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Building a Smart Hydroponic Farming with Aquaculture using IoT and Big data

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ABSTRACT: Recent era, agriculture is the inevitable process of all the countries in the world to improve their livelihood and economy of their society. The agricultural process is done by various classical approaches and methodologies but smart agriculture is the best among all for developing the cultivation quickly. The time is taken to get crop growth and yields are very long duration is the challenging task in smart agriculture. Though manpower and a huge amount of land are used in this system it takes plenty of time to produce the crops. To overcome the above problem soilless agriculture is introduced in popular countries for developing the crops using Rockwool. This innovative technique is used to increase the productivity within a small land and other resources required for cultivation. Hydroponics is the name of that technology plays a major role in agriculture and it helps the small-scale farmers to get benefit within a short period. This soilless agriculture technique is utilized the water resources for plant growth then will be recycled to avoid the wastage of water. To motivate this concept, Aquaculture is combined with this technique for effectively use the resources of nature. The entire system is automated using the IoT framework; further, it will be controlled and monitored through a centralized controller. Aquaculture is the concept of using fishes to grow in a box of water or a glass bed in a small place. Implementing this structure along with a smart hydroponic system on horizontal or vertical frames can reduce the work and recycling process improves the sustainability of natural resources in an agriculture field. This research work will improve the growth of the plants and fishes count effectively, similarly their economy also grown in a small place of land. The entire system is implemented with Big Data analytics framework for maintaining the details of the Smart Hydroponic-Aquaculture Farming (SHAF) systems effectively.

Keywords: Rockwool, Hydroponics, Aquaculture, Cloud storage, sub marine motor, small scale farmers, smart agriculture farming

1. INTRODUCTION

Hydroponics the new innovative technology used in the agriculture field for making soilless crop cultivation and increasing yields within a short duration. The hydroponic system is normally used in a very wast to dry area, due to the usage of water is very less and recycling with the help of this. Smart scale farmers are easily adapted to this system and it will be cultivated with short-range but more yields[1]. Normally huge areas and manpower are required to get more crops on the land but this technique overcomes that problem and given more crops and plants to a smaller area. The purpose of using hydroponics is to produce plants and vegetables without soil and small land area space [2]. For developing this need two approaches like horizontal hydroponics and vertical hydroponics are used. Both are using the same methodology but varied in their structure [3]. Horizontal used a little bit of space when compared to vertical but water usage and recycling of water concepts used in this technique is the same. Aquaculture is also a new technique that is used to grow fish farming in a smaller area and less maintenance of system work[1][4]. Both systems are monitored and controlled with a help of a centralized server with the help of an IoT framework. A submarine motor is used to circulate the water among the pipes fitted in this hydroponics and recycling of water gives the water to the fish tank continuously. The following figure 1 denotes the general structure of the hydroponics with aquaculture system and development.

Figure 1: Hydroponics with Aquaculture

2. RELATED WORKS

There is a lot of research is going on in agriculture fields for the optimization man work and increase the system work disseminate. For achieving these hydroponics are the new technology that is used in developing countries and developed countries for the appreciation of soilless agriculture. To promote this all places of the world have undergone so many researches in hydroponics especially using the IoT framework. For improving agricultural aspects IoT Framework is used sensors to monitor the activities of the crops and plants also controlled with a centralized microcontroller. All the decisions are taken by the

microcontroller unit based on the programming written on that module. It also provides control to the nutrition tank unit and recycling water unit. More number of researchers worked on optimized hydroponic with the horizontal and vertical farming system along with IoT Framework [5]. They have introduced soilless and less area agriculture system with IoT supported framework. This system will increase the economy of the small-scale farmers and improve their livelihood on village sides effectively.

Perhaps, to add additional impact to this system Aquaculture is the technique which smartly added as hybrid agriculture. All the systems reveal the same concept in a hydroponic system that is soilless and small area cultivation for improving the efficiency of the farmers during summer seasons also. In the summer season, water usage level is very low, and recycling capability in this system is used to avoid water wastages and nutrition wastages on system architecture [6]. The entire system is developed in the same area which is controlled by an IoT framework and the data generated by the sensors are stored on a cloud server located remotely using the internet. Horizontal hydroponics is used in this system to make it a simple architecture when compared with a vertical hydroponics system. Moreover, the water flow in this system is easily transferred from one pipe to other pipes without any deviation in the reaching time [7]. Nevertheless, aquaculture system fishes are grown very quick time and the energy was given from the nutrition tank and oxygen supply tank also. However a lot of hybrid systems are used in agriculture, hydroponics is the effective one for improving the farmer's cost economy and manpower utilization on a remote centralized system is the best model for all [8]. Other systems are either controlled or monitored or supply the water and nutrition to the plants whereas this Smart Hydroponics Aquaculture system provides control over all techniques involved on a single framework.

