± 6.1 kg/m2 /y, water and energy demands of 20 ± 3.8 L/kg/y and 90,000 ± 11,000 kJ/kg/y (±standard deviation) respectively. In comparison, conventional production yielded 3.9 ± 0.21 kg/m2 /y of produce, with water and energy demands of 250 ± 25 L/kg/y and 1100 ± 75 kJ/kg/y, respectively. Hydroponics offered 11 ± 1.7 times higher yields but required 82 ± 11 times more energy compared to conventionally produced lettuce. In the present paper author concluded that hydroponic gardening of lettuce uses land and water more efficiently than conventional farming and could become a strategy for sustainably feeding the world"s growing population, if the high energy consumption can be overcome through improved efficiency and/or cost-effective renewable.

The study was carried out by installing the Flood and Drain Vertical Hydroponic System for cultivating Chinese leafy vegetable Pak-choi of family Brassicaceae. The sowing of 112 seeds of Pak-choi was done in perforated net pots containing media of coco-pit (8% N: P: K treated) and vermiculite in 1:1 proportion. Irrigation technique used for the crop was deep flow technique through beds. The average pH readings before and after each irrigation was 6.40 and 6.76 and the average values of electrical conductivity (EC) before and after each irrigation was 0.79 mmhos/cm and 0.97 mmhos/cm, respectively and also the average moisture content of media before and after each irrigation was 18% and 71% respectively, available moisture content for complete growth of crop ranged from 46.73% to 57.05%. The water requirement of Pak-choi crop was 2.63 cm and the fertilizer applied was 1.9 gm N: P: K for overall growth of crop. The harvesting of crop was done after 70 days from sowing and the yield of crop was 7 kg from 1.8 m2 area. The total cost of system was estimated to be Rs. 3400/-.

"Design of Flood and Drain Vertical Hydroponic System" by Ashwini Patwardhan 6 (2016), 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. Yield of Pak-choi crop in hydroponic system 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.

Philomena George et al., (2016), has conducted a research on "Hydroponics- (Soilless Cultivation of Plants) for Biodiversity Conservation". Hydroponics is a system of agriculture that utilizes nutrient-laden water than soil for plant growth. The fertile land in order to be effective does not required natural precipitation, this shows people living in rural and urban regions can grow food by this technique and gain profit. Aeroponic and hydroponic systems do not require pesticides, they require less water and space compared to traditional agricultural systems and it can also be stacked (Vertical Farming) in order to limit space use. It makes them optimal for use in cities, where space is particularly limited and populations are high-self-sustaining city-based food systems. It results in reduced strain on distant agriculture farms, transportation costs and fewer carbon emissions. Optimization of land area and the preservation of biodiversity has become the need of the hour in both developing as well as developed countries. Hydroponics helps to limit terrestrial biodiversity loss through the reversion of large tracts of current farmland into sustainable and fundamentally natural environments. In short hydroponic gardens produce the healthiest organic, pesticide free crops with high yields and are consistently reliable. Hydroponic growing is the best way to overcome global food and water shortages and produce the highest quality, nutritious produce in any type of climate. It is a precise scientific growing method developed from experiment, experience and observation. The hydroponic growing method provides for reliable and repeatable and safe food production.

Ali AlShrouf (2017), has conducted a research on “Hydroponics, Aeroponic and Aquaponic as Compared with Conventional Farming”. Hydroponic growing systems use mineral nutrient solutions to feed the plants in water of using soilless media while Aquaponics is the integration of aquaculture and hydroponics. Many studies of commercial-scale hydroponic, aeroponics and 7 aquaponics production showed the potential positives role in the present new technologies in the sustainable food security. In the present, agricultural farming systems could be one sustainable alternative to provide different type of produces that it requires less water, less fertilizer and less space which will increase the yield per unit area. In this paper, author concluded that modern cultivation systems are the conservation of water and increase productivity per unit area. While all three can be implemented in a raised garden, all three are very similar in every way except hydroponics and aeroponics requires the addition of fertilizer and there‟s no fish in the nutrient solution. In aquaponics, plants and fish live a symbiotic life with the fish feeding the plants, and the plants cleaning and filtering the fish’s environment. Hydroponics is the base for all these methods and would be the easiest to set up. It could be later adpted to create an aquaponics setup. However, the aeroponics requires more maintenance and care in creating a semi-enclosed to fully-enclosed environment. Aeroponics, hydroponic and aquaponics systems reduce water loss and increase water use efficiency compared to the conventional agriculture.

2.2 Design of NFT System

Roberto Lopez - Pozos et al., (2011), has conducted a research on “The Effects of Slope and Channel Nutrient Solution Gap Number on the Yield of Tomato Crops by a Nutrient Film Technique System under a Warm Climate”. Inadequate oxygenation of the nutrient solution (NS) in recirculation hydroponic systems leads to root hypoxia in several plants as a result of low oxygen solubility and it is most notable in warm climates. Hypoxia affects crop 14 nutrient and water absorption which results in reduced crop yield. However, increased air supply to the NS serves as a source of oxygen for the roots. To evaluate the incorporation of oxygen into the system, author varied the slope of 14-m long containers from 2% to 4% and applied zero, one, two or three gaps of NS. The channel width measured 10 cm and was equidistant from the end points. The effect of the dissolved oxygen in the NS was measured by the production of a tomato cultivar. The oxygen dissolved in the NS was 5% greater in the channels with a 4% slope compared with those with a 2% slope. The channels that included the gaps incorporated a higher quantity of dissolved oxygen during cultivation. The author concluded that the slope of the container influenced the oxygenation of the NS with 4% slopes resulting in higher dissolved oxygen compared with the 2% slope. These results suggest that in warmer climates, the use of a steeper slope and the incorporation of gaps in the NFT channel can significantly improve crop productivity.

Dian Siswanto et al., (2017), has conducted a research on "Design and Construction of a Vertical Hydroponic System with Semi-Continuous and Continuous Nutrient Cycling". The hydroponic system was used adapts the ebb and flow system and the nutrient film technique (NFT). It was constructed from four polyvinyl chloride (PVC) pipes with a length of 197 cm, a diameter of 16 cm and a slope of 4°. The author concluded that in semi-continuous irrigation treatment, nutrients flow, four to six times for each of ten minutes depending on plant development and the estimated evapo-transpiration occurring, while in a continuous nutrient system the nutrients are streamed for twenty-four hours without stopping at a maximum flow rate of 13.7 L per second.

2.3 Selection of Plants

Kunio Okano et al., (2001), has conducted a research on "Single-Truss Tomato System - A Labor-Saving Management System for Tomato Production". In the single-truss system of tomato growing, the main shoot in pinched, leaving a few leaves above the first truss and only the first truss is harvested. The objective of single-truss system is to reduce labor requirement for training, pruning and harvesting. A "wet-sheet culture" system has been developed, in which a water-retaining sheet made of non-woven fabric is used as 15 a growing medium. Fruit quality can be easily improved by the application of salinity stress. A large number of nursery plants are required in the single-truss system because of the dense planting and frequent replanting. Mass production of nursery plants in plug trays is recommended. In the single-truss system, no serious problems occurred even when very young plug seedlings were transplanted. An alternative way might be the use of cuttings. The roots of tomato plant cuttings emerge easily if the cutting is placed in a medium such as rockwool. The single-truss system may be suitable for large-scale production of tomato. Continuous predictable production may be possible if the environment in the greenhouse could be adequately controlled.

