Controlled Environment for Aquaponic Farming with Various Grow Lights

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Abstract: **Eating well is essential for good health and well- Being, but Conventional farming practices has reduced yield over the years, as well as production of the vitamins, minerals, proteins and phytonutrients in fruits and vegetables, all while polluting food with pesticide residues.[1] In this paper we proposed work presents a Hydroponic farming; Hydroponics system means growing plants without soil with better results, especially in areas with space and environment unsuitable. The proposed design of Smart Hydroponic farm using Internet of Things technology to investigate its benefits will prove to be a green technology which will serve community towards healthy environment.**

This system aims to provide the ideal environment for plants to grow, a system where pH, water level, air temperature and relative humidity are constantly monitored. Additionally, with the use of simple mechanisms, this system provides controlled irrigation of water, and nutrient solution intake.

Keywords— Arduino, MQTT, MCU Node, Sensors.

I. INTRODUCTION

Agriculture is an important sector in India. It is indispensable for the sustenance and growth of the Indian economy. On an average, about 70% of the households and 10% of the urban population is dependent on agriculture as their source of livelihood. Due to India's geographical location, certain parts experience different climates, thus affecting each region's agricultural productivity differently. India is very dependent on its monsoon cycle for large crop yields. India's agriculture has an extensive background which goes back to at least 9 thousand years.[2]

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The objective of this study work is to design and develop a solution to overcome the above-mentioned challenges lies in making an effective use of the most modern tools and technologies in classical agriculture such as Internet of Things (IoT) to ensure optimum usage of the available resources in achieving better quality and higher yield of crops. It provides a suitable growth environment through engineering techniques under artificial facilities protection conditions. It is a combined product of biology, environment, engineering and IT. Our project is an automated indoor vertical farming system that uses RGB LEDs to provide light to the crops.

II. WHY HYDROPONIC?

In a traditional soil-based garden, a plant wastes most of its energy developing a huge root system for it has to search far and wide in the soil for its food and water. In soilless gardening, these are directly available to the plant roots. The plant gets everything it needs, in all the right proportions, at just the right time and utilizing it most efficiently. Here the plant shows its full genetic potential. They just bypass the soil and the plant's requirements are met by nutrient rich water. It is known as Hydroponic cultivation.[3]

Advantages of Hydroponics:

- Hydroponic uses 90% less water than traditional farming.
- With our system, we can grow any time of year, in any weather, anywhere on the planet.
- Because aquaponics recycles the water in the system, we can grow in droughts and areas with little water.
- Less pests to deal with since we are growing indoors.
- There's no weeding!

III. INTRODUCTION OF IOT

Internet of Things is environment where small smart devices are connected always, anytime and anywhere with each other via internet. A question is every one mind why we use IoT?, because of IoT enable all kinds of devices to connect together and share information seamlessly and number of things connected to the Internet is more than people present on earth that reason we used IoT. Generally IoT classified in two type first is outside of IoT and second is inside of IoT.

In outside of IoT types physically possible, outside of IoT are RFID (Radio Frequency Identification), WSN (Wireless Sensor Networks (for example Sensors and actuators)), Addressing schema, DSA (Data Storage and Analysis) and Visualization[4].
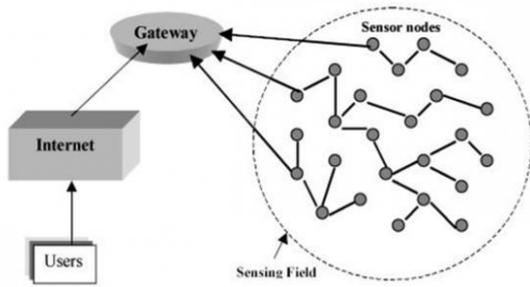
Figure 1: Sensor Network
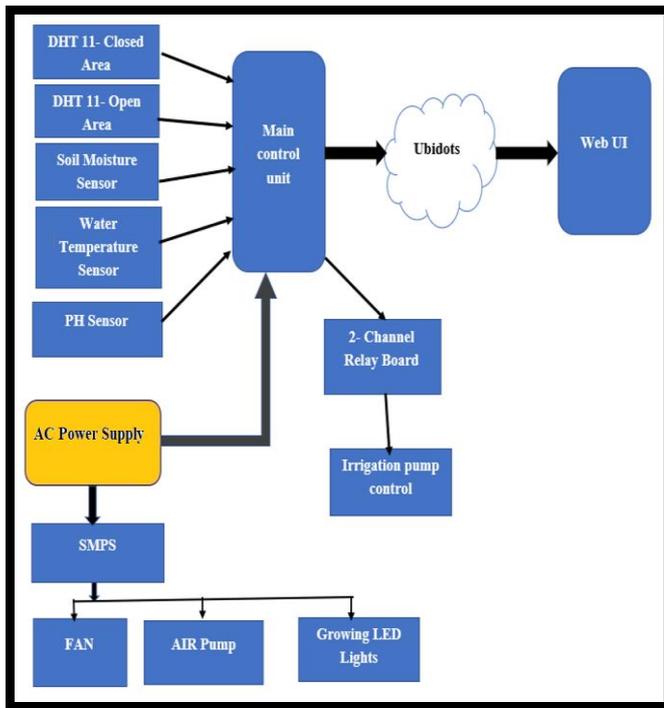
IV. PROPOSED WORK

