DESIGN AND DEVELOPMENT OF HYDROPONIC FARMING SYSTEM

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Abstract
This paper is a explains the concept of the agricultural science of hydroponic farming to address the challenges of food needs. By lessening the use of water and chemicals, it promotes organic farming. Also, it does not need soil, so it can be done regardless of area or fertility of soil. In this paper, we have used Nutrient Film Technique (NFT) to keep control over crop growth. Due to flowing nutrient solution, we need 90 percent less water. It is not dependent on soil degradation and pollution. We have used IoT to automate the system. We have used the ESP8266 microcontroller with the DHT11 sensor. This enables data-based decision-making for crop development. However, it does leave a carbon footprint because of power consumption but can be handled using solar energy in the future. Hydroponic systems are viewed as the future of farming, with future scopes in metro cities. It provides all-season food production. Using eco-friendly substances like coco peat shows its harmless for nature. It is the technology of Agriculture 4.0.

Keywords: *Hydroponics, Arduino, Automation, Sensors, Smart Farming, Iot, Sustainable Agriculture, Soil-Less Cultivation*

I. Introduction

The population of the world is 828 crore and will reach up to 990 crore by 2050. That means the population is adding 17.2 percent. According to it, we need to increase food production too. A population is increasing, and civic areas are also adding, making soil-based farming delicate [1]. Old agriculture techniques involve plants in soil, and hydroponics allows crops to absorb nutrients directly from nutrient water. It'll support original food systems and ameliorate social and profitable conditions [2]. Hydroponics was acclimated from ancient societies and vulgarized in the 20th century. It gives control over water and chemical use [3]. With the increasing need for food, the use of technology in farming is a must-have. So, hydroponics eliminates soil reliance and reduces the use of water by 90 percent [4].

Hydroponics is gaining popularity due to its effectiveness, growing crops out of season, and low water use. Demand for organic farming is in demand, so we don't have to use numerous chemicals [5]. Recent events like COVID-19 put food products in peril; hydroponics will allow us to produce food in similar situations [6]. Originally, non-biodegradable substances like rockwool and perlite were used, but because they cause pollution, exploration has increased to identify sustainable, biodegradable results similar to coconut coir and peat moss [7]. With global warming and climate conditions worsening, we're facing soil fertility issues, so to solve this issue, we can use the hydroponic system to produce higher yields [8].

