I. Methodology

A. Working of the system

One way to take hydroponics to the next level is by implementing advanced automation systems that allow for self-sustaining agriculture. These systems use controller and sensor like LDR sensor, Water level sensor, Vibration sensor, DHT11 sensor, and other technologies to monitor and control growing conditions. By automating these devices, it's possible to create an efficient and highly productive DWC hydroponic system.

Automating a DWC (Deep Water Culture) hydroponic system can significantly increase its efficiency and productivity. Incorporating devices such as a UV light, fan, nutrient-rich water pump, and air pump can provide plants with the ideal growing conditions for optimal growth. A UV light can be used to prevent the growth of algae and other harmful microorganisms in the nutrient solution. A fan can help regulate the temperature and humidity levels in the growing area, which is crucial for plant growth. The nutrient-rich water pump and air pump can provide the plants with the necessary nutrients and oxygen.

B. **Block Diagram**

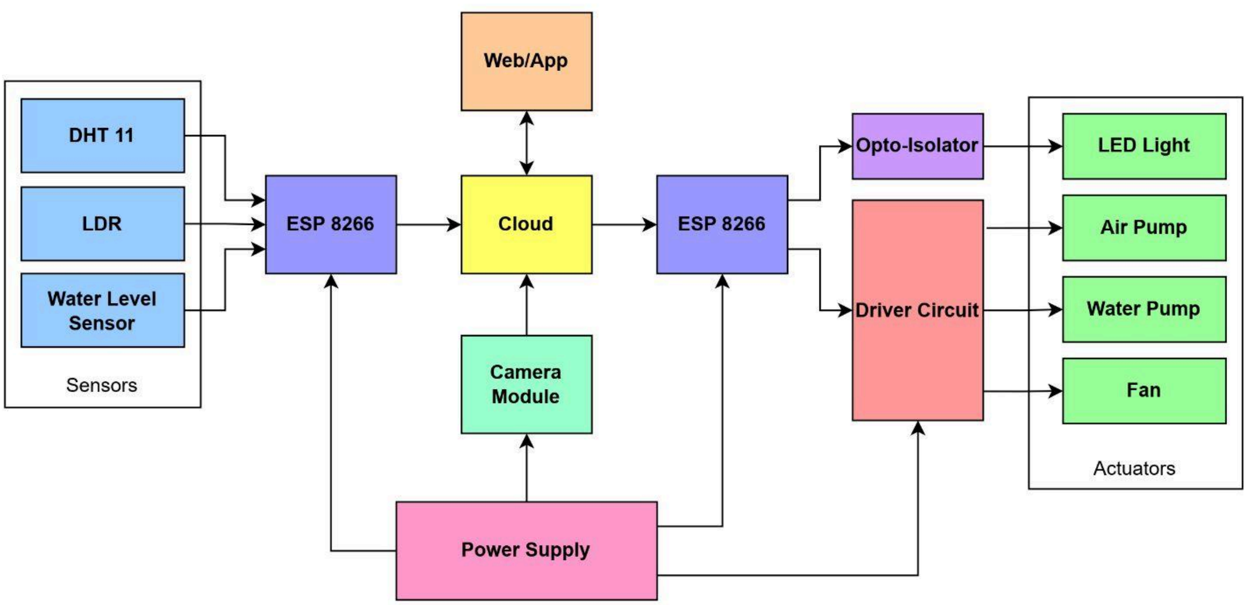


Fig. 4.1: Block Diagram of the System

Working of the system

The hydroponic system functions through a series of interconnected blocks, each playing a crucial role in maintaining optimal conditions for plant growth. The Sensors Block incorporates various sensors essential for monitoring environmental parameters. The Water Level Sensor ensures that the water level within the hydroponic setup remains within the desired range, crucial for sustaining plant growth. Simultaneously, the Temperature Sensor tracks temperature levels and humidity, ensuring an ideal atmosphere for plant development. Additionally, the Light Dependent Resistor (LDR) assesses ambient light conditions, determining the necessity for supplemental artificial lighting.

The Controller Block is centered around the Wemos D1 mini Microcontroller, a compact and cost-effective WiFi module facilitating wireless connectivity. This microcontroller serves as the central processing unit, coordinating data acquisition from sensors and issuing commands to actuators based on predefined parameters.

The IoT & Cloud Block enables communication with external networks or devices, allowing for remote monitoring and control. Utilizing MQTT and HTTP protocols, data transmission to and from the cloud facilitates real-time monitoring and management of the hydroponic system.