Figure 2: System Block Diagram

The figure (2) shows block diagram consider sensor network DHT11 (Open and closed area), soil moisture sensor, water temperature sensor and pH sensor connect to the main control unit. Microcontroller collects the sensor node data and send it to the NodeMCU. NodeMCU publishes all the data through MQTT broker on Ubidots server. Microcontroller helps drive the relay board, where the flow of water is control using irrigation pump from reservoir. The SMPS is connected to the growing LED lights and air pump.

The block diagram is divided into two parts:

1) Hardware and Sensor Node 2) Website with Data base connectivity.

The below sections will explore in detail about Hardware and Sensor Node:

1) Hardware and Sensor Node:

Sensor node consist of different blocks like sensors, Arduino, Wi-Fi module. These all blocks are connected to each other which form a sensor node which transmits sensor data to Arduino and Arduino data to MQTT broker simultaneously. The sensor node explains in detail in below section:

A. Arduino UNO

This little Arduino board is modified to get information from the Server, sends information from the Water Temperature sensor, Humidity Sensor, pH Level Sensor and DHT Sensors to the Server. It is additionally used to control the fan, LEDs and water in the aquaculture framework.

Figure 3: Arduino UNO

Model	ATmega328P – 8-bit AVR family microcontroller
DC current on 3.3v	50mA
Flash memory	32KB
SRAM	2KB
EEPROM	1KB

Table 1: Specificaton of Arduino

B. DHT 11

DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process this changed resistance values and change them into digital form.[5]
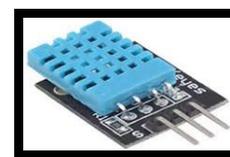

Figure 4: DHT11

C. Soil Moisture Sensor

The fork-Shaped probe with two exposed conductors, act as a variable resistor whose resistance varies with the water content in the soil. The sensor produces the output voltage according to resistance, which by measuring we can determine the moisture level. A_o (Analog Output) pin gives us an analog signal between the supply value to 0V and D_o (Digital Output) pin gives Digital output of internal comparator circuit. [6]
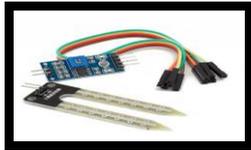
Figure 5: Soil Moisture Sensor

D. pH Sensor

One essential element of a functional hydroponics system is water quality monitoring. In order for hydroponically grown plants to get the nutrients they need, the water in a hydroponic system must be nutrient enriched. The pH levels in a hydroponic system can monitored by using pH sensor.[7]

Figure 6: pH Sensor

E. Water Temperature Sensor

Water Temperature Sensor is a 1-Meter-Long Waterproof, sealed and pre-wired digital temperature sensor probe based on DS18B20 sensor. These 1-wire digital temperature sensors are fairly precise (±0.5°C over much of the range) and can give up to 12 bits of precision from the onboard digital-to-analog converter. They work great with any microcontroller using a single digital pin, and you can even connect multiple ones to the same pin, each one has a unique 64-bit ID burned in at the factory to differentiate them. Usable with 3.0-5.0V systems.

Figure 7: DS18B20 Sensor

F. Water Pump

This is used to control the inflow of water in the system. Control of the water flow will be based on computation process from the Arduino board based on other sensors.