3. PROPOSED ARCHITECTURE

The proposed Smart Hydroponic -Aquaculture Farming (SHAF) architecture contains a horizontal structure in nature which contains 3 same size pipes and a fish tank with oxygen motor supply is located at the top of the frame full of Rockwool’s. The nutrition tank is also connected to this system for giving nutrition to the plants at regular intervals. A motor is connected to the water tank hub for providing water continuously to this system. The recycling process is working in this system for avoiding water wastage on the whole structure. A horizontal structure helps to improve the water flow very fast when compared with a vertical system. Moreover a lot of connecting pipes and small tubes to this structure for optimizing the water flow on all areas along with nutrition. An oxygen tank is located inside the fish tank to improve the breathing system of the fishes on the top. The following figure 2 describes the proposed architecture of the Smart Hydroponic-Aquaculture system neatly.

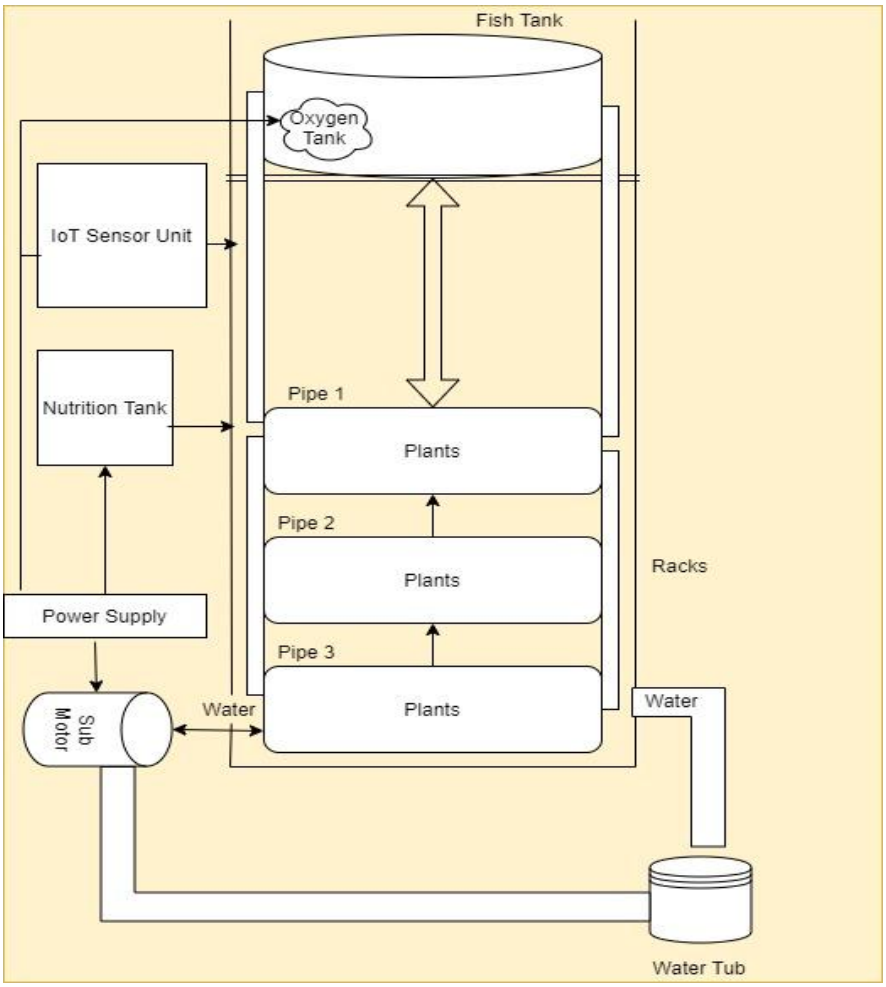

Figure 2: Proposed SHAF Architecture

4. EXPERIMENTAL SET UP

The experiment has taken on the test bed with 3 pipes and one rectangular glass fish tank along with connecting pipes and wires. All the sensors and microcontroller unit has been incorporated with power supply unit in the structure. The motor is connected at the bottom of the structure and directly connected to the water tank which supplies the water continuously. The oxygen tank is internally connected to the fish tank and provides an oxygen supply regularly. The main setup is created either in the home or open place where sunlight is needed for agriculture. Otherwise, we have to use a light source as a colored bulb for creating heat over the system. The following table 1 listed out the number of sensors and units used in this system.