Valenzano V et al., (2008), has conducted a research on "Effect of Growing System and Cultivar on Yield and Water-Use Efficiency of Greenhouse Grown Tomato". The aim of the present 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). Two trials were carried out, one in Winter-Spring (WS) and the other in Autumn-Winter (AW). In both trials, four tomato cultivars were used: two of the beefsteak fruit- type (Diana F1 and Jama F1) and two of the cherry fruit-type (Naomi F1 and Conchita F1). The author concluded that the two hydroponic systems showed greater earliness; on average, 10 day and 8 day earlier than in soil, in the WS and AW trails, respectively. In the hydroponic systems, total yields were 11% and 7% higher in the WS and AW trials, respectively, than in the soil system. Cultivation in soil gave good results in term of WUE in both trials, due to the use of tensiometers, suitable watering volumes and mulching. Between the two hydroponic systems, NFT gave a higher yield, with lower water and fertilizer use and a greatly reduced environmental impact.

The nutrient uptake ability of tomato plant in Nutrient Film Technique (NFT) culture was investigated by using NFT method. All the treatments started with rainwater and then six different concentrations of nutrient solution were added to each system according to solution consumption. The concentration of each mineral element in the nutrient solution increased with the addition of the supplement solution until the 3rd day and thereafter leveled off until the 7th day, 16 indicates that when absorption concentration became in stable state, except for the ion in the highest strength solution for potassium and magnesium elements, and that most of the newly added ions were absorbed stably by plants from low to high concentration of nutrient solution. At that point when each ion concentration in the nutrient solution reached a critical level, the tomato plants were no longer able to uptake ions from the solution and the minimum uptake concentration was evaluated. The critical concentration for tomato obtained in the present experiment was 0.01-0.02 me/L for NO3-N, 0.20 me/L for PO4-P, 0.05- 0.10 me/L for K, 0.40-0.50 me/L for Ca and 0.10 me/L for Mg. In the present paper "Uptake Ability of Tomato Plants (Solanum Lycopersicum L.) Grown Using Nutrient Film Technique (NFT) by Ascending Nutrient Concentration Method" by Jocelyn Amihan Gonzales et al., (2010), 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 given season.

"Growth and Yield of Tomato (Solanum lycopersicum L.) as Affected by Hydroponics, Greenhouse and Irrigation Regimes" by Francisco Suazo-Lopez et al., (2014), concluded that it is convenient to utilize the nutrient solution at 75% in seven irrigations per day and substratum volume of 10 L for tomato production in hydroponics and greenhouse in order to obtain the highest profit (73.9%). As a result of increase in the cost of agricultural inputs (chemical fertilizers, containers, and pesticides) and to water shortage, the results of the present study contribute to increasing efficiency in tomato production and producer competitiveness.

The tomato variety Anagha was raised in Ebb and flow hydroponic system (flood and drain system) to evaluate the ideality of growing media (coco peat, expanded clay pellets and pebbles). "Standardization of Growing Media for the Hydroponic Cultivation of Tomato" by T Reshma et al., (2017), revealed that the plants grown in coco peat medium performed the best in terms of 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 contained comparatively high amount of potassium (0.36 %) and also possessed high water holding capacity. Performance of plants grown in expanded clay pellets was very poor. Fruit quality in terms of total soluble solid content and titrable acidity was not significantly affected by the treatments.

From the above literature review the tomato plant (Jocely Amihan Gonzales, 2010) uptakes the nutrient even from low concentration and has fiborous root system. Coco coir and expanded clay pellets were suitable growing media (T Reshma). (Arjina Shrestha, 2015) Wastewater as nutrient solution parameters analysed were N, P, K, C, Mg, S, Fe, B, Cu, Mn, Zn and Cl. Closed type Nutrient Film Technique was considered (Valenzano V, 2008) for higher yield with lower water and without fertilizer which reduces environmental impact. NFT design considerations were (Dian Siswanto, 2017) pipe length, diameter, slope, number of holes and spacing in pipe, size of netpot, discharge of nutrient solution and water-use efficiency. Climatic parameters considered were temperature, relative 18 humidity, carbon dioxide and light intensity (Andre Ndumimana, 2017). Physical parameters considered were stem elongation, internodes length, plant height, leaf area, number of aborted flowers, fruit yield and dry weight (Andre Ndumimana, 2017).

From the literature it can be concluded that cherry tomato has fast growth rate, good yield and fibrous root system, the clay pebbles has the property of maintaining pH and also have water holding capacity hence considered in this research work. The parameters like Nitrate, Phosphorus, Potassium, Calcium, Magnesium, Sulphur, Iron and Chloride are most important for plant growth and photosynthesis process. Physico-chemical parameters such as BOD, COD, DO, pH, electrical conductivity and climatic conditions such as temperature, light intensity and relative humidity are considered in this research work. From the literature, the NFT design considerations were pipe length, diameter, slope, number of holes and spacing in pipe, size of netpot, discharge of nutrient solution and water-use efficiency.

CHAPTER 3
METHODOLOGY

3.1 Project Scope

This project may have a Mobile & Dynamic setup and this project is developed to design an efficient system in terms of water usage, and a higher crop yield. It will helps to reduce inefficient and destructive farming and increase awareness relating to the benefits of Hydroponics.

This Project will have Manual Integrations of all the Sensors and other hardware. Using IoT Devices like Arduino with sensor interfacing. Besides project scope, there are intangible skills we look to gain as well.

3.2 Introduction on Hydroponic System

Soil-less culture mainly refers to the techniques of Hydroponics. The term Hydroponics was derived from the Greek words hydro' means water and ponos' means labour. It is a method of growing plants using mineral nutrient solutions, without soil. Terrestrial plants may be grown with their roots in the mineral nutrient solution only or in an inert medium such as perlite, expanded clay pellets, coco coir, gravel and mineral wool. Hydroponics is the technique of growing plants in soil-less condition with their roots immersed in nutrient solution. This system helps to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources and mitigating malnutrition. In India, Hydroponics was introduced in year 1946 by an English scientist, W. J. Shalto Duglas and established a laboratory in Kalimpong area, West Bengal. Mr. Shalto Duglas has also written a book on Hydroponics, named as "Hydroponics the Bengal System". Later on during 1960s and 70s, commercial hydroponic farms were developed in Abu Dhabi, Arizona, Belgium, California, Denmark, German, Holland, Iran, Italy, Japan, Russian Federation and other countries. During 1980s, many automated and computerized hydroponics farms were established around the world. Home hydroponics kits became popular during 1990s. There are different types of hydroponic system as shown in Figure 3.1

3.3 Type of Hydroponic System

3.3.1 Passive systems

In a passive system, the plants roots are in touch with the nutrient solution and the plants are supported using a suspension method. The main disadvantage of this system is that it is difficult to support plants as they grow and get heavier. However, a passive system is a very basic system and is therefore easy for a beginner to set up. A passive system tends to be very portable and quite inexpensive. One example of a passive system is the Wick System.