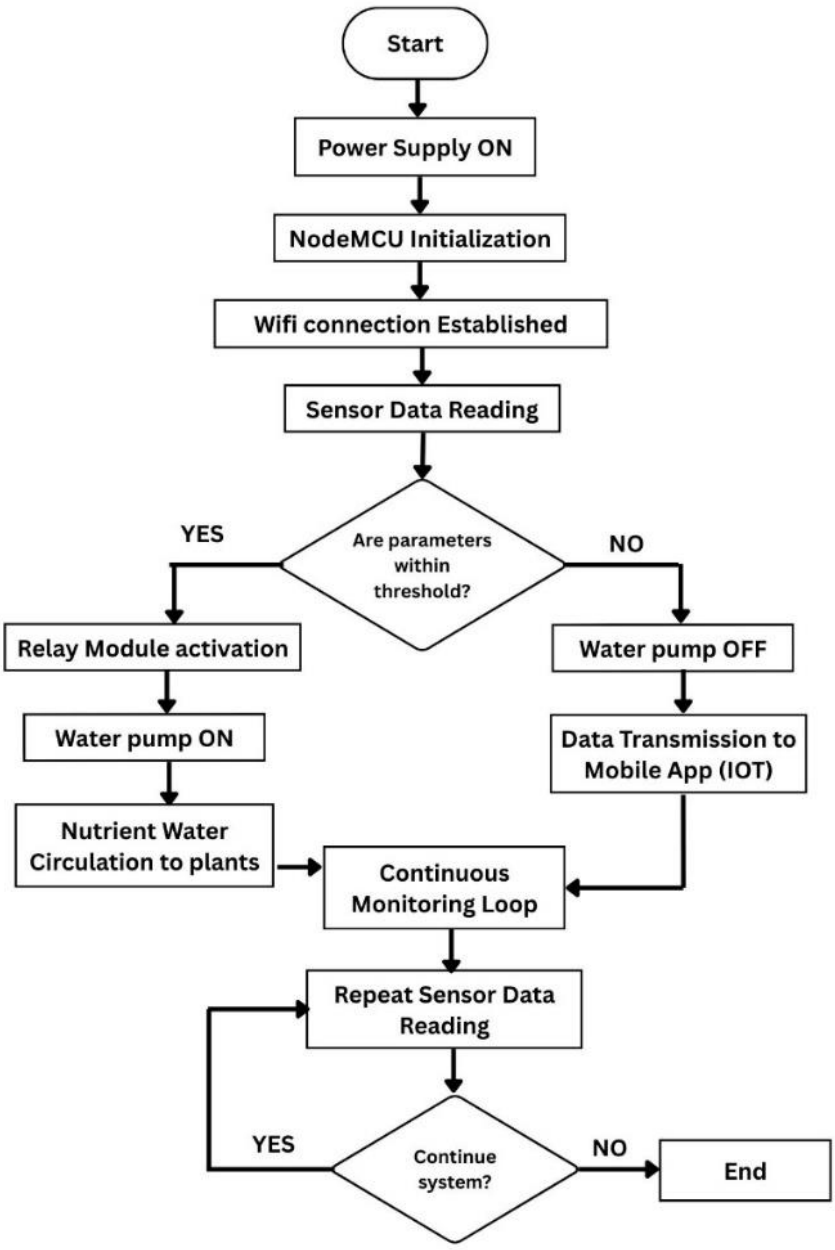
II. Literature Review

Sr. No.	Research Papers	Methodology Used	Conclusion
1	Emily Hon Tshin Yapp "Urban farming: Challenges of hydroponic & vertical farming" 2025	Analysis of challenges in metropolitan hydroponic farming systems	An Innovative Approach to Urban Agriculture The sources conclude that hydroponics is a promising approach to agriculture that offers several potential benefits, including increased crop yields, reduced water usage, and year-round production
2	Olasehinde "Biodegradable Growth Media Alternatives" 2025	Evaluation of coconut coir, peat moss and biochar	It is a viable option for areas with limited land or water; further research is required to improve accessibility and affordability for small-scale farmers
3	Aline Banboukian, Yongsheng Chen "Controlled Environment Hydroponic Farming" 2025	Life cycle study of lettuce production	Hydroponic farming is a viable and effective soilless solution for creating a productive agricultural environment while providing benefits like water conservation and precise nutrient control.
4	C. S. Deshpande "Hydroponics Sustainable Farming" 2025	Environmental performance comparison	The system is economically viable when aligned with sustainable practices like solar power and rainwater harvesting.
5	Yoeurn Bunyuth, Serey Mardy "Overview of Hydroponic Systems" 2024	Analysis of opportunities and risks	This review concludes that hydroponics has undergone a transformative journey from traditional methods to a highly efficient science.
6	Umesh Thapa et al. "Advancements in Hydroponic Systems" 2024	In-depth educational examination	It is presented as a pivotal solution for food production under resource constraints, with future growth depending on crop optimization and system scalability to meet global challenges like climate change.
7	Tarun Kumar Patel "Growing Beyond Soil" 2024	Study of hydroponics with IoT integration	Use of IoT & eco-friendly resources The Future of Farming with Hydroponics The paper concludes that hydroponics offers compelling benefits for modern agriculture, especially through innovative techniques like vertical farming and integrated pest management.
8	Vyshnavi et al. "Study on Hydroponic Farming" 2023	Study of hydroponic system styles	The research concludes that hydroponics is a highly efficient and innovative method that provides greater control over nutrient uptake and environmental conditions, resulting in higher yields.
9	D. Dutta et al. "Optimizing Plant Growth through Hydroponics" 2023	Study of sustainable production methods	A Review Hydroponics is an essential resource-management tool that allows for higher yields and the ability to grow crops where soil is unsuitable.
10	Aarati Ghimire et al. "Hydroponics in Urban Agriculture" 2023	Study of urban performance	The advances in urban farming in Malaysia reflect a significant agricultural evolution, yet practitioners face five specific challenges: regulatory limits, financial constraints, operational limits, environmental factors, and volatile market dynamics.

III. Methodology

The existing system has no integration with IoT. Still, this proposed system includes the use of an Arduino-based EP8266 microcontroller and a DHT11 sensor to measure temperature and moisture. The microcontroller is programmed using Arduino IDE using Python programming. The system compares the threshold values and real-time values for changes. It has a 4CH relay module, which is used substantially to control the water pump. The pump is turned ON to continue the flow of nutrients water once the conditions are met. All data is stored in real-time in the Blynk web dashboard. The system continuously monitors the environmental conditions. By integrating these sensors, the system enables plant growth in all seasons, increases effectiveness, and encourages sustainable farming.

The working of the system is as follows: first, the system receives power, and NodeMCU is initialized. With it, a Wi-Fi connection is established. After that, the decision sense is enforced. Sensors are used by the system to measure conditions, which are then compared against threshold levels. If the condition is met, the relay is activated and the nutrient solution is circulated. But if the condition isn't met, it keeps the pump off, and data is sent to the Blynk cloud, which is based on the Internet of Things. It keeps track of the system constantly and stops when the power is turned OFF.



IV. Conclusion

The main conclusion is that it is a soilless farming method. It does not need favorable environmental conditions. It saves water by 90 percent. It provides higher yields in shorter period of time. Also, it produces crop in all seasons. It is the mixture of IoT. It reduces physical work by automation. It enables smart farming. Also, it reduces the use of chemicals promoting organic farming. Its only drawback is it is now powered by electricity but we can overcome it by using solar energy in the future, It has the use of biodegradable medium like cocopeat, making it eco-friendly.

By considering population increase, hydroponics is perfect solution for ensuring food safety. It is used in vertical farming to utilize space in urban areas. It is also used in some desert areas. It is used in industries for study and research purposes. Commonly uses are in schools, colleges, restaurants, buildings, in house farming, etc. So in conclusion, this system has commercial as well as IPR potential.

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