The Web/App Block provides users with a user-friendly interface accessible through a mobile app or web application. This interface allows remote monitoring and control of the hydroponics system, empowering users to adjust parameters as necessary for optimal plant growth.

The Actuator Block encompasses various components responsible for executing commands based on sensor readings and user inputs. The LED Light controls artificial lighting to supplement natural light, ensuring consistent illumination levels for plant growth. The Fan regulates ventilation and air circulation within the hydroponic environment, preventing stagnant air and facilitating gas exchange. The Air Pump manages aeration of the nutrient solution, essential for maintaining oxygen levels conducive to root health. Similarly, the Water Pump controls the flow of nutrient-rich water to the plant roots, ensuring proper hydration and nutrient uptake.

The Camera Block, utilizing the ESP32-CAM module, enables visual monitoring of the hydroponic setup. This compact module, equipped with a built-in camera, facilitates image capture for various IoT applications, allowing users to visually assess the condition of plants and system components.

Finally, the Power Supply Block ensures uninterrupted operation of the system by providing a steady 5V 2A power supply. This requirement can be met using standard mobile adapters or USB ports, ensuring flexibility and accessibility in power provision for the hydroponic system.

6.3 Cloud Architecture

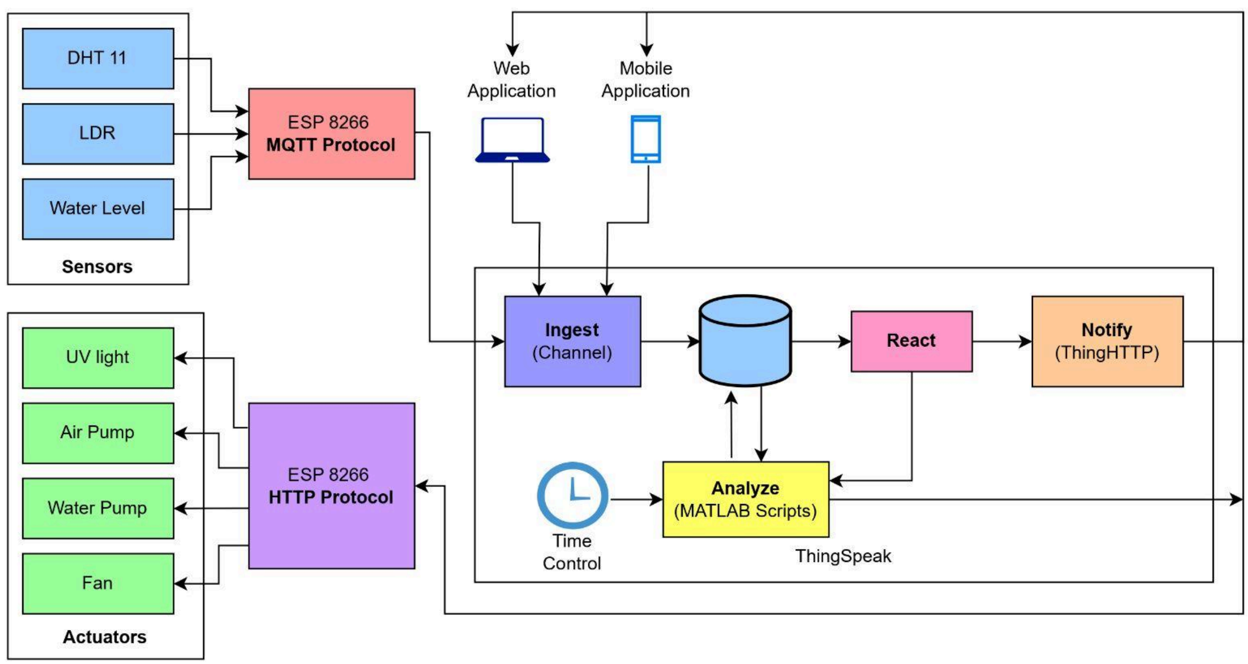


Fig. 6.3: Cloud Architecture

Working of cloud architecture

In this system, the operation begins with a network of sensors designed to monitor crucial environmental parameters. The DHT 11 sensor accurately measures temperature and humidity levels, while the Light Dependent Resistor (LDR) evaluates ambient light intensity. Additionally, the Water Level Sensor ensures constant vigilance over water levels within the hydroponic setup. These sensors collectively gather data essential for maintaining optimal conditions for plant growth.

The data collected by the sensors is transmitted to an ESP8266 module, a versatile microcontroller facilitating communication between sensors and actuators. Utilizing MQTT protocol, the ESP8266 efficiently communicates with the sensors, acquiring real-time data regarding environmental conditions.