3.3.1 a Wick System

A wick system uses a lamp wick or wick made of nylon, polyester or rayon to supply nutrient solution to the roots. Some of the more commonly used growth material is Vermiculite, Perlite, Pro-Mix and Coconut Fiber. A pot is supported above the nutrient tray solution and a wick soaked in this solution is passed through the drainage hole into the nutrient tray. Leave 10cm of the wick inside the pot and ruffle the ends for better circulation of nutrient solution. The main drawback of this system is that plants that are large or use large amounts of water may use up the nutrient solution faster than the wick can supply it.

3.3.2 Active System

Active systems are more efficient and productive because they use pumps to supply nutrient solutions to the plants and a gravity system to drain off any excess solution which is then recycled and reused. Various types of materials used to quick drain system are perlite, rockwool, expanded clay pebbles or Coconut Coir. The main difference between an active and passive system is that an active system uses pumps to supply nutrient solution whereas a passive system uses a wick to draw in the nutrient solution.

3.3.2 a Water Culture

In this method, styrofoam sheets are used to float plants (which are fixed in baskets) on top of the nutrient solution. An air pump supplies air to the air stone that bubbles the nutrient solution and supplies oxygen to the roots of the plants. Usually, short term crops are cultivated using this system and any problems in relation to stagnation of the solution is solved by circulating air from the bottom. This system is used for lettuce production and to cultivate other greens. The main drawback of this system is that it doesn‟t work well with large plants or with long term plants.

3.3.2. b Ebb and Flow System

An Ebb and Flow System is also called a flood and drain system. Using this system provides uniform distribution of nutrient solution to all the plants. Here, the nutrient solution can flood the material for 15 minutes every hour or two hour. The Ebb and Flow system has the additional benefit in that it can be automated 21 using a computer. The main drawback of this system is that the roots can dry out quickly when the watering cycles are interrupted.

3.3.2. c Nutrient Film Technique (NFT)

The Nutrient Film technique uses an automated pump and reservoir system to supply and recycle nutrients. NFT system has constant flow of nutrient solution so no timer required for the submersible pump. The nutrient solution is pumped into the growing tray and flows over the roots of the plants and then drain back into the reservoir. The main drawback of this system is that the plants can suffocate and die because of a lack of oxygen using this system.

3.3.2. d Drip (or Top Feed) System

One of the advantages of the Drip system is that it is able to withstand short-term power / equipment failure. Nutrient solution is dripped onto the plants with the remaining solution being drained back to the reservoir. The supply of the solution is timed and as a result, this system can be very expensive and difficult to set up.

3.3.2. e Aeroponics

A recent development in which plants are suspended in midair and then supplied with nutrients has resulted in a system known as Aeroponics. Nutrients are sprayed to the roots and their exposure to air provides them with maximum oxygen. In this system, the supply of nutrients and oxygen is maximized. However, care needs to be taken in order to maintain 100% relative humidity. The main drawback of this system is the functioning of the pump and reservoir in the event of power failure. As it is a reasonably new system, it is currently quite expensive to set up and is more often used in laboratory studies.

From the above Review, we considered that in a closed type hydroponic method, the amount of nutrient solution per plant largely affects the changes in concentration and composition during the cultivation period. In general, smaller the quantity of the nutrient solution more variable in the quality of the nutrient solution. Thus, the management system for nutrient solution is very important. It is therefore necessary to measure the nutrient and water uptake rate of the plant for better management of nutrient solution. In most of the studies they used pots or containers, showed that there is a change in the concentration and the amount of water uptake for a certain period. However, under low mineral concentration in hydroponic solution it is difficult to get exact values because solution concentration changes within a short period of time. In the NFT system, the root system of the plant can contact nutrient solution frequently and this method was thought to be better to measure the minimum absorption concentration compared with other growing systems. Hence, NFT was adopted in this study.

3.4 Selection of Nutrient Film Technique

3.4.1 Nutrient Film Technique (NFT)

The system of Nutrient Film Technique (NFT) was originally designed and developed by Allen Cooper. The concept is described by Cooper as follows: “A very shallow stream of water containing all the dissolved nutrients required for growth is recirculated past the bare roots of crop plants in a water tight gully. Ideally, the depth of the recirculating stream should be very shallow, little more than a film of water-hence the name nutrient film. This ensures that the thick root mat which develops in the bottom of the gully has an upper surface which although moist is in the air. Consequently, there is an abundant supply of oxygen to the roots of the plants”.

The nutrient film technique (NFT) is similar to the ebb and flow system in that it utilizes a pump to move nutrients in a continuous constant flow. The difference with NFT is that the solution flows directly over the roots. The nutrient film technique use shallow tubes that are slightly angled so that the pump moves the nutrient solution to the higher portion of the system. The nutrient solution gradually moves by gravity to the lower portion. A tube system with holes bored for the plants is used instead of trays, mainly because this system is easier to angle for proper flow over the roots. Most horticulturalists plant directly through the holes, but it is okay to use net pots and many horticulturalists use no planting medium (e.g., potting soil) with the nutrient film system. The roots fall through the net directly into the nutrient solution. The nutrient solution does not completely soak the roots. The film ensures that the entire root is not submerged so the upper part of the roots remains dry. Because it contains moving parts, NFT is considered an active system as shown in Figure 3.2

When using the nutrient film technique it is important not to grow heavy plants that require a lot of support because the roots are not in a medium that can sustain the weight of a heavy plant. It is necessary to use a self-standing trellis to support plants with heavy fruits such as tomatoes.

The Crops grown in NFT system are tomatoes, lettuce, endive, Chinese cabbage and similar leafy crops, cucumbers, zucchini and courgettes, beans, sweet peppers, egg plants, chillies, parsley and other herbs, silver beet, strawberries and many types of ornamentals. The system is not, in its normal form adapted for the production of root and tuber crops. In the NFT system, the root system of the plant are in direct contact with organic nutrient solution frequently and this method was thought to be better to measure the minimum absorption concentration compared with other growing systems. Hence, NFT was adopted in this study. Also in NFT system the water consumed by plants is less compared to conservation method.

