Aquaponics for Agriculture using IOT

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***Abstract*— Agriculture is one of the important sectors in India. Food is a basic need of every person. But traditional farming has drawbacks of being dependent on soil quality, climate conditions, chemical fertilizers and pesticides water. To overcome the problems of traditional farming problem there is one technique called Aquaponics which is combination of aquaculture and hydroponics. Aquaculture deals with growing of fish and hydroponics deals with growing of soilless plants by providing with necessary nutrients. Aquaponics system which will provide natural food for the country. It will provide fish as well as plants too for humans. As using this technique water is reused, it requires less space, user gets natural food. Aquaponics can be automatically managed and controlled by making use of IOT technology with the help of sensors like pH, temperature and humidity, dissolved solvents, water level sensors. Operating the sensors on microcontrollers like NodeMCU and Arduino UNO whose reading can be obtained on Blink application for monitoring purpose. This technique can be built indoor as well as outdoor system. Sensors reading can be further used for research purpose.**

Keywords—Aquaponics, Hydroponics, fish, IOT, farming

I. INTRODUCTION

Agriculture has provided the most of the population with natural food but nowadays the use of pesticides has been increased for fast growth of the crops because of which it has caused damage to human health and the problems related to soil also increased in the past few years[4]. Because of which we have introduced aquaponics system for the growth of the plants naturally with the help of fish extract [6]. Hydroponics is used to supply nutrient to plants without soil [8].and aquaculture is just growing of fish naturally like fish farming. Also, most of the people prefer fish in their diet so its beneficial for them too as growth of fish also takes place in this system with proper and natural care. Years before everything was natural so to bring up the same natural food, we have introduced this aquaponics system that resolves soil and natural food issues together [5]. The purpose of the contribution statement is this system is automatically getting monitor by using IOT domain. Water temperature, surrounding temperature, humidity. pH factor, total amount of dissolvent and water temperature can be monitored using sensors. Grow light and Water pump get automatically turn on-off using relays. User gets notification of all data about via message using BLYNK application [11]. Using combination of Aquaponics and IOT user will be benefited by following:

- Less water is required as water get reused. So, farmers don't have to depend on rainwater.
- Less space is required as layer wise farming is done.
- Farmers don't have to worry about soil related problem as it is soilless planting. Nutrients for plant are provided using fish extract.
- Profit percentage is increased.

This project focuses on making the agriculture soilless as well as making it feasible to use anywhere. For which we will be using all the knowledge of hydroponics and aquaponics. The aim is to make an aquaponics system that will help grow fishes and plants together indoor. The sensors are used to take certain readings which will let us know whether the system is normal or not. That will go to Blynk cloud, which will keep the readings on the cloud, then send the readings to the Blynk application on the smart phone [11]. Using the knowledge of Arduino and the cloud, we will send the data to the cloud that will display the results. Using the readings, we will be able to know the system is working properly or not. Sensors, Arduino and Cloud is used to take readings and display the readings too. This is the main paper of this research, this paper totally focuses on recent development in soilless farming, hydroponics and aquaponics making it feasible for farming at individual level or even can be used by farmers. Also, the system once automated then it will reduce most of the manual work of farming and will help in having the natural growth of plants. The system was developed taking the idea of hydroponics and aquaculture. The fish extract contains ammonia and the nutrients needed by the plants too that's why it became helpful in developing the system combining this both. The system is built keeping in mind that the fish should be grown naturally and the plants too simultaneously. The plants extract nitrogen which is needed from the fish and then it will grow naturally without any use of artificial chemicals and fertilizers. In fact, the system eliminates the use of artificial use of chemicals and other fertilizers. Information obtained from cloud is used to give accurate readings to determine the readings that affects the system. The system presented in this paper aims to highlight the soilless farming with the help of plants.

II. EXISTING SYSTEM

In today's time the world has faced many health issues because of unavailability of natural food. Also, the artificial fertilizers and chemicals are used for the fast growth of plants due to which the soil loses its original nature and it takes years to regain that back. Farmers have no alternative than to grow plants artificially with the help of chemicals and fertilizers available.