Actuators within the system respond to the data received from sensors, executing commands to maintain desired conditions. The UV Light, for instance, regulates UV exposure, critical for plant development. The Air Pump manages air circulation, ensuring adequate ventilation within the hydroponic environment. Similarly, the Water Pump regulates the flow of nutrient-rich water to plant roots, while the Fan controls cooling mechanisms to prevent overheating.

The ESP8266 module, acting as the central hub of the system, not only communicates with sensors but also interfaces with actuators via HTTP protocol. This bidirectional communication ensures seamless coordination between data acquisition and execution of commands, ensuring that environmental parameters are constantly adjusted to meet predefined thresholds.

Data from the sensors is ingested into a channel, which serves as a conduit for transmitting data to external platforms for further processing. ThingSpeak platform, known for its versatility in IoT applications, serves as a hub for real-time data processing. Through reactive mechanisms, notifications, and sophisticated analysis conducted by MATLAB scripts, the ThingSpeak platform enables proactive management of the hydroponic system, responding to fluctuations in environmental conditions and optimizing plant growth parameters.

Finally, users can access the system through web and mobile applications, providing a user-friendly interface for monitoring and controlling the hydroponic setup remotely. This accessibility empowers users to make informed decisions regarding system adjustments based on real-time data and analysis provided by the platform.

discussion

A. *The effect of light*

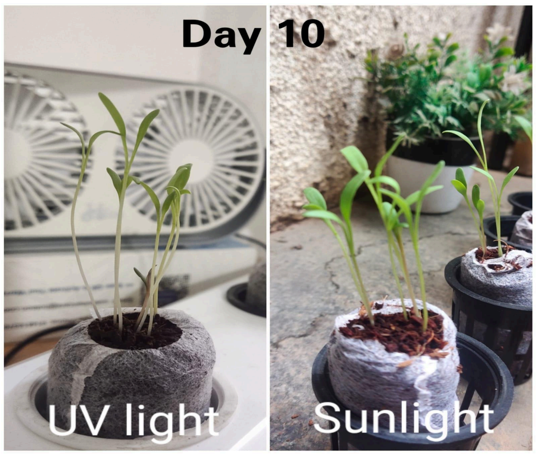


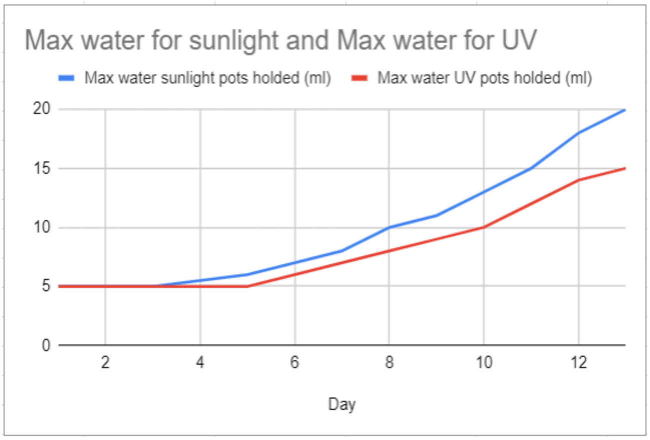
Fig 4.3: Photo of difference, taken after day 10

After physical examination, it was observed that the plants growth rate was significantly higher under UV light, which under simple measurement showed an improvement about 30-50%.

This further supports that plants kept in the hydroponics system with a controlled environment grow 30-50% faster than normal farming.

A. *Water usage*

After physical examination, we can see that at first glance, the difference is less, but as they sprout and grow they show a linear difference in water consumption, and later on stabilize over 30 percent, on average our system consumes nearly 21.2% on less water than the plants kept outside in the sunlight or soil, but that value, as difference rate stabilizes it is around 25-30%. we believe this fluctuation to environmental factors like temperatures etc..