Table 1: Sensors used in SHAF

S No	Equipments	Descriptions
1	Arduino	Control all the systems
2	Temperature and humidity sensor	Measure the temperature and humidity levels

4	Ultra sonic sensor	Calculate the height and width of the plant
5	Sub marine motor	Provide water to all plants
6	Nutrition tank	Provide all nutrition to the plants
7	Nodemcu	For sending data to cloud/ mobile app
8	pH sensor	For water purity level

5. RESULTS AND DISCUSSION

The test bed has created and worked this system for continuous 15 days controlled with IoT sensor units. Cloud storage is used to store the original data generated by all the sensors during processing time. Then it will use for analytics purposes and the decisions have been taken according to these results. The following table 2 taken the results from this test bed and compared them with normal hydroponics vs. smart hydroponics including aquaculture also.

Table 2: Comparison of smart hydroponics vs. Smart Hydro-aquaculture systems

Details of the Plants in pipes	Smart Hydro-Aqua culture System				General Hydro-Aqua culture System			
	First	Second	Third	Fourth	First	Second	Third	Fourth
Length(cm)	10.6	10.2	9.9	11.4	9.8	8.9	8.6	11.0
Leaf width (cm)	6.4	6.3	6.5	6.3	5.5	5.3	5.7	5.4
No of Fishes in tank	9	8	8	8	9	8	7	7
No of leaf generated	11	11	11	11	10	10	10	10

Since there are three pipes are used in this system and one fish tank which contains 9 fishes initially in the SHAF system. When IoT framework starts their work using sensors the water flow on the pipes are started and reached the 3 pipes at different timings. When it will reach the fish tank, the level of water is checked and if it is full then automatically go down to the water tub for saving water. When the first trial happens and several trials have taken. The following figure 3 denotes the water level on pipes at different trials.

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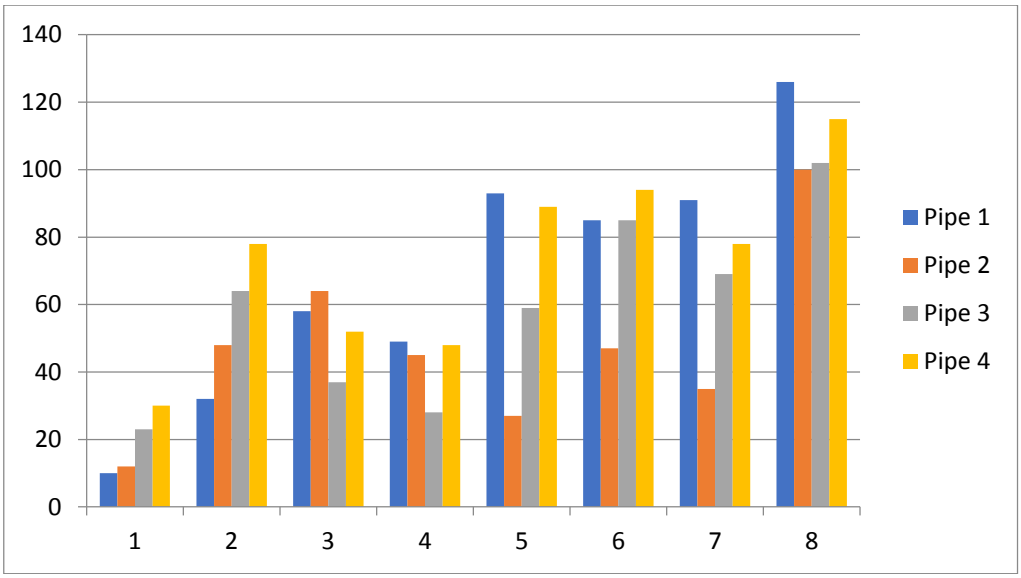

Figure 3: Water level on pipes at different trials

The water level is reached in the pipes and then it will be used for the next trial whenever required. So the amount of water filled in the pipe is not always the same. More over after the plant grow each plant is required a different level of water while compared with other plants. The following figure 4 describes the percentage of water level filled in pipes at different levels.