III. PROBLEM STATEMENT

Due to artificial use of fertilizers and chemicals the soil has lost its originality. The farmers have no idea or

either forced to use this for growing crops. It has become difficult too for farmers too to waive off loans with the help of crops as they are dependent on nature of soil and climatic conditions. Always this has created problem, so it is necessary to find out solution for this.

A. *Limitations*

The system is being developed humanly with the help of various components. It is possible that some components may fail to give the accurate result over the period, so it is necessary that when such failure of components fail to work then it needs to be replaced. Also, the feeding of fish needs to be on time which is not automated so it will consume small amount of time for feeding fish.

B. *Scope*

The scope of the project is in the places where soil erosion and fertility of the soil is the main problem. Also, the monetary issues of the farmers get resolved. In this way we acquire natural food by this system, also the use of pesticides and other chemicals are avoided so anyway this also keeps a proper health among the people. So, in the end we acquire natural food, good health and extra source of income with the help of this system.

C. *Review of literature*

The aquaponics system makes use of various components like pH sensor, temperature sensor, grow bed and nodeMCU [1]. The conditions of water like the pH and temperature with the help of sensors is being sent on pocketIOT app with the help of thingspeak and nodeMCU. This system is going to take fish extract as a nutrient for plant with the help of tubes and water. There is an aerator to pull out the extract with the help of water. Filter system is used to obtain extract of fish and waste materials for plants and some will be flushed off [7].

An Autonomous Aquaponics System using 6LoWPAN based WSN project focuses on making aquaponics system for growing plants and fish naturally [1]. For which we will be using all the knowledge of hydroponics system and aquaculture. The aim is to grow plants naturally with the help of fish extract. Aquaponics systems do not typically discharge or exchange water under normal operation, but instead recirculate and reuse water very effectively. The system relies on the relationship between the animals and the plants to maintain a stable aquatic environment that experience a minimum of fluctuation in ambient nutrient and oxygen levels. Plants can recover dissolved nutrients from the circulating water, meaning that less water is discharged, and the water exchange rate can be minimized. Due to artificial use of fertilizers and chemicals the soil has lost its originality. The farmers have no idea or either forced to use this for growing crops. It has become difficult too for farmers too to waive o loans with the help of crops as they are dependent on nature of soil and climatic conditions. Always this has created problem, so it is necessary to find out solution for this. Fish extract will be provided to plants with the help of necessary bacteria. This is the main paper of this research; this paper totally focuses recent development in farming by making use of hydroponics and aquaculture and making it useful for farmers as well as for the people who are interested in indoor farming and want natural food. Aquaponics installations rely in varying degrees on man-made energy, technological solutions, and environmental control to achieve re-circulation and water/ambient temperatures. However, if a system is designed with energy conservation in mind, using alternative energy and a reduced number of pumps by letting the water flow downwards as much as possible, it can be highly energy efficient. While careful design can minimize the risk, aquaponics systems can have multiple 'single points of failure' where problems such as an electrical failure or a pipe blockage can lead to a complete loss of fish stock. Aquaponics system makes use of LED lights which may be red or blue for helping the plants in photosynthesis process and helping the plants grow naturally like it takes sunlight for making its own food. The bacteria are also used for nitrification process as the plants also needs nitrogen to make its own food. So, this system can be adapted indoor too and its best way as it recycles the water too. The system makes use of fish, plants and bacteria only for the whole functioning of the system and some components will be needed to just monitor the system. In order for aquaponics systems to be financially successful and make a profit whilst also covering its operating expenses, the hydroponic plant components and fish rearing components need to almost constantly be at maximum production capacity.

