Indoor Farming: Hydroponic Plant Growth Chamber

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***Abstract*— Hydroponic cultivation is increasingly favored globally due to its efficient resource management and high-quality food production capabilities. Traditional soil-based agriculture faces numerous challenges, including urbanization, natural disasters, climate change, and the overuse of chemicals and pesticides, all contributing to declining soil fertility. This proposed explores various hydroponic systems such as wick, ebb and flow, drip, deep water culture, and Nutrient Film Technique (NFT), detailing their operations, advantages, limitations, and the performance of different crops like tomatoes, cucumbers, peppers, and leafy greens. Hydroponics offers numerous benefits, including shorter growing periods compared to conventional methods, year-round production, reduced disease and pest incidences, and the elimination of tasks such as weeding, spraying, and watering. Notably, the NFT system has been commercially successful worldwide, achieving 70 to 90% water savings while effectively producing leafy and other vegetables. Leading countries in hydroponic technology include the Netherlands, Australia, France, England, Israel, and Canada.**

***Keywords* — Hydroponic, Nutrient Film Technique (NFT), soil-based agriculture**

I. INTRODUCTION

Certain plants and vegetables can be cultivated hydroponically—that is, without the use of soil; instead, the plants are grown in a solution made of nutrients and water-soluble solvents. Soil-free cultivation is known as hydroponic farming. Our technology creates the ideal growing environment by utilizing artificial sunshine, air flow, intelligent water supply, and intelligent drainage.

Growing plants (typically crops) without soil by utilizing mineral fertilizer solutions in an aqueous solvent is known as hydroponics, a subset of hydroculture. Only the roots of terrestrial plants may be exposed to the nutrient-rich liquid throughout growth; alternatively, the roots may receive physical support from an inert medium like perlite, gravel, or other substrates. Even in the presence of inert medium, roots have the ability to alter the pH of the rhizosphere and influence its biology through root exudates. The recycling and reuse of nutrient solutions and supporting material determines the customization and modification of hydroponic systems. Systems including wick, drip, ebb-flow, deep water culture, and nutrient film technology are frequently employed.

When a scientist called Dr. William F. Gericke of the University of California began conducting laboratory tests in plant nutrition on a commercial scale in the 1920s, the news media began to feature hydroponics. He so gave these nutriculture systems the name "hydroponic." The name literally means "water working," and it comes from the Greek words HYDRO (water) and PONOS (labor). The project aims to develop an ecologically sustainable indoor plant growth system and to increase and enhance the use of hydroponics. Instead of being planted in soil, a hydroponic system submerges a plant in a solution made of soluble nutrients and water.

When setting up most typical hydroponic systems, variables like the water solution's pH and EC are adjusted to the desired values. We created a mechanism for plant growth without the need for soil in this project. The basic procedure is to make a nutrient solution specific to the plant being grown, add it to a bed of water, and then plant the germination such that the exposed roots are in contact with the solution. The plant should develop more quickly and healthily than it would naturally if the parameters are kept at ideal levels. In most cases, human participation is necessary in hydroponic systems to regulate specific factors that enable plant growth.

Without the need of power, hydroponic farms may be cultivated inside in greenhouses or warehouses. In a single year, modern hydroponic farming systems may yield 240 times more crops than conventional agricultural methods. Additionally, 98% less water and 99% less land are used. They are known to produce vegetables with a high nutritious content, may aid in problem solving without consuming excessive amounts of space or water, and can produce veggies more quickly than standard growing techniques. This kind of agriculture is almost a given to be the main supplier of fruits and vegetables in the future.

II. RELATED WORKS

Within this document [1] Growing in popularity, urban gardening improves food security in metropolitan areas. One type of urban farming is aeroponics, in which nutrients are sprayed on plant roots that are hung in the air. An Internet of Things system for tracking and managing evapotranspiration in an aeroponic setting is described in the study. A microcontroller, a single-board computer, actuators, and sensors make up the system. The system's sensors gather information on the temperature of the water, total dissolved solids (TDS), humidity, air temperature, and pH of the plant environment. The outcome of the experiment demonstrates that our IoT system can lower evapotranspiration, which will enhance the quality of the plants.