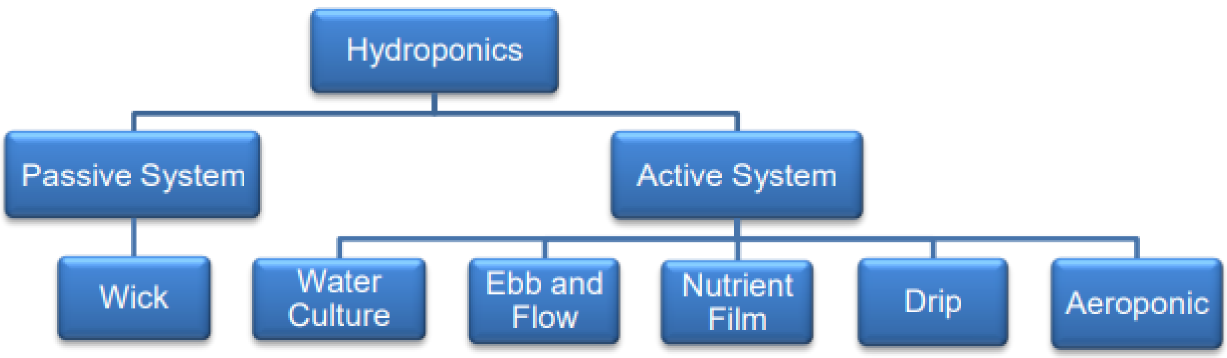

Figure 3.1 Classification of Hydroponic System

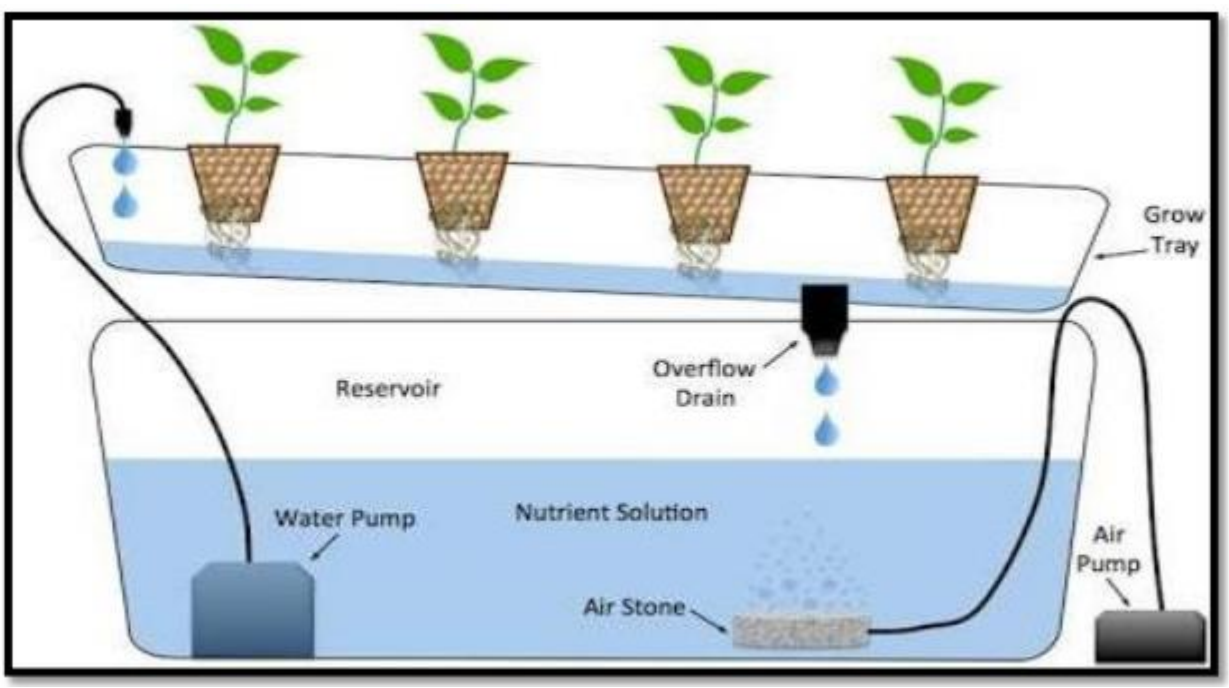

Figure 3.2 Nutrient Film Technique Setup

3.5 Assumptions and Dependencies

- You’ll have access to all the resources you need to complete the project, both human and material.
- Project team members will have the resources they need to complete their individual tasks on time, from specialized equipment and software down to electricity during working hours.
- Personnel costs will not change during the project cycle.
- Other material and resource costs will remain consistent throughout the project.
- All equipment will be in working condition through the project cycle.
- Most important Dependency is the location where the system is built. It should be spacious enough.

3.6 Advantages and Disadvantages of NFT

3.6.1 Advantages of NFT

- Produces healthy, plants in a few weeks
- Lower water and nutrient consumption
- Avoids the supply, disposal and cost problems associated with media based systems
- Relatively easy to disinfect roots and hardware compared to other types of system
- The absence of medium makes it easy to inspect roots for signs of disease, feed, adequacy, etc.
- Regular feeding prevents localized salt build-up in the root zone and maintains uniform root zone pH and conductivity
- Environmentally friendly - minimal potential for localized groundwater contamination

3.6.2 Disadvantages of NFT

- NFT system are dependent upon electricity, which means additional costs and the threat of loss of power
- Pump failure can result in plant death within a few hours, especially in hot weather
- Not suitable for plants with large tap-root systems (e.g. carrots)
- Compared to run-to-waste systems, it is less suitable for saline (salty) waters because the salinity of the recirculating water gradually increases