An Automated Solar-Powered Aquaponics System towards Agricultural Sustainability in the Sultanate of Oman paper presents a multidisciplinary research that involves the design, construction and implementation of some modules [2].Water circulation system which integrates an aquaculture tank for growing fish with hydroponics beds for growing plants. Aquaponics control and monitoring system that uses microcontroller interfaced with sensors, actuators, I Lab View software and GSM shield to monitor and control the necessary water quality parameters and greenhouse environmental conditions for healthy fish and plant growth. Solar energy conversion system that supply power to the entire project using the concept of a renewable energy source. Cooling and heating system to keep the air and water temperature within the acceptable ranges. With this research project, fish and vegetable products are yielded in one production unit while utilizing cheaper energy source, minimal production inputs of water and fish feed, and low operational cost; thus, making it cost effective. This increase in supply of the aquaponics products generates additional income that can support the local economy. Renewable energy sources in terms of solar energy, water recycling and waste management are employed to save the environment; hence, making it environmentally sound. Furthermore, the harvested fish and vegetable products are organic and are healthy for consumption. In addition to the commercial benefits of the project, aquaponics can be used as a training aid in vocational agricultural programs and biology courses as well as for engineering students to apply their technical knowledge and skills to agriculture and fisheries sectors.

Smart Growbox is a design of a smart box equipped with various features as a supporter of environmental engineering with various sensors and actuators that serve to optimize agricultural products with the application of technology in it [3]. Smart Growbox is the work of previous writer's research

and will be developed again. In its development in is the addition of supporting features as a refinement tool. The system hardware design consists of sensors, actuators, relays, Ethernet shield. Arduino, and routers. Hardware components connected to each other to run the control and monitoring process. Temperature and humidity monitoring system is done by using Arduino microcontroller device, Ethernet Shield, FC-28 as humidity sensor on ground and DHT11 as temperature sensor. Router is used to connect Arduino Ethernet with server. The relay module acts as a control switch on/off of various actuators as a response to the sensor output. The Internet of Things, also known as the IoT abbreviation, is a concept that aims to expand the benefits of continuously connected internet connectivity. As for capabilities such as data sharing, remote control, and so on, including also in objects in the real world. For example, food, electronics, collectibles, any equipment, including living things that are all connected to local and global networks through embedded and always-on sensors. This also uses the concept of Internet of Things because the information from the value of the sensor can be accessed through smartphone applications and websites from anywhere with the Internet connection. Relative humidity is a measure of the amount of water vapor contained in the air which is usually expressed as a percentage of moisture. Humidity and temperature are very important environmental elements and must be controlled for ideal plant growth. Humidity can control the rate of transpiration and how nutrients are received by plants. Air temperature and humidity should be adjusted to the needs of plants therefore required a parameter to be able to measure the value of temperature and humidity on the aquaponics box. Temperature and humidity should not be too high and vice versa, when the humidity level is too high, the plant will form entire colonies, fungi, and moss. Similarly, the biochemical functions of plants are necessary for growth and temperature dependent survival. The optimal temperature range in which certain plant species will carry out photosynthesis at the maximum level. The soil moisture sensor is the sensor used to measure soil moisture. The working principle of the soil moisture sensor is to provide the output value of the amount of electricity as a result of the water that is between the capacitor plate of the sensor. Type of soil humidity sensor that the writer uses is fc28 soil moisture sensor.FC-28 soil moisture sensor is equipped with LM393 and potentiometer comparator, so we can perform sensitivity calibration when using digital output.Growlight LEDs are plant lights that are widely implemented on indoor plantations. Growlight LEDs can replace the spectrum of sunlight so plants can photosynthesize well. Led Grow Light with Full Spectrum is designed to be optimal in stimulating plant growth. Powered using energy-efficient SMD epistar chips.

Automatic Feeding Control for Dense Aquaculture Fish Tanks paper introduces an efficient visual signal processing system to continuously control the feeding process of fish in aquaculture tanks [12]. The aim is to improve the production profit in fish farms by controlling the amount of feed at an optimal rate. In Knowledge Based Real Time Monitoring System for Aquaculture Using IoT paper, the quality of water is monitored continuously with the help of sensors to ensure growth and survival of aquatic life. The sensed data is transferred to the aqua farmer mobile through cloud [13]. As a result, preventive measures can be taken in time to minimize the losses and increase the productivity.