Figure 8: Water Pump

G. RGB LED Strips

The use of artificial lights (Super Bright LEDs) for crop Hydroponics. To compare the growth of plants grown in natural light. The experiments are carried out in a closed dark enclosure, the control of the lights (LEDs) is ON and OFF for the plants.[8]

LED lights are used to grow plants. Hydroponics is tubes ran the length of light waves that we want. In this case, we will choose the length of light waves at 430-460nm and 630-660nm estimated that due to the length of the light wave is ideal for the photosynthesis of plants and also help in the growth of more trees.

Figure 9: RGB LED Strip

H. Cooling Fan

Indoor growers typically require an exhaust fan capable of exchanging the volume of air in the room within five minutes.

Figure 10: Cooling Fan

I. NodeMCU

The NodeMCU ESP8266 development board comes with the ESP-12E module containing ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. Node MCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects.

NodeMCU can be powered using Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface.[9]

Figure 11: NodeMCU

Model	NodeMCU ESP8266
Microcontroller	Tensilica 32-bit RISC CPU Xtensa LX106
Operating Voltage	3.3V
Input Voltage	7-12V
Digital I/O Pins (DIO)	16
Analog Input Pins (ADC)	1
Clock Speed	80 MHz
I2Cs	1
Flash Memory	4 MB
SRAM	64 KB

Table 2: Specification of NodeMCU ESP8266

2) Website with Data base connectivity

a. Introduction Ubidots

Ubidots is an IoT Platform empowering innovators and industries to prototype and scale IoT projects to production. In this project we Used the Ubidots platform to send data to the cloud from any Internet-enabled device.

b. Steps for Connect a NodeMCU to UBIDOTS over MQTT

- Setting up the Arduino IDE
- Sending (PUBLISH) Data to Ubidots
- Receiving (SUBSCRIBE) Data from Ubidots

- *Setting up the Arduino IDE*

1. Install the ESP8266 platform using the preconfigured Arduino Board Manager.
2. With the ESP8266 platform installed, to select your board from the Arduino IDE, select Tools > Board "NodeMCU 1.0(ESP12E module)".
3. Download and install the UbidotsMQTTESP8266 library.

- *Sending (PUBLISH) Data to Ubidots*

1. To publish your first value in Ubidots, open the Arduino IDE and paste the sample code.
2. Verify your code within the Arduino IDE. To do this, in the top left corner of our Arduino IDE you will see the "Check Mark" icon; press it to verify your code.
3. Upload the code into your "NodeMCU 1.0(ESP12E module)". To do this, choose the "right-arrow" icon beside the "check mark" icon.
4. To verify the connectivity of the device and the data sent, open the serial monitor by selecting the "magnifying glass" icon in the top right corner of the Arduino IDE to see the connectivity logs.
5. Confirm your data in Ubidots. Now you should see the posted data in your Ubidots account, located the device called "my-new-device".

Example: client.ubidotsPublish("my-new-device");

- *Receiving (SUBSCRIBE) Data from Ubidots*

1. To begin receiving values from Ubidots, open the Arduino IDE and paste the code for to subscribe a value from Ubidots. Once you have pasted the code, be sure to assign the SSID(WiFi Name) & Password and Ubidots TOKEN
2. Verify & Upload the code into the board following the same steps provided in the PUBLISH step above.
3. To verify the connectivity of the device and the data which is being received.
4. In the serial monitor, you will be able to see the last value received in Ubidots of the variable specified in the firmware.
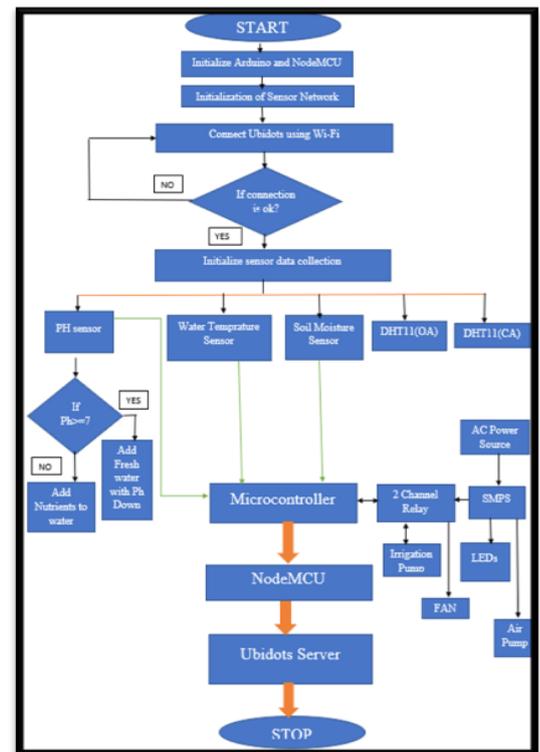
V. FLOW OF DATA

Figure 12: System Flow Chart

A. Hydroponic System Structure Design

Hydroponics refers to plant roots in direct contact with nutrient solution without substrate cultivation.