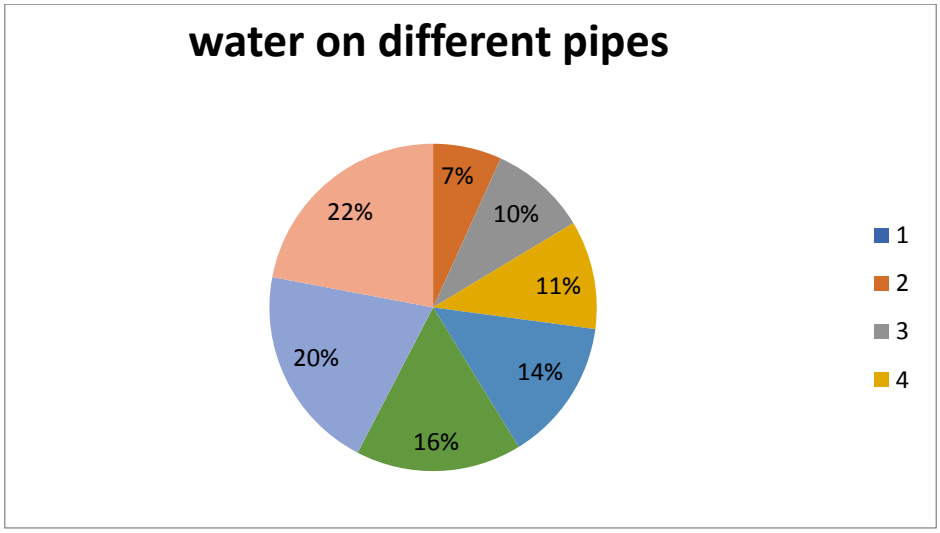

Figure 4: Water reached level on pipes at trails

The horizontal hydroponic system is used three same-level pipes on a horizontal structure, the water is reached at a different timing at each end. The motor is not continuously running when the microcontroller unit provides the control to the motor about the levels on the fish tank and pipe then only it is working. The following figure 5 describes the change in water flow at different timings on the pipes.

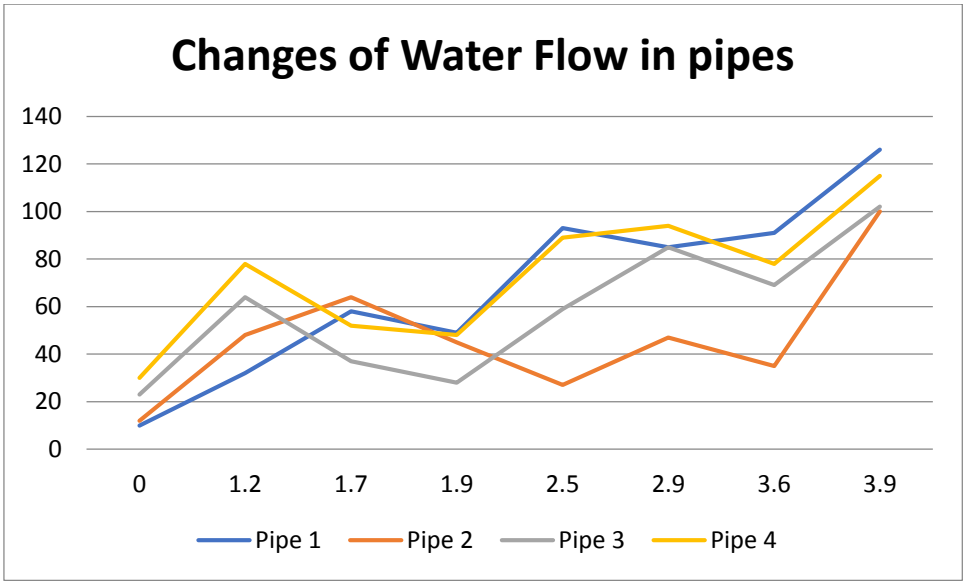

Figure 5: Water flow on pipes at different timings

The system is monitored and controlled using IoT sensors continuously, when the plant is required of water and nutrition then the microcontroller sent this notification to the motor and it will work accordingly. The following is denotes the water requirements on pipes at different days.