IV. WORKING

Aquaponics system consists of hardware components like DHT11 , DS18b20, pH sensor, TDS Sensor, Ultrasonic Sensor, ESP8266 NodeMCU, 5V Relay,Water Pump, Arduino UNO, Wires, Breadboard, Resistors(4.7k), 3 Carters(Growbed, Fish Tank, Sump Tank), Air Bubble Stone, Bacteria(Nitrosomonos), Clay Plates, LED Strips(Red,White as growlight),Growbox, Sponge,
Fish(Koi,Tilapia),Fishfood,PlantSeeds(Cucumber,Spinach,Tomato), Pipes, Sunmica Sheet and Software Requirements are Arduino Sketch, Blynk Application.

Firstly, all 3 carters are placed one above the other in the order Sump Tank, Fish tank and Growbed. All three carters are connected with pipes in vertical manner. The sunmica sheet is placed above the last growbed with holes for growbox fitting. The plant seeds are initially kept in a sponge with some water for growing into sapling. After one week of growth of sapling, it can be kept into the growbox which is placed in last growbed. The sump tank below will have clay plates for filtering of water to some extent. The fishes in the fish tank , that is, the second tank will be fed with fish food for fish growth. Fishes will leave some extract which will settle down the tank and with help of pipes this wastewater will come into the sump tank which is having motor to circulate the water to the plants in the growbed. The sump tank will have clay plates which will help storing some amount of water.

The plants will get nutrients for its growth from fish extract water and with LED strips placed above the plants will help the plants to do photosynthesis process as well. More the water is recycled more efficient the system will be for future. The sensors are used for testing whether the system is working properly or not. The pH of the water in which fish exist can change which may be harmful for fish life. Also, the temperature of water shouldn't exceed a certain limit which is necessary to be maintained. The ultrasonic Sensor is used to check the height of water in fish tank .

Blynk app is freely available in Google Playstore which is used to show sensor readings in graphical format which makes it easy to read it[11]. Also, the TDS sensor is used to check the dissolved solvents in the fish tank and its readings is taken by the Arduino which is interfaced with Blynk App to get readings. Also, the relay is used to interface the Arduino for switching on and off automatically so that motor supplies water efficiently to the plants. DS18b20 is used to check the temperature inside the water and DHT11 is used to check the temperature outside the carter. All this sensors will be interfaced with NodeMCU to Blynk app. Also, the aquaponics system require pH of 6.8. The air bubble stone will be used to supply oxygen for the fishes.

A. Algorithm:

- Collect the information of the aquaponics system from various available sources.
- Study of all hardware components and software requirements for project from IOT point of view.
- Finding the estimated cost of components for the project.
- Designing a basic outline for implementation purpose.
- Preparing an aquaponics system:

- Gathering of all hardware components.
- Establish model of Aquaponics system.
- Interfacing of sensors, components (relay, led light, air pump, water pump, grow light etc.) with microcontroller.
- Testing of connection.
- Achieving Readings and data.
- Processing it to finding out trends.

B. Block Diagram :

The components below shown are used in functioning of the aquaponics system, also the sensors are used to handle the worst-case scenarios.

Component used are mostly the sensors for the proper functioning of the system as if there are any inappropriate conditions arising then the sensors will always give the readings for awareness.