CHAPTER 4
SYSTEM DESIGN

4.1 System Architecture

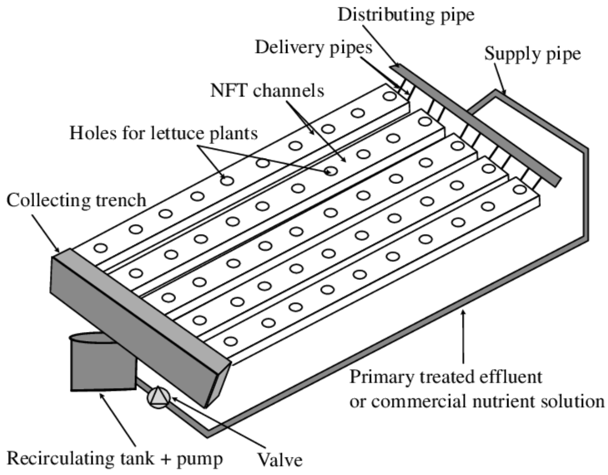

Figure 4.1.1 Expected Architecture

Figure 4.1.2 3d Model of implementation 1

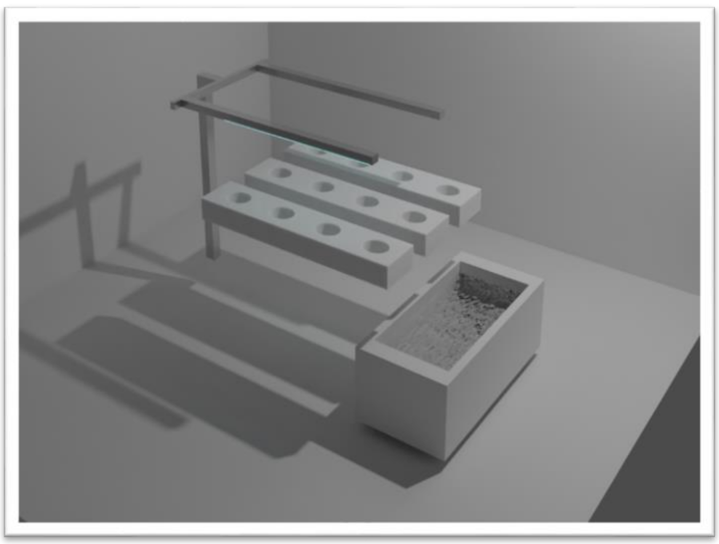

Figure 4.1.3 3d Model of implementation 2

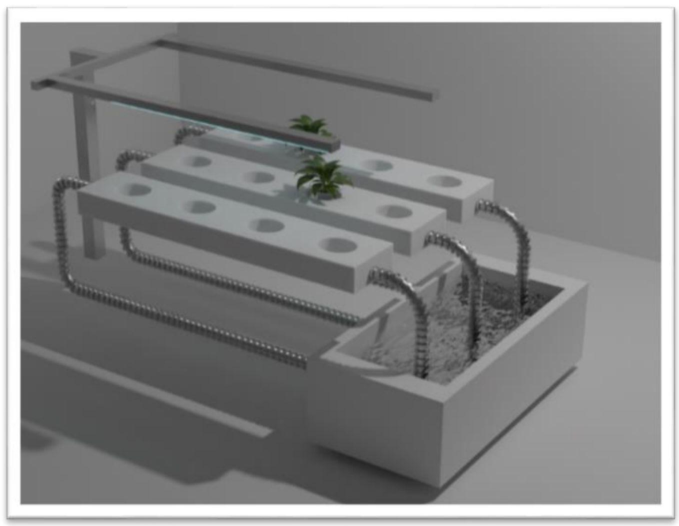

Figure 4.1.4 3d Model of implementation 3

4.2 Data Flow Diagram

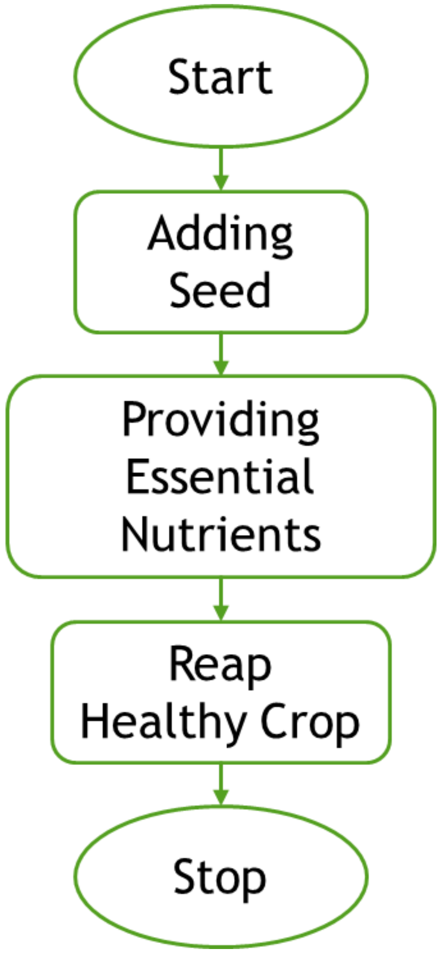

Figure 4.2.1: Level 0 DFD

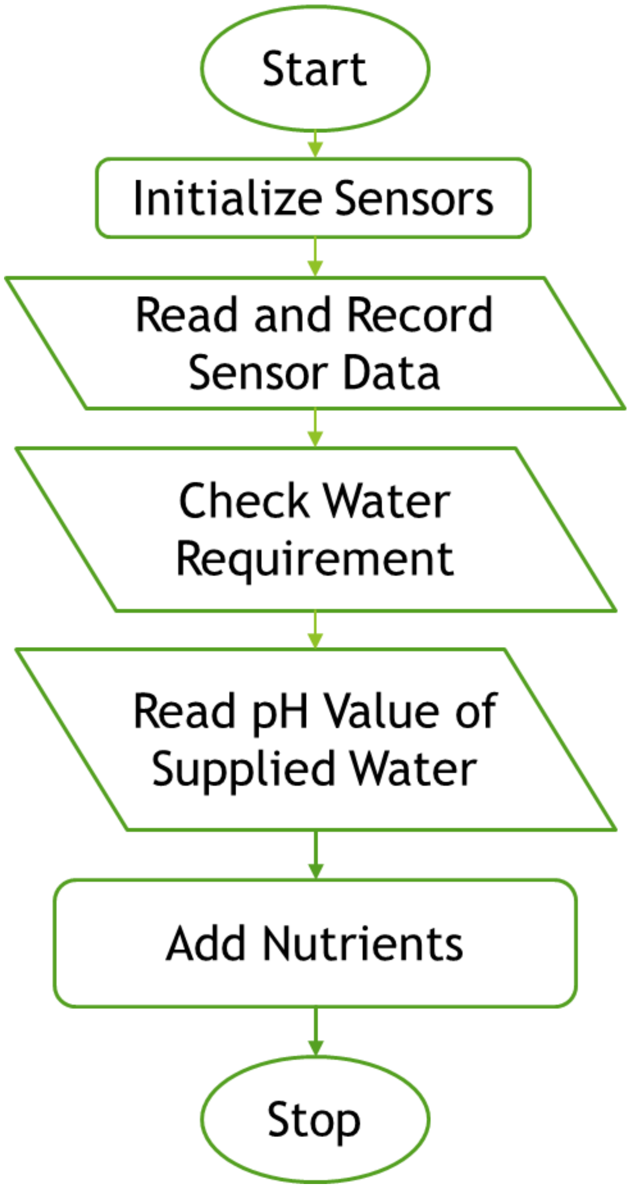

Figure 4.2.2: Level 1 DFD

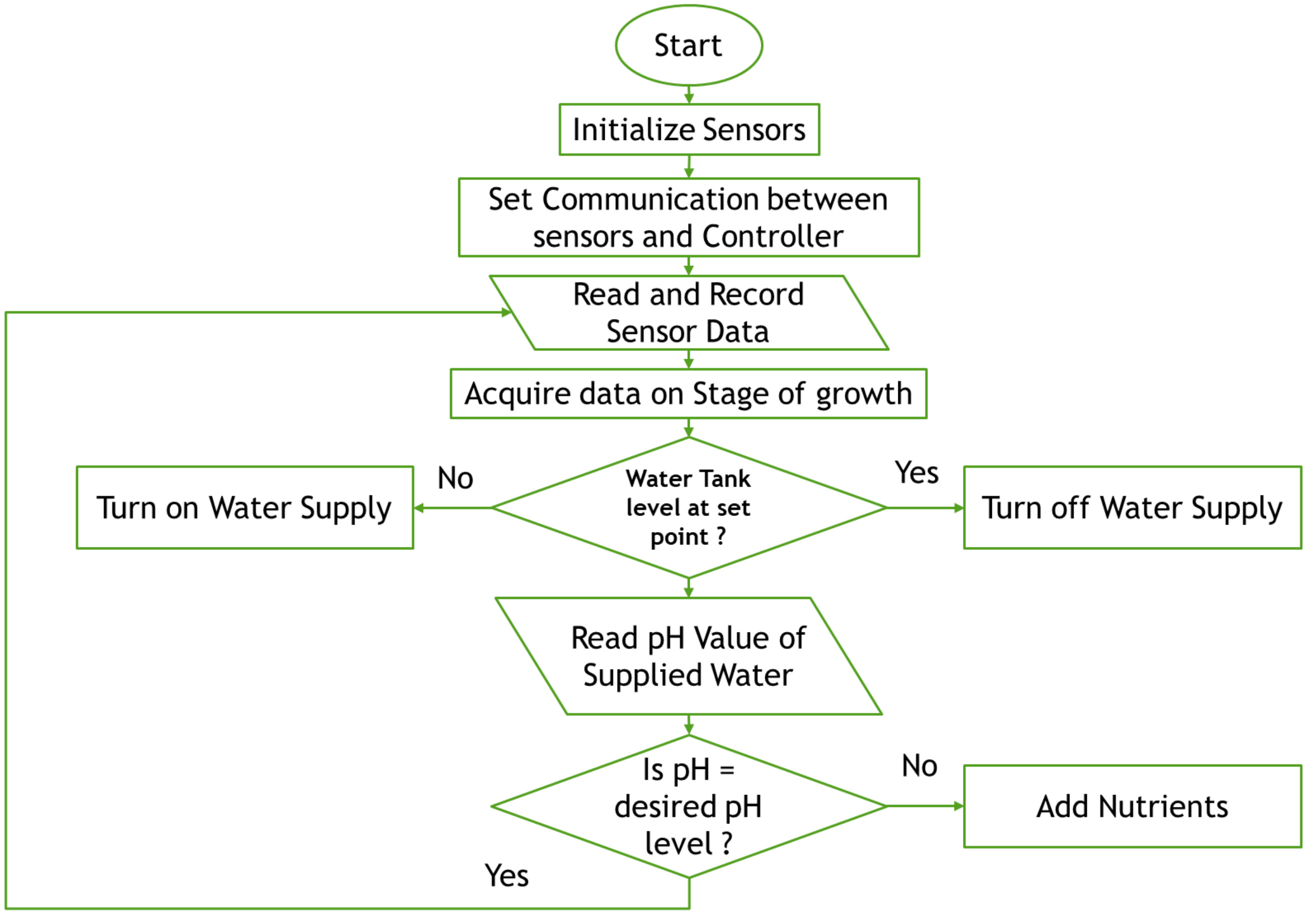

Figure 4.2.3: Level 2 DFD

4.3 UML Diagram

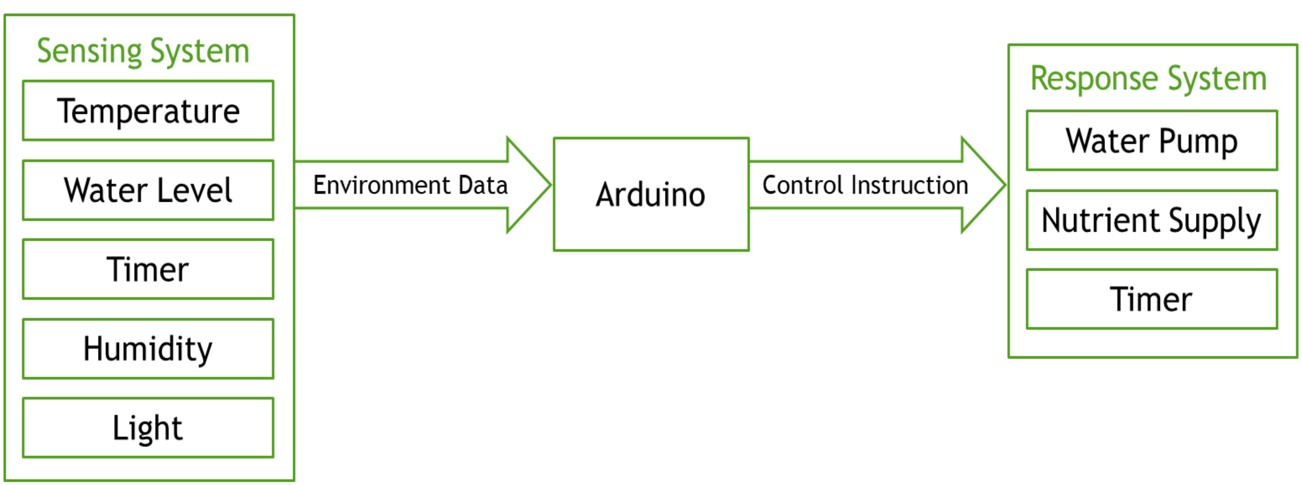

Figure 4.2.4: UML Diagram

4.4 Mathematical Model

Micronutrients + Macronutrients = Total Nutrients required(N)

Total Nutrient(N) + Water(W) = Nutrient Solution(NW)

Check Potential of Hydrogen Level(pH)

pH(NW) < 7 = Acidic Water

pH(NW) > 7 = Basic water

pH(NW) = 7 = Neutral Water

Make sure to have appropriate pH level for particular plant

G(p)= Water Circulation Time + Amount of Nutrient Solution

Where G(p) = Growth of plant

4.5 Algorithm

Step 1: Start

Step 2: Set Op-time of Grow Light with desired intensity

Step 3: Set Op-Time of Water circulation

Step 4: Set-up Temperature Sensor

Step 5: Turn on the Sensors

Step 6: Add nutrients to water

Step 7: Regulate water supply

Step 8: Check for Water Level after Circulation

    If Level is not as desired Level :

    Go to Step 7

Step 9: Check pH Levels

    If pH level is not as desired:

    Go to Step 6

Step 10: Stop

CHAPTER 5
OTHER SPECIFICATIONS

5.1 Advantages

When Compared To Traditional Soil-Grown Crop Production, Hydroponics Has the Following Advantages:

- Up to 90% more efficient use of water.
- Production increases 3 to 10 times in the same amount of space.
- Many crops can be produced twice as fast in a well-managed hydroponic system.
- Decreasing the time between harvest and consumption increases the nutritional value of the end product.
- Indoor farming in a climate controlled environment means farms can exist in places where weather and soil conditions are not favorable for traditional food production.
- No chemical weed or pest control products are needed when operating a hydroponic system.

5.2 Limitations

- Putting together a hydroponic system isn't cheap.
- Constant monitoring is required.
- Hydroponic systems are vulnerable to power outages. In the event of a power outage that outlasts your generators you will be manually watering your garden.
- Micro-organisms that are water-based can creep in rather easily.
- Growing a hydroponic garden demands technical expertise.
- Production is limited compared to field conditions
- If a disease appears, all plants in the system will be affected.
- Without soil to serve as a buffer if the system fails plant death will occur rapidly.

