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Indoor vertical hydroponic farming unit

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Abstract : *As the world population is also growing there is a large demand to find more resilient way of farming and growing. The aim of this project is to assess the environmental performance of employing residual material flows for vertical and hydroponic farming in urban environments in order to support more circular, resilient, and sustainable urban food supply. We can achieve this by using a technique called as hydroponics.*
In this process the roots of the plants are suspended in mineral nutrients solutions which provide the initial boost for the growth. This system has different sensors which will control the respective parameters for the adequate growth of the plants. Not only do plants grow without soil, they often grow a lot better with their roots immersed in water instead. Various studies suggest that important aspects for the vertical and hydroponic system include the proper selection of medium, pots & availability of electricity. Through this way, this technique will provide a better way for sustainable growth.
Keywords *- Hydroponic farming, Vertical farming, Nutrient solutions, Resilient farming, Sustainable growth.*

I. INTRODUCTION

The purpose of the project is to expand and improve the utilization of Vertical farming along with Hydroponics as so as to create an environmentally independent system for indoor plant growth. Hydroponics is not any machine, but rather it is a technique to grow plants without any use of soil, especially vegetables. Vertical farming is being practiced in many Countries like USA, Japan, Taiwan, South Korea, Singapore etc.

By the year 2050, nearly 80% of the earth's population will reside in urban areas. Also, by 2050, the world's population is expected to grow to about 9.7 billion people, and feeding it will be a huge challenge. Increasing food demand due to a growing population is one of the greatest challenges of the future and vertical farming can be the answer to this challenge.

As we go towards the future there are increasing pressures from climate change, soil erosion and biodiversity loss and from consumer's changing tastes in food and concerns about how it is produced. Soil erosion is reducing the amount of land available for agriculture, and declining biodiversity affects the pollination of crops.

II. LITERATURE REVIEW

Iswanto et.al, 2020 [1] from the research we concluded that, the system can be successfully controlled automatically by Arduino, making it easier to cultivate without having to check all the time.

Michael Martin, Elvira Molin, 2019 [2] The aim of this article was to understand the environmental impacts of vertical hydroponic farming in urban environments applied to a case study vertical hydroponic farm in Stockholm, Sweden.

Shreyash Mahadev Ghatage et. al, 2019 [3] published a research journal on how vertical farming infused with hydroponics can be a viable option for small scale small size plants by growing lettuce.

Preethi Rajan et.al, 2019 [4] Published a paper on advancement in vertical farming. It covers major vertical farming considerations like crop selection, media selection, led and photosynthetic photon flux density, led and energy efficiency, carbon dioxide temperature, humidity, light source, nutrients etc.

Aisha Mehboob et.al, 2019 [5] Article shows on how electrical conductivity and ph. of nutrient solution can affect plant growth. It explains how electrical conductivity of nutrient solution can be adjusted by controlling nutrient supply to water

Kurt Benke, Bruce Tomkins, 2018 [6] published a research article in which it puts light on how agriculture land is on decline with time and other source of farming must be made available. It also showcases how some companies around the world started vertical farming projects.

Vaibhav Palande et.al , 2018 [7] Article shows how electrical are implemented in modern farming systems like Arduino microcontrollers, led, clock, and sensors like ph sensor, water level , air temperature/humidity etc. It also shows how such systems can be controlled / monitored via IOT systems.

Luechai Promratrak, 2017 [8] published a research article on how LED lighting affects the growth of crop in hydroponic systems. It has proved that LED lighting can produce the same effect as that of LED or in some cases causes better yield than produced by sunlight.

III. PROBLEM STATEMENT

One of the major problems is that we have a lot of land but not all of it suitable for farming. Only 12% of the world's land can be used for farming. Irrigated agriculture remains the largest user of water globally & accounts for 70% of fresh water usage worldwide out of the 3% available. The reality is that very little innovation has taken place in the industry as of late, nothing to indicate that food scarcity and hunger will not be an issue in the coming decades.

There is more need of organic foods due to changing customer expectations. Various health hazards are linked to the use of pesticides can lead to the development of diseases such as cancer, kidney and lung ailments.. Many factors affect the growth of plants in urban household conditions like too much or too little light or water, what soil to be used and what size of pot to use. Proper plant selection is also critical usually plants native to tropical areas are best for growing in the home because temperatures are similar.

IV. METHODOLOGY

We shall design, construct, install and execute the project wherein we shall be providing a unit of controlled environment which shall aid in the production of vegetation (home garden) with the help of hydroponic and vertical farming techniques. Automated hydroponics systems or vertical farming systems currently on the market are either very expensive or don't control all the parameters necessary for a healthy plant growth.

A vertical farm is usually installed in a big indoor facility to enhance the production and control the environment within the facility. This is usually to gain maximum profit. Our objective here is to make such an environment on a smaller scale which will be price effective, user friendly and will be able to deliver for better yields. Below is the part list of items we would require for building the unit with approximate cost of the items.

4.1 Nutrient Film Technique (NFT)

Nutrient film technique (NFT) is a circulating hydroponic growing method, which irrigates plants held in plant pots with a shallow stream of nutrient solution in growing channels. NFT is one of the most popular techniques for commercially growing leafy greens. One of the biggest advantages of NFT is the ability to grow a bunch of plants on a small reservoir.