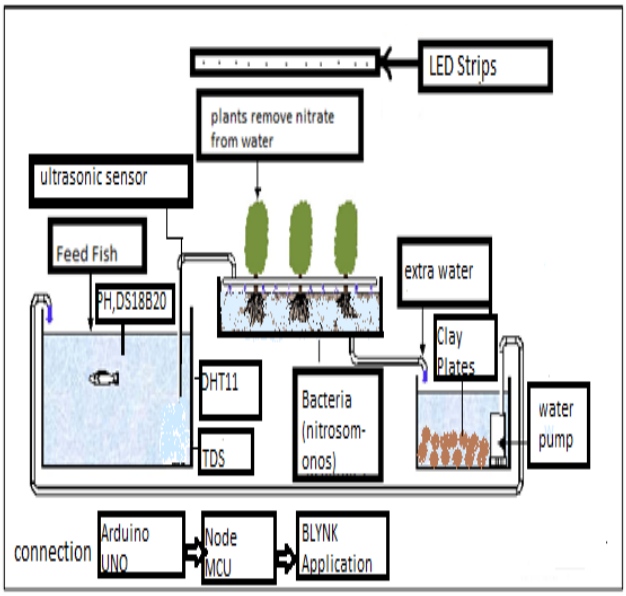

Figure 1:Aquaponics System Model

Figure Labels: Ultrasonic Sensor,Feed fish,pH,DS18b20,DHT11,TDS,plants remove nitrate from water,Bacteria(Nitrososmonos),LED Strips,Extra water, Clay Plates, Water Pump,Arduino UNO, Node MCU, BLYNK Application.

C. Data flow and sequence Diagram

A data-flow diagram (DFD) is a way of representing a flow of a data of a process or a system. The DFD also provides information about the outputs and inputs of each entity and the process itself [10]. Level 0, level 1 and Level 2 DFD for aquaponics system is shown in figure 2, figure 3 and figure 4.

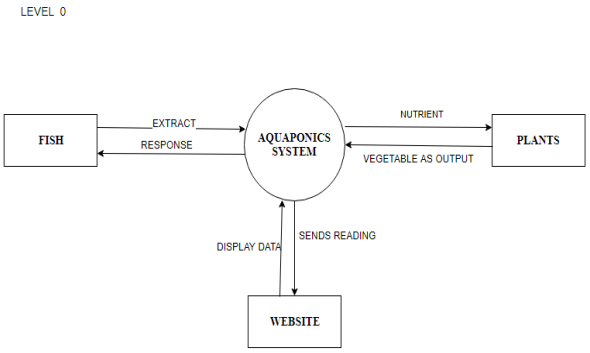

Figure 2: Level 0 DFD

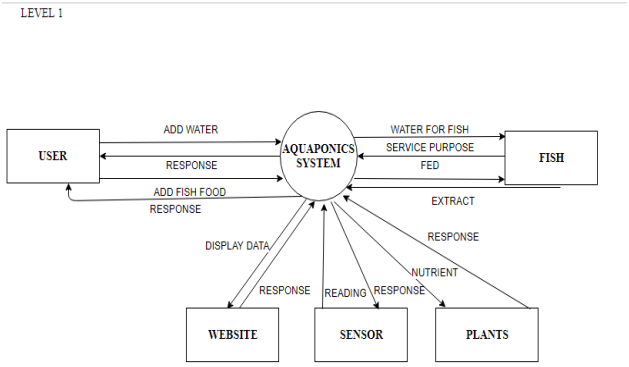

Figure 3: Level 1 DFD

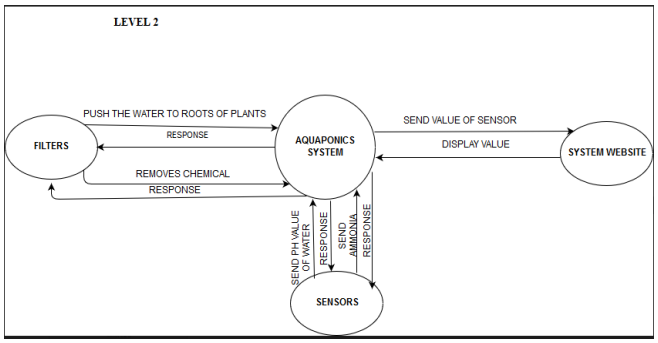

Figure 4: Level 2 DFD

A sequence diagram shows object interactions arranged in time sequence. It depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario [9]. Sequence diagrams are typically associated with use case realizations in the logical view of the system under development. Sequence diagrams are sometimes called event diagrams or event scenarios. Figure 5 shows sequence diagram for aquaponics system.