I. Hydroponics Frameworks and Pipelining

- In this Hydroponic system frame MS Steel bars are great for frame materials as they are easy to work with and have a good strength capacity.
- It is in steel material, an anti-rust which helps elongate the life span of the frame.
- The NFT channel are made by PVC rounded pipes.
- The 4"PVC pipe are used in this channel. Both ends are need to capped with a socket-type female threaded clear-out. Always used Teflon tape to avoid the leakages.

Figure 13: **Frame** and Pipelining

II. *Net Cup and Cocopeat*

- This 2 inches of Net cups allows liquid to flow freely through the roots of the plants, facilitating the uptake of nutrients.
- Cocopeat, also known as coir pith, is a spongy material that binds the coconut fiber in the coconut husk. It is a natural and organic media.

Figure 14: Net Cup and Cocopeat

III. *Crop Nutrients*

- Nutrients are one of the basics of any hydroponic system. In order for a fertilizer to be incorporated into a hydroponic system it must be soluble in water. If not, the plant cannot access it.
- The composition of the nutrients is important and there are over twenty elements that are needed for a plant to grow.
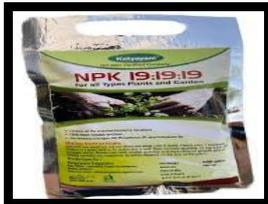

Figure 15: **Crop** Nutrients

IV. *The Reservoir*

- In this system 30-liter capacity reservoir are used to store the water. First, it will allow you to add another set of channel layers on your frame.
- Second, it keeps the water temperature cooler than surface temperatures. This is considered important when it come in Hydroponics.

B. *Seeds Germination Process:*

Steps	Procedure	Plantation Photos
Step 1	Socking of seeds and Moisturization of Seeds	
Step 2	Placing a Seeds in Grow Medium	
Step 3	Prepare Hydroponic System	
Step 4	Shifting the sprouted seeds of 1 or 2 leaves on into the Hydroponic System	
Step 5	Adding NPK in to the system with seaweeds extracts and Fish waste	
Step 6	Monitoring the plant health or plant leaves sizes	

Step 7	Adding Micronutrients	
Step 8	Plant Monitoring	
Step 9	Harvesting of Plant	
Step 10	UBIDOTS Results	

DHT11 Humidity

Soil Moisture

DS18B20 Sensor

Table 3: Seeds Germination Process

DAY	Ph	TDS	Fertilizers	Length in Full Spectrum	Length in White Light	Length in Open Air
7	6.5	50	-	1.8cm	1.6cm	1.5cm
10	6.7	62	-	2.4cm	2.1cm	2.2cm
15	6.4	120	NPK	3.8cm	3.7cm	3.7cm
18	6.3	210	NPK+ Micronutrients	6.9cm	6.8cm	6.8cm
22	6.4	250	Magnesium Sulphate	10.4cm	10.2cm	10.1cm
25	6.5	380	Calcium Nitrate	16.8cm	16.5cm	16.2cm

Table 4: Comparison of Plant Grow

VI. CONCLUSION

The study tested the use of LED for lighting in the plant instead of natural light. The results were that the light from the LED can help plants grow. In this study, used First layer for white LED light, second layer of mix LED light and Third layer in sunlight. spinach grow well in controlled pH, moisture and water temperature using sensors 35-40 days. Spinach grows better in the mix LED lighting and controlled temperature. In hydroponic system creating ideal conditions of climate ensures plants receive the perfect amount of nutrients, which come in direct contact with roots. Additionally, microclimates allow for year-round growth and faster crop cycles. All of this adds up to create far higher yields than traditional farming methods. In fact, we've found that our hydroponic greenhouses can produce about 240 times the yield of other farming practices.

VII. REFERENCES

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C. Grow Lights Result

Data from Project studies of all data recorded 25 days of data were collected. Table 3 shows comparing, the data from cultivation in closed enclosure first layer white light bulb LED, Information from second layer mixed light bulb LED and third layer sun.