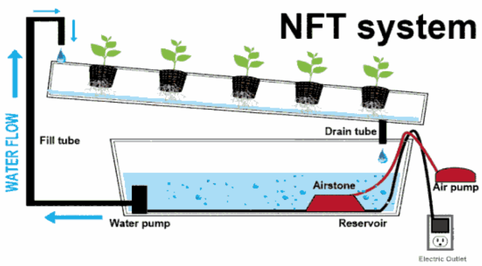

Fig 4.1: Nutrient Film Technique (NFT)

4.2 Frame

The frame will be made of wood and MS sheets to accommodate the plants and the pipe system. AutoCAD model of the frame is given below. The proposed dimensions of the unit will be as follows: the total height will be around 3 ft., 3 ft. in length and 1.5 ft. in width. Sections will be cut out on the sides to accommodate the temperature control fans on both sides of the frame. The front doors will be made of Plexiglas, clear acrylic sheet is a translucent plastic sheet with superior clarity and strength for display purpose. Two doors made of Plexiglas will be provided in the front which open through the middle, which will be provided with magnetic door holders/catcher.

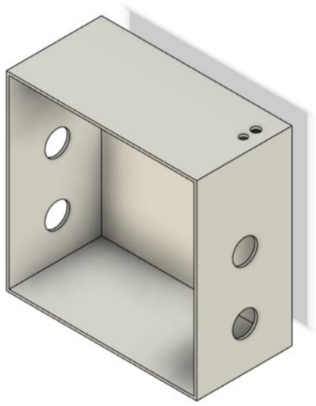

Fig 4.2: CAD model of frame.

4.3 Pipe layout

PVC pipes of 3” in diameter will be used for the piping system and to hold the plant cups. We are planning to do two horizontally layered 3” pipes in one row and to accommodate 3 such rows in the unit. One layer of the pipes will be fixed to the bottom of the unit and two more layers will be placed on right angles mounted on the back of the frame such that there is enough space between the 2 rows for adequate growth of the plants. So the average height difference between the rows in the unit will be around 1.34 foot or about 400 cm.

The length of these pipes will be same as the length of the unit and circular sections will be cut on the top of these pipes as shown in the figure to mount the plant cups. All the 3 rows of the system will be connected to a pipe system through one of the two ends and this pipe system will be of 1” pipes to supply the water though the pump in the water tank below. The 3” and 1” pipes will be connected with PVC elbow connectors. The 3 inch pipes will be mounted on the base as well as on the right angled holders with the help of C-clamps.

Fig 4.3: An example of vertical stacking of PVC pipes for Hydroponic farming.

4.4 Plant pots & Substrate

Pots and trays are used to hold the substrate and plant itself. Circular plastic pots are generally easiest to find.

Fig 4.4.1: Plant pots.

We have a choice between high risk with fast growth and low risk with slower growth. The decision of selection of plant pot is primarily based on the porosity of the substrate and the ability of the roots of a particular plant to breathe. Substrates that can be used are Stone wool, coconut coir, coco peat, coco chips, etc.

Fig 4.4.2 Substrate for Hydroponic systems.

4.5 Water pump

The major factors to consider when selecting a water pump are delivery height, required flow rate, and size of the output pipe. It is generally better to select a pump that may be slightly overpowered than a pump that could be underpowered for a particular system. It is possible to reduce flow using valves, but it is not possible to increase flow.as the size of the unit is 4ft. for NFT systems of around the height of 4 to 5 ft. It is recommended to use a pump which is able to deliver 800 L/hr. Fittings like flood and drain, tubing connectors, elbow joins, etc. are used to connect the pump to the pipe system.

4.6 Arduino UNO

The system uses Arduino UNO which is programmed using the Arduino IDE. It is a modified version of the C++ programming language. This software is responsible for controlling the various sensors, lights and fans used in the unit. It will be connected to a small LCD display for indicating the values from the sensors to the users.

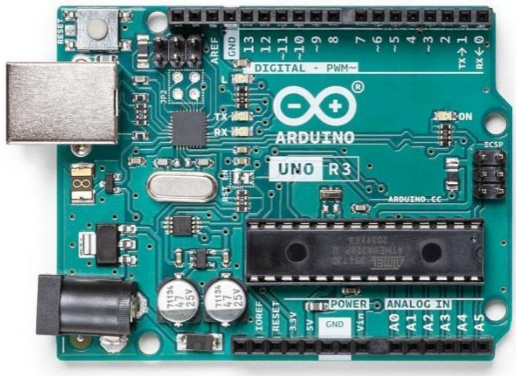

Fig 4.6 Arduino Uno Rev 3.

4.7 Sensors

The various factors affecting the growth of plants in the system is monitored by using various sensors. The system contains electrical conductivity probe, a pH sensor, a water temperature sensor, and an air temperature/humidity sensor.

4.8 Grow lights & Exhaust/intake fan

Fluorescent grow lights are probably the most beginner-friendly grow lights and are also widely available relatively cheaply compared to other grow lights. Their dimensions are 105 cm long and 2 cm wide which perfectly fit inside the 4 ft. wide unit. For climate control, depending on the climate outside of a grow tent, we may be able to control the inside climate with inline fans located on either side of the unit. Square exhaust fans of 20 x 20 cm in dimensions will be used.

Fig 4.8 Fluorescent LED grow lights.

V. CONCLUSION

The system is aimed to manufacture a fully automated unit that is cost effective and easy to operate for average user. With the use of Arduino, other open-source software, few sensors and hardware, this aim can be achieved.

It can be stated as an advantage that in such a system, there is complete control over aspects that allow a plant to thrive. Also, this system can me modified and altered so as to meet needs of variety of plants and it does not depend on outside atmosphere or environment. Not all plants can be grown in same unit as size of unit is non variable, which will be a factor that user may expect. Further this system can be worked upon to accommodate plants of various sizes as well.

When compared to other vertical farming units and hydroponic units, this system proved its importance by its automation aspect as well as size and cost for consumer needs.

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