5.3 Applications

- The setup is portable with less space occupant and provides high yield in less duration hence, can be used in hotels, canteens and hostel mess to grow vegetables and green leaves

- This technique can also be used in apartment and houses to grow green leaves and vegetable in small quantity using kitchen wastewater
- Reuse and purification of wastewater which provides end product as purified water used for gardening

The vertical farming technique can also be used in reducing air pollution using pollutant absorbing plants obtained from Mexico

CHAPTER 6
CONCLUSION AND FUTURE WORK

6.1 Conclusion

The business is relied upon to fill dramatically additionally in future, as states of soil developing is becoming troublesome. Uncommonly, in a nation like India, where metropolitan substantial aggregate is developing every day, there is no choice except for taking on soil-less culture to assist with working on the yield and nature of the produce so that we can guarantee food security of our country. Notwithstanding, Government intercession and Research Institute interest can drive the utilization of this innovation.

6.2 Future Work

A general conception among the Indian farming community is that staple crops and vegetables cannot be grown in absence of good soil, good water and plenty of sunlight. This conception is true to an extent, but certainly, the farming trends across the globe are changing, and India is standing on the brink of adopting this valuable change.

Today new farming practices are being adopted, which clearly show healthy plants need water, nutrients and high-quality seeds. There is absolutely no requirement of soil. The term Hydroponic Farming refers to this type of farming. Growing plants with hydroponics technology require no sunlight, but blue, red and yellow spectrum.

By all means, hydroponic farming in India is in its nascent stage. As a matter of fact, farming practices in India are largely traditional. The current market for this type of hydroponic farming is only limited to metropolitan and cosmopolitan towns with a mere mention of tier-1 cities. Hydroponic Farming is under the innovation and creative technologies are being adopted in India by the progressively thinking farmers. The extent of green units operational in India are only designed for growing micro greens. The plan to grow full blown staple crops like rice, wheat, bajra etc., is a dream.

Growing lettuce and other vegetables in hydroponic units is expensive for the reason that their growth cannot be taken to the surplus levels in these units. The earning potential from hydroponic farming units is high, but the costs of establishing such units are even higher.

Population size of India is indiscriminately increasing, and this is one of the major reasons why size of arable land is reducing in availability. Since arable land area is continuously reducing, it is becoming difficult to produce staple crops for rapidly growing population. With hydroponic farming method, the arable space problem in India will be solved in the future. More cultivars of staple crops can be grown, and consumption of soil and water will be reduced, or just not required.

How it would appear, when crops will be grown in visible light spectrum, and there will be fresh food available for everyone on the land. This could be a start of new green revolution; which millennia's out here are going to witness.

Another significant benefit of Hydroponic farming evolution in India will alleviate the burden on poor people and the environment in which we breathe and survive. How this will happen? Since hydroponic farms requires less of space and water, and growth is alarmingly quick than the traditional farming, fruits and vegetables will be grown quickly. With surplus food available for everyone, there will not be fight for the hunger. In this innovative process water is also saved, which means more water is available for various other purposes.

Finally, the hydroponic farming will reduce pests and weed production on alarming levels. Therefore, the use of pesticides, insecticides and weedicides will be reduced. There will nit be any land pollution. For now, this technological revolution is a fringe movement, and much of exploration is underway.

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Appendix A

Nutrients Required for Plants Nutrients are divided into two groups:

Macronutrients and micronutrients.

A.1 Macronutrients

- Nitrogen: Nitrogen is central to plant growth. It is a major component of amino acids which are the building blocks of all proteins including enzymes, which control metabolic processes. Nitrogen is present in chlorophyll, the green pigment required for photosynthesis. It is also responsible for the plant‟s overall growth, increasing seed and fruit production and leaf quality. Calcium nitrate and potassium nitrate are major fertilizers used in most hydroponics mixes. Ammonium nitrate and Ammonium sulphate are also used in small amounts to supply the ammonium form of nitrogen
- Phosphorus: Phosphorus is used in photosynthesis and in the production of flowers and seeds. It also encourages root growth. Plants deficient in phosphorus can develop sparse dark green leaves with brown or purple discoloration of the lower leaf surface. The most common fertilizers used to supply phosphorus in hydroponics mixes are mono-ammonium phosphate and potassium dihydrogen phosphate
- Potassium: Potassium is necessary during all stages of plant development, particularly during fruit development. It is absorbed by plants in larger amounts than any other nutrient with the exception of nitrogen and in some cases calcium. It is involved in the production of chlorophyll, sugars and starches and regulates stomatal opening in the leaves. The main fertilizers used to supply potassium in hydroponics mixes are potassium nitrate and potassium dihydrogen phosphate. Potassium sulphate and potassium chloride can be used to supply small amounts
- Calcium: Calcium is used for the manufacture and growth of plant cells. It controls the transport and retention of other elements as well as overall plant strength. The main source of calcium in hydroponics mixes is calcium nitrate. Calcium chloride can be used in small amounts
- Oxygen: Oxygen is required for plant respiration and for water and nutrient uptake. Plant roots grown in water quickly exhaust dissolved oxygen and need additional air which can be supplied by aerating the nutrient solution

- Magnesium: Magnesium is essential for photosynthesis as it is central to the chlorophyll molecule structure. It also helps activate many enzymes required for plant growth. Magnesium is supplied in the hydroponics nutrient solution as magnesium sulphate or magnesium nitrate
- Sulphur: Sulphur is essential for protein production. It promotes enzyme activation and is a component of some vitamins, improving root growth and seed production. In hydroponics mixes sulphur is supplied as magnesium sulphate and is often also supplied as part of many micronutrients.

A.2 Micronutrients

While micronutrients are only needed in very small amounts they are vital to healthy plant growth as they are either involved in photosynthesis or important components of many enzyme processes.

- Iron: Iron is important in both photosynthesis and respiration. It is needed for the plants to make sugars and starches. Iron also has an important role in the activity of many of the enzymes in a plant. Iron is supplied in the nutrient solution most commonly as iron chelate EDTA. There are other types of iron chelates, such as iron EDDHA and iron DTPA which can be used. Iron can also be supplied as iron sulphate
- Chlorine: Chlorine is essential for photosynthesis. It activates the enzymes which release oxygen from water. Chlorine is supplied in the nutrient solution, if necessary with calcium chloride, potassium chloride or manganese chloride
- Manganese: Manganese is used in chlorophyll and is needed to make enzymes work. It is also used by plants to take up nitrogen. Manganese is supplied in the nutrient solution as with manganese sulphate or manganese chelate. Manganese chloride can also be used • Boron: Boron is important in flowers and pollen development. Boron is usually supplied in the nutrient solution as sodium borate (borax) or boric acid
- Zinc: Zinc is used by the plant to access stored energy. It is also part of enzymes and plant hormones. Zinc is supplied in the nutrient solution as zinc sulphate or zinc chelate
- Copper: Copper is used in a range of plant processes and is a component of enzymes. Copper is supplied in the nutrient solution as either copper sulphate or copper chelate Molybdenum: Molybdenum is used by the plant to process nitrogen. Molybdenum is supplied in the nutrient solution as either sodium molybdate or ammonium molybdate.