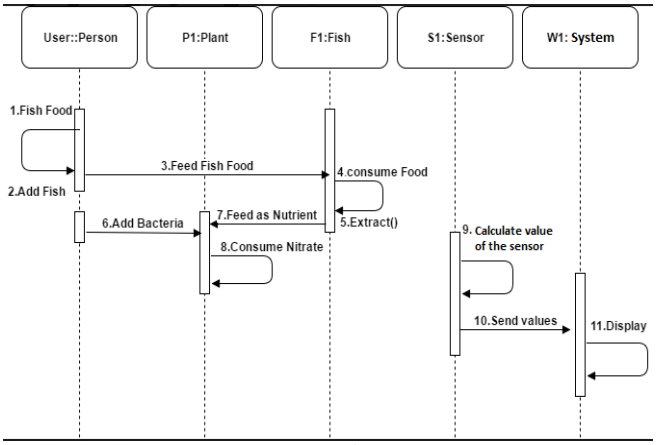

Figure 5: Sequence diagram for Aquaponics system.

D. IMPLEMENTATION

The fish is fed with fish food in second carter (fish tank) to leave extract. The fish tank has sensor like TDS to check the solvents(extract) in water. Also, the carter has pH sensor to check the pH of the water. The fishes needs pH between 6 to 7. Also, the fish extract will go into the sump tank with help of pipes in the fish tank. The sump tank consists of clay plates which will keep the water cool and will also act as filter. The fish extract in the sump tank will be sent to the first carter (Growbed) with help of motor in the sump tank. The ultrasonic sensor is kept in sump tank to determine the water level and DS18b20 sensor is placed inside the tank to determine the water temperature. Also, the plants in the first carter will absorb the fish water obtained from the sump tank and will start growing. The LED light is placed above the plants as the plants need to do photosynthesis process. The DHT11 Sensor is placed outside the carter to determine surrounding temperature and humidity.

This tank consists of clayplates which keeps the water cool and acts as filter. The tank consists of ultrasonic sensor to determine the water level and consists of DS18b20 sensor to determine the temperature of water. The tank consists of motor to draw water from sump tank to the growbed.

The fish tank consists of fishes which is fed with fish food to leave extract for plants. The fish tank consists of pH sensor to determine the pH level of water and consists of TDS Sensor to determine the dissolved solvent(extract).

The growbed consists of sunmica sheet with holes in which growbox is kept with clayplates. The plants are placed in the growbox and the LED light is placed above third carter which will keep in photosynthesis process.

Koi fish is easily available and is cheaper than other fishes. Also, this fish is less prone to diseases compared to other fishes. The fish extract is rich in Nitrates and nitrites which is required by the plants. And the extract contains magnesium, phosphates, carbohydrates, sulphates in a very small amount which is also needed for plants. A koi's diet should consist of six main building blocks: protein, fats, carbs,fiber,vitamins, and minerals. A young koi needs more protein than an older one. Koi will get their fats from wheat germ, fish meal, and corn oils in prepared foods. Avoid koi food made from rice, wheat, and corn they contain too many carbs. Instead, look for ones deriving carbohydrates from vegetables and fruit.

Spinach plant can grow fast easily. It requires nutrients which is already available in fish extract. Spinach requires soil in the pH range of 6.2 to 6.9. Spinach plants require a fertilizer that is rich in nitrogen when they are about halfway through the growing cycle. Hence instead of using artificial fertilizer we can use fish extract which is natural fertilizer.