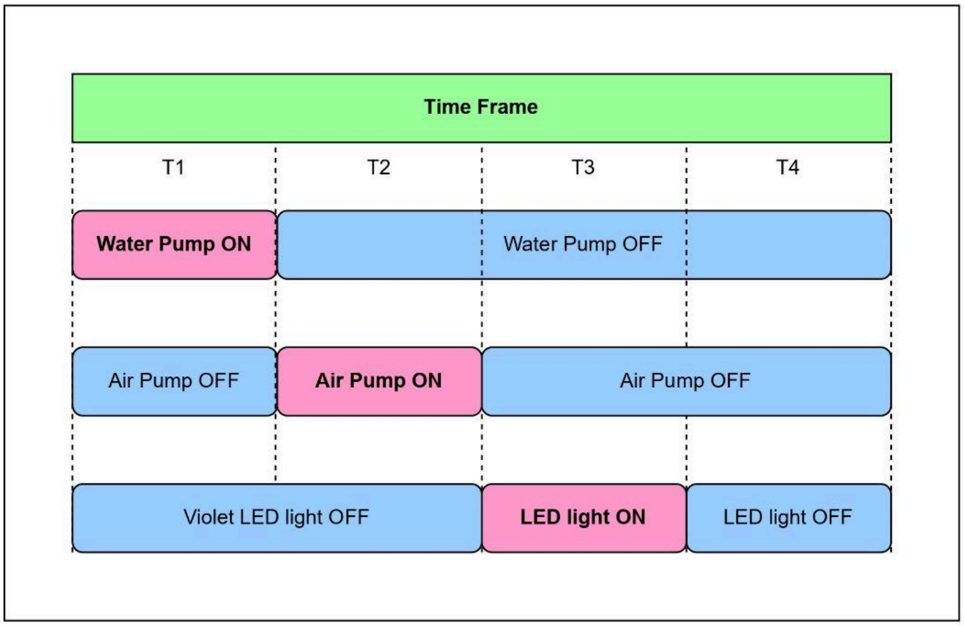


The graph clearly shows that the plants kept under the UV light consume less water day by day than the end plants kept in the sunlight. This further supports that plants kept in the hydroponics system with a controlled environment consume 10-25% less water than normal farming.Thus, it is observed that the hydroponics system consumes less water and plants grow faster in the hydroponics system than in normal farming.

A. Power optimization

The hydroponics system was designed to be as energy-efficient as possible, with all components running on DC 5V. To optimize the power, we programmed the system to use one major function at a time without changing its effectiveness. And this is completely possible as agricultural systems have no real-time operating systems demand

and even allow for tasks to be intermittent. The rough way of time allocation can be understood from the following Figure.



Hence, the system consumes 5V 2A power at a time, which was found to be sufficient to run all the components. The use of a low-power DC 5V system ensures that the energy costs are kept low, making it an affordable and viable option for indoor gardening.

A. The nutrients given to flowing plants

Water in liter: 1 liter, type: RO, Nutrient Used: Hydroponic nutrient, N K P, Concentration: N 5 - 0 – 0; K 4 - 0 – 1; P 1 - 6 – 0.

Sr. No.	Week no.	Quantity of NPK	Quantity of water used to prepare a solution	TDS range
1	0 (Germination time)	0.5 ml each	1 liter	250 – 300 PPM
2	1	0.5 ml each	1 liter	250 – 300 PPM
3	2 (Post transplantation)	1 ml each	1 liter	500 – 600 PPM
4	3	1.5 ml each	1 liter	750 – 900 PPM
5	4	2 ml each	1 liter	1000 – 1200 PPM
6	5	2.5 ml each	1 liter	1250 – 1500 PPM
7	6 (Harvest stage)	3 ml each	1 liter	1500 – 1800 PPM

Table 2 shows the nutrient doses given and the expert-recommended dosage per week for spinach. We filled the above-made solutions in the tank below the DWC reservoir, as the hydroponic system consumes water, the freshly prepared nutrient solution will enter the tank.

If any water is left over in the tank before putting newly prepared nutrients, the system removes that water and gives it to the other plants. Similarly, if the water from the tank is below level, the system refilled the water with the nutrient dosage of the same week.