Due to the world's growing population, it is becoming increasingly difficult to feed billions of people at the current rate of agricultural food production, which is frequently hampered by a variety of natural phenomena including droughts, floods, climate change, pests, disease vectors, and so on. In addition to the inclination toward conventional farming practices and farmers' outmoded abilities, this would result in a decrease in agricultural food output, which, according to current projections, will not be sufficient by 2050 due to population growth. The purpose of this research is to determine and investigate how IoT may be used to advance smart agriculture. Therefore, in this study, we summarize the current difficulties, prospects, Hence in this study, we synthesize the recent challenges, opportunities, and future directions for IoT-based smart agriculture, for doing more studies in this field, and for advancing human society [2]

Within this document [3] For the duration of their growth cycle, orchids are extremely delicate plants that need special care. Many varieties of orchids may be found in Indonesia's tropical forests, such as those in Kalimantan and a few woodlands on the island of Java. However, as time went on, Indonesia's ecology suffered, distinguished by a very lengthy dry season and a very short windy season. Many wild orchids in Indonesia's timberlands are threatened with extinction as a result of this problem. This issue can be resolved with a smart greenhouse. In order to allow the system to function autonomously, fuzzy-based automated control is also included. After testing the fuzzy system to determine its error percentage, the defuzzification process's error percentage came out to 1.176%, indicating that the system can function well.

This study looks at An effective and sustainable method of growing plants without soil is hydroponics. This study presents the design and development of a unique hydroponic structure with remote monitoring capability. An electrical conductivity sensor, temperature sensor, humidity sensor, acidity (pH) sensor, and ESP 8266 module make up the architecture of the suggested system. Moreover, Blynk, a cloud server enabled program, shows the hydroponic system's condition on a mobile device. By tracking the development of tomato and lettuce seeds over a two-week period, the efficacy of this arrangement has been confirmed. The data obtained indicate that the tomato and lettuce seeds grew by 6.3 cm and 3.9 cm, respectively. The suggested program might assist farmers in enhancing the monitoring efficiency of hydroponic farms [4].

Farming practices are evolving along with the world's rapid advancements in science and technology. Traditional farming has significant challenges from soil erosion and infertility; thus, soilless farming, commonly referred to as hydroponics, is gaining popularity as a solution. Hydroponics is a regulated method of growing plants without the need of soil by giving the crop the nutrients it needs. By automating the watering procedures, the hydroponic farming system may solve all of these issues and lessen the workload for the farmer. The concept behind the suggested hydroponic vertical farming system is to automate the process by using the Internet of Things (IoT) to sense and monitor critical variables including pH, TDS, temperature, and humidity. The project's unique features include email notifications for problematic circumstances, an app that shows crucial information, and the ability to automate the watering process [5].

This study looks at For the entire esparto process, nourishment is an essential requirement. It takes brilliance to develop a consumable item in such a forceful manner. India ranked second globally in terms of achieving the results of agriculture. India is a nation surrounded by agriculture, with the majority of its people working in this field. For their growth, plants need vital nutrients, which they obtain from the soil. A variety of nutrients, such as calcium, magnesium, potassium, nitrogen, and phosphorus, are necessary for the healthy growth of plants. The current state of forcing plants to thrive in the absence of accessible food is difficult, and the progressive increase in water scarcity has made it possible for technology to infiltrate the plant world and help it become enlightened with little to no water management. A useful technique for growing plants without soil is hydroponics. Moreover, adding well-mixed manures to hydroponic systems improved the plants' ability to become more proficient on their own. This work elaborates on the use of several disciplines to implement hydroponics logistics aiding sensors, including the internet of things, and shows the results observed in the expansion of mint plants, which are projected to occur when fish waste is removed from fish aquariums [6].

The system may be used to alter the nutrient values as needed and is utilized in this article to record the sensor results. The focus of this study is on extending drip control to hydroponic farming through the development of an interface between software and humans that enables continuous pH and sensor monitoring, including the ability to track a plant's location using camera capture and mobile application monitoring. Big data is used to monitor and record the supply of nutritional levels. The irrigation system may be further automated with the use of this collected data [7].

According [8], a hydroponics method can help combat the various effects of climate change, fresh water scarcity, and the pressing need to meet the world's growing food demand while producing wholesome, high-quality, locally grown fruits and vegetables that are fresh and residue-free. This review examines the benefits and problems of hydroponics. The focus is on the knowledge required for hydroponic farming, together with an outline of the major businesses involved and the current trends in the field.