The carters are placed one above the other and are having holes in first two carters which is fitted with pipes to height of carter. The last tank is not having any hole and is filled with water till half. It contains clayplates to keep water cool and to also filter water. And the motor is also placed in the tank to draw the water from sump tank to the first tank which is the growbed. The sump tank consists of the ultrasonic sensor to determine the height of water level. The DS18b20 sensor is also placed in sump tank to determine the water temperature. The second tank is filled with water for fishes and the fish is given fish food to leave extract. The TDS sensor is placed in second tank to determine the dissolved soluble like extract of fish and contains the pH sensor to determine the pH of the fish tank. Also,

DHT11 Sensor is placed outside the carters to determine surrounding temperature and humidity. The sensors are controlled with the help of microcontroller. The sensors like DHT11, DS18b20 and Ultrasonic are controlled with help of NodeMCU and sensors like TDS and pH is controlled with help of Arduino UNO microcontroller. The first carter contain pipe from sump tank for the supply of water. The carter is placed with sunmica sheet which is used to keep growbox by making holes. The growbox contains some clayplates and plants placed between them. The bacteria named Nitrosomonas is being sprayed for two to three times in a week for its proper growth. The fish water contains ammonia which needs to be broken down into smaller and simpler molecules by plants and nitrosomonos help in that process. Figure 6 shows implementation of aquaponics system.

Figure 6: Implementation of aquaponics system.

Figure 7 shows seeds added in sponge to grow it into sapling and shows how after 8 days seeds grows into sapling.

Figure 7: Seeds added in Sponge and Sapling after 8 days.

Sponge are given water regularly and kept into sunlight. Figure 8 shows actual implementation setup of the aquaponics system.

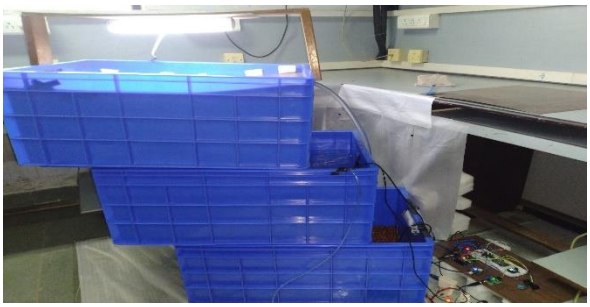

Figure 8: Implemented Aquaponics System

Figure 9 shows the internal structure of the system. All three tanks are visible over here.

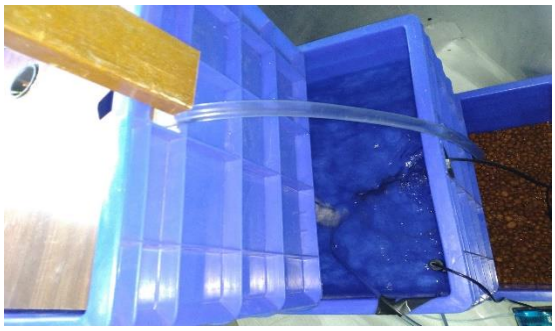

Figure 9: Internal Aquaponics System.

Interfacing of all sensors with Arduino UNO and ESP8266 NodeMCU is shown in figure 10.

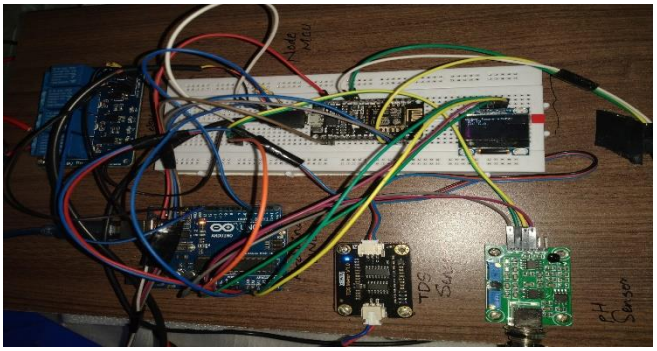

Figure 10: Circuitry of IOT sensors of Aquaponics System.

Figure 11 shows successful soilless plantation as a final output.

Figure 11: Final output.

Blynk Application data is shown in figure 12 below.

Figure 12: Data on Blynk Application.

V. CONCLUSION

This system is developed to avoid the use of artificial fertilizers and chemicals that is used to grow the crops. The farmers who face this issue of growing natural food will get solved using this system. The fish extract used here is natural nutrient for the growth of the plants. In future the farmer will make profit out of this and the loan issues might get resolved to certain extent.

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