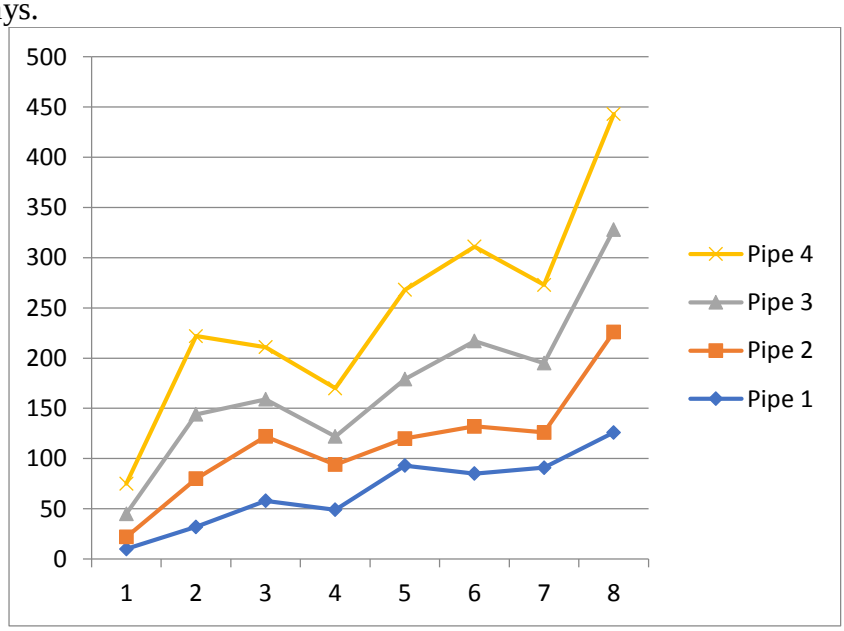

Figure 6: Water levels required on pipes at different days

6. CONCLUSION

Smart Hydroponics-Aquaculture Farming (SHAF) system is developed and experimented with the results for the first 15 days duration. From that lot of information is collected about the decision-making scenario. The first and foremost thing is the entire system is working without soil and controlled by an IoT framework that gives continuous monitoring throughout 15 days. Normally, the water usage of the plants is varied due to their growth level. With the impact of this system, manpower and area usage will be reduced and

the cultivation of vegetables and crops must be increased in the count. The growth of plants also got increased when compared with the normal hydroponics system. The SHAF system will identify the poor grow plants and provide water with nutrition to them at required percentage levels. The aquaculture unit used the water from the plants which are very pure and give a lot of nutrition to the fishes. The fishers are grown with heavy energy and their lifetime is getting increased while using the plant usage water. Because it will get purified and natural contaminants are added naturally to the water contents. Moreover cost wise the entire system is working with low-cost expenditure but will give products with high cost. The manpower and area utilized are very low and the fertilizers, nutrition are limited for the plants will increase the productivity at a higher level. Finally, the small-scale farmers have utilized this technology for improving their livelihood and cost economy within a short period of agriculture field. At the same time, they are using their lands for some other crop cultivation work, so they are getting multiple profits to improve the wealthy life.

7. FUTURE ENHANCEMENTS

SHAF system is working with small architecture in size of pipes and fish tank where it will be increased in future in order to increase the productivity. The connection between the sensors and IoT unit is limited distance for the better results and it will also improve in future. More over cloud storage used in this architecture is less volume of space where as in future it will be increased to manage the big data on IoT Framework [9-11] .The level of monitoring of all system is deal with 15 days and in future it will be for the entire cultivation period to get better productivity. Water usage is only from the small unit which is used for 3 pipes and in future the frames of hydroponics will be in a big area and minimum of 50 pipes would be used for hydroponics, 50 fishes are used for aquaculture systems. Sensors used in this system are only used to calculating temperature and humidity of the small room where as in future sensors will used for water level leakage, plant leaf health and other purposes. The entire system is made with minimum level of cost for initial level where in future level it will used for big cloud storage servers for controlling and monitoring to the maximum level with security with wireless networks [12-15].

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