III. PROPOSED METHODOLOGY

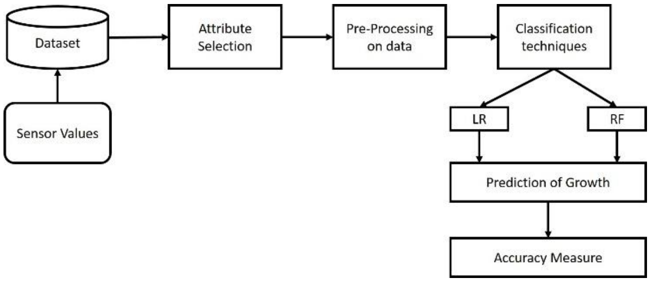


Fig. 1. Proposed Model Architecture

The nutrient solution continuously passes past the roots in a continuous-flow solution culture. Because sampling and temperature and nutrient concentration changes can be done in a huge storage tank that may potentially service thousands of plants, it is far easier to automate than the static solution culture. A well-liked variation of the nutrient film technique, or NFT, involves recirculating a very shallow stream of water that contains all the dissolved nutrients needed for plant growth past the bare roots of the plants in a watertight thick root mat that forms in the channel bottom and has an upper surface that is in the air but still moist. Following this, the roots of the plants receive a enough amount of oxygen.

Flow rates for each gully should, in general, be one liter per minute. Rates may be half of this during planning, and the highest limit of 2L/min seems to be the maximum. Excessive flow rates are frequently linked to issues related to nutrition. When channels are longer than 12 meters, numerous crops have been shown to grow at reduced rates. Studies show that even while the oxygen level has been sufficient, the gully's whole length may be losing nitrogen. Consequently, the channel's length shouldn't be greater than ten to fifteen meters. If it isn't feasible, you can still stop the growth declines by adding another fertilizer supply halfway down the gully and making sure that each outlet has the same flow rate.

A. *ML Module for Prediction*

Module 1: Dataset Training

- **Functionality:** A training dataset is a collection of instances that are used to fit the parameters and aid in the learning process. The process of methodically obtaining and measuring data on certain variables is known as data collection. A formal data collection method is necessary to guarantee that the data is precise and well-defined, which is necessary for the validity of judgments based on the data. The essential data for mariculture is the same data needed for the data on water quality.
- **Input:** Datasets containing activity data, and other water quality data.
- **Output:** Train the Machine

Module 2: Data Pre-processing

- **Functionality:** The following are all included in the preprocessing of genetic data:
  - Data Conversion:
  - Normalization entails scaling the data to a predetermined range.
  - Aggregation: giving each gene a probabilistic value.
  - Construction: adding or changing genes based on inferences from the current genes
- **Input:** Datasets
- **Output:** looking for the lowest dimensions space that will best capture the information. deleting information from the genome dataset that is not useful. Using a little dataset, sampling can make the categorization process simpler.

Module 3: Data Synthesization

- **Functionality:** To exclude features that weren't important, the gathered data were combined. For instance, the ID column was eliminated because it was deemed irrelevant for creating a prediction model. List-wise deletion was used to manage null values, meaning that an observation was eliminated if it had one or more missing values. The ML technique was then applied to extract superfluous features from the dataset.
- **Input:** Pre-processed Data
- **Output:** Labelled Data

Module 4: Prediction

- **Functionality:** It is possible to predict the test data using the classified dataset (training dataset). And with their related probabilities, the positive and negative predictions are obtained. In order to produce predictions about mariculture, algorithms were created and their precision evaluated. following the achievement of outcomes from different supervised learning models, such as linear.
- **Input:** Data Input from hardware modules to Algorithms
- **Output:** Prediction and Classification

IV. RESULTS AND DISCUSSIONS

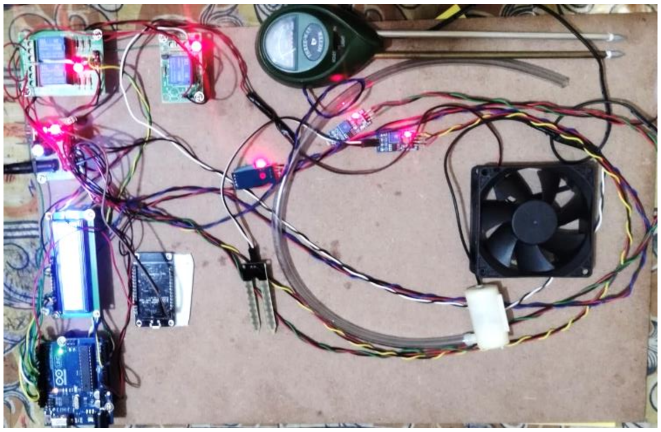
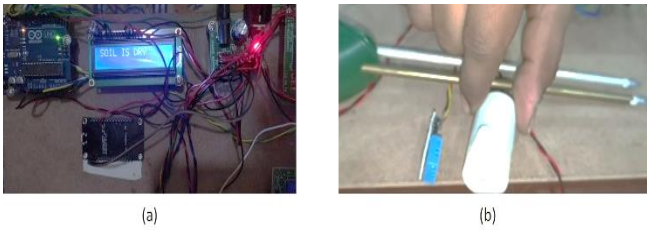