B. the nutrients given to non flowering plant

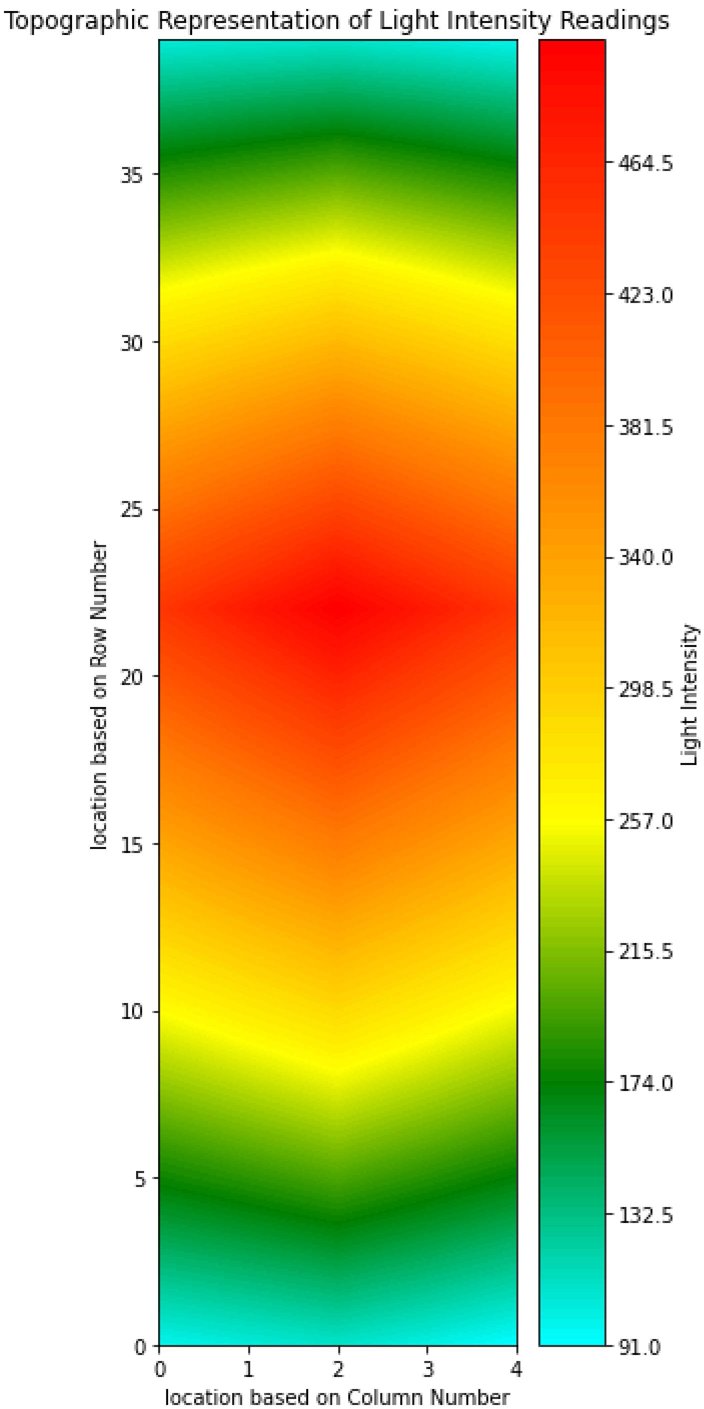
For non-flowering plants, the nutrient requirements may vary compared to flowering plants. Here's a table showing the recommended nutrient intake per week for a non-flowering plant using a hydroponic nutrient solution with the given concentrations of NPK (Nitrogen, Phosphorus, Potassium). We'll maintain a consistent water volume of 1 liter:

Week Number	Nutrient Solution (ml)	TDS (ppm)
1	10 N, 8 K, 2 P	200
2	15 N, 12 K, 3 P	300
3	20 N, 16 K, 4 P	400
4	25 N, 20 K, 5 P	500
5	30 N, 24 K, 6 P	600

This feeding schedule ensures that non-flowering plants receive adequate nutrition throughout their growth stages, promoting healthy development and robust foliage. Adjustments can be made based on plant response and specific nutrient requirements.

B. Violet light for spinach and air pump

Plants requires full and direct sunlight, hence Violent light as substitute for sunlight (why this is viable option is explained in above review) was at maximum intensity for 12 hours a day and kept off for another 12 hours. Also, we observed that the plant grows efficiently with 30 mins air pump and 1-hour intervals instead of keeping the air pump on for 24 hours a day. Following is representation of light intensity, as can be seen we have maximum reading at the center and reading becomes less as we go on away from centre, we this effects the plants growth slight as in plant closer to center grow faster, but this difference in growth in smal and in acceptable margins.



List of plants grown using our setup

The hydroponic automation system has been successful, enabling the cultivation of various plants, from flowers to herbs, effortlessly. By precisely understanding the nutrient needs during different growth stages, we can efficiently nurture multiple plant varieties in hydroponic systems. This advancement simplifies the process, making hydroponic gardening accessible to all.

Non flowering plants

1. Wheat
2. Chickpea
3. Mung Bean
4. Safflower
5. Bajra

Flowing plants

6. Marigold Scarlet
7. Marigold Orange
8. Mesembryanthemum
9. Ornamental Kale Fringed
10. Amaranthus

Non Flowing plant were grown in above compartment and flowing were grown in below compartment, plants were selected based on their close range of nutrients intake.