Appendix B

B.1 Tissues of Plants

The ground tissue of plants includes all tissues that are neither dermal nor vascular. It can be divided into three types based on the nature of the cell walls i.e., Parenchyma, Collenchyma and Sclerenchyma cells and plant have different type of transport tissue i.e., Xylem and Phloem cells as Shown in Figure B.1

B.1.1 Parenchyma cells: It has thin primary walls and usually remains alive after they become mature. Parenchyma forms the "filler" tissue in the soft parts of plants usually present in cortex and pith of stems, the cortex of roots, the mesophyll of leaves, the pulp of fruits and the endosperm of seeds. They have large central vacuoles, which allow the cells to store and regulate ions, waste products and water. The main function of this cell,

- In leaves, they form the mesophyll and are responsible for photosynthesis and the exchange of gases, parenchyma cells in the mesophyll of leaves are specialised parenchyma cells called chlorenchyma cells (parenchyma cells with chloroplasts)
- Storage of starch, protein, fats, oils and water in roots, tubers (e.g. potatoes), seed endosperm (e.g. cereals) and cotyledons (e.g. pulses and peanuts)
- Secretion (e.g. the parenchyma cells lining the inside of resin ducts)
- Wound repair and the potential for renewed meristematic activity
- Other specialised functions such as aeration (aerenchyma) provide buoyancy and helps aquatic plants in floating

B.1.2 Collenchyma cells: It has thin primary walls with some areas of secondary thickening. Collenchyma cells are usually living and have only a thick primary cell wall made up of cellulose and pectin. The main function of this cell,

- It provides extra mechanical and structural support, particularly in Epidermis regions of new growth mainly in growing shoots and leaves
- Chlorenchyma cells carry out photosynthesis and manufacture food

B.1.3 Sclerenchyma cells: It has thick lignified secondary walls and often dies when mature. Sclerenchyma provides the main structural support to a plant. Sclerenchyma is the tissue which makes the plant hard and stiff. Unlike the collenchyma, mature sclerenchyma is composed of dead cells with extremely thick cell walls (secondary walls) that make up to 90% of the whole cell volume. The main function is strengthening and supporting elements in plant parts that have ceased elongation. Two types of sclerenchyma cells exist: fibers and sclereids. Their cell walls consist of cellulose, hemicellulose and lignin.

- Fibers: Fibers or bast are generally long, slender, so called prosenchymatous cells, usually occurring in strands or bundles. Such bundles or the totality of a stem's bundles are colloquially called fibers. Their high load-bearing capacity and the ease with which they can be processed have since antiquity made them the source material for a number of things, like ropes, fabrics and mattresses. Sclerenchyma fibers are of great economic importance, since they constitute the source material for many fabrics (e.g. hemp, jute and ramie)
- Sclereids: Sclereids are a reduced form of sclerenchyma cells with highly thickened, lignified walls. These have a shape of a star. They are small bundles of sclerenchyma tissue in plants that form durable layers, such as the cores of apples and the gritty texture of pears. Compared with most fibres, sclereids are relatively short

B.1.4 Xylem: It transports water and solutes from the roots to the leaves.

B.1.5 Phloem: It transports food from the leaves to the rest of the plant. Transpiration is the process by which water evaporates from the leaves, which results in more water being drawn up from the roots.

Plant Respiration and Photosynthesis Formula

- Respiration: Oxygen + Water -> Carbon dioxide + Water + Heat energy
- Photosynthesis: Carbon dioxide + Water + Light Energy -> Oxygen + Glucose

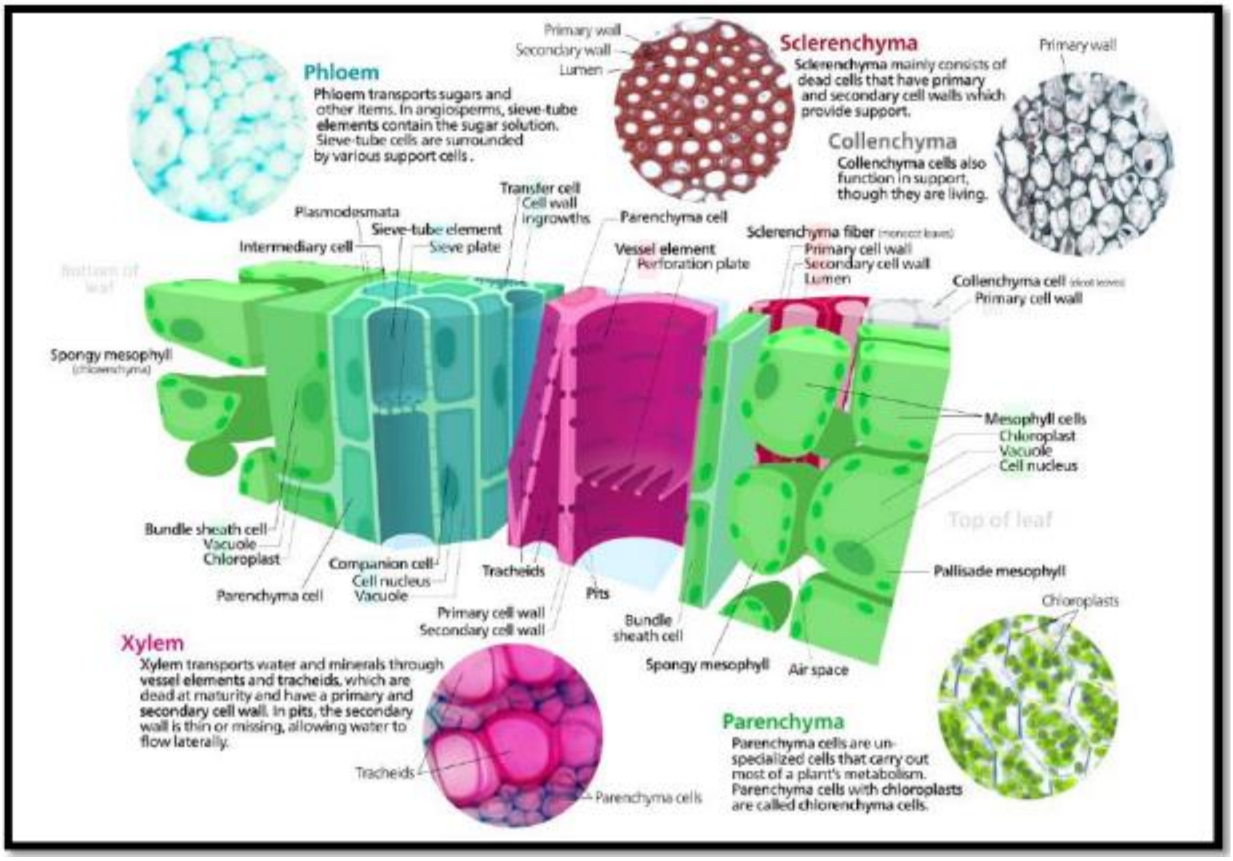

Figure B.1: Plant Tissues