Fig 2. Proposed System Hardware Model

As seen in the above figure 2 (a), it shows the proposed system hardware model which consists of Arduino UNO, LCD, Submersible pump, Soil moisture sensor and LED light and LDR. Figure 2 (b) shows the project title display once the model is turned ON.



(a) (b)

Fig 3. Soil Moisture Sensor Level (a) Motor ON (b)

Figure 3 (a) describes where the soil is dry state during which the motor turns ON and activates the water for the plants (b).

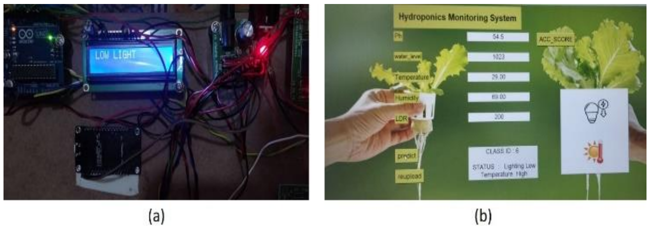


Fig 4. LDR state update

Initially when the LDR is sensing the sunlight the LCD displays Normal light state. When the light is low, the same is updated on the cloud and displays the temperature level and low light. While the light on the model switches ON.

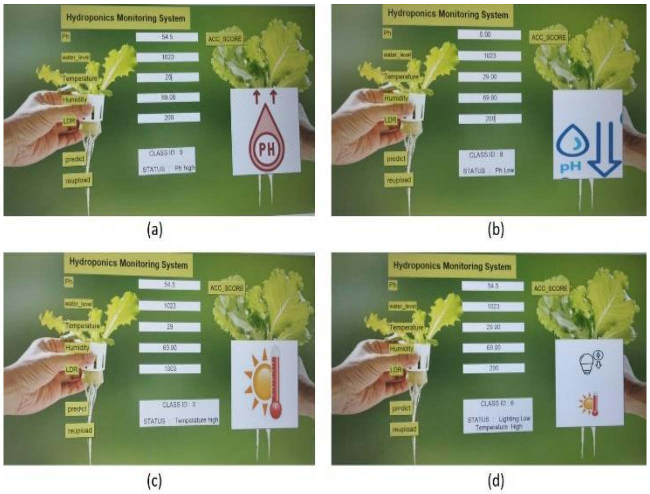


Fig 5. Other sensors updates with its states

Fig 5. Shows the Ph levels fluctuations high and low (a0 and (b). (c) Displays the temperature level being high. And (d) is the state of low sunlight and high temperature level.

V. CONCLUSION

A hopeful answer to the increasing problems that conventional soil-based agriculture is facing is hydroponic farming. Hydroponics is a feasible option that tackles problems including urbanization, natural catastrophes, climate change, and soil deterioration from chemical usage because of its effective resource management and ability to produce high-quality food. This examination of several hydroponic systems—wick, drip, ebb and flow, deep water culture, and the Nutrient Film Technique (NFT)—highlights their working principles, advantages, and disadvantages as well as how well they cultivate crops like leafy greens, tomatoes, cucumbers, and peppers.

Reduced growth times, year-round output, lower disease and insect incidence, and the removal of labor-intensive chores like weeding, spraying, and watering are just a few of the many benefits of hydroponics. Of these methods, the NFT approach is the most successful commercially due to its significant water savings (70–90%) and is especially useful for producing green vegetables. Leading nations in hydroponic technology, like the Netherlands, Australia, France, England, Israel, and Canada, show how scalable and globally applicable hydroponics can be. Hydroponic agriculture is expected to play a significant part in sustainable and effective agricultural practices globally as these technologies continue to advance and proliferate.

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