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Sustainable Agriculture Using Iot And Aquaponics

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Abstract: *A system to monitor an aquaponic farm and allowing automation to utilize sustainable farming with the added benefit of real-time data. The system comprises of various sensors that communicate over the internet and provide the live status of the farm regarding various parameters and provides the user with an option to manage the farm and take actions in response to it. Since implemented over an aquaponic farm user gets all the benefits that come with it. It utilizes NodeMcu as the communicator and aggregator of sensor data which is delivered to a web server and then this data can be visualized as required. The architecture is simple and can easily be replicated to a large-scale setup. It has the potential to help farmers manage various resources like water and also get insights regarding plant health for optimum productivity. The system is capable of enabling farmers to get the most out of their efforts.*

Keywords : *Aquaponics, Automated farming, IoT, Online farming, Sustainable farming.*

I. Introduction

In this epoch where IOT is making our daily tasks easier by automating them it's become easier for us to use similar strategies to boost farming particularly using sustainable farming which is self-reliant and efficient. Traditional farming suffers from the excessive land requirement, ever-increasing manpower and constant fertilization and management of soil. To solve these issues, we propose the use of aquaponics with IoT. Aquaponics is a symbiotic system which enables aquatic life and plants to coexist. Aquatic animal waste gathers in water as a byproduct of the rearing them in a closed system or tank. The effluent wealthy water becomes high in plant nutrients, however, is harmful to the aquatic animal. Plants are grown in a grow media based on this water that utilizes the nutrient in water. The plants successively assimilate the nutrients, reducing or eliminating the toxicity of the water that was harmful to the aquatic animal. The water, now clean, is returned to the aquatic animal surroundings and also the cycle continues. There are a variety of Aquaponics plants to decide from. Aquaponic systems don't discharge or exchange water. The systems consider the natural relationship between the aquatic animals and the plants to keep the environment favorable for both. Water is added externally to interchange water loss from soaking up by the plants or vaporization into the air [1]. The freshwater fish produce Ammonia as a byproduct of their waste. A nitrifying microorganism (Nitrosamines) converts the Ammonia to nitrite. Another nitrifying microorganism (Nitro-bacteria) then converts the nitrite to Nitrate. The plants then use the Nitrate and therefore "cleans" the water for the fish. There is a variety of Aquaponics fish to decide on from.

In this paper, we propose the use of aquaponics with IoT for an automated sustainable agriculture. Aquaponics is a noteworthy subject for anyone trying to grow their own plants with the good thing about using fish for producing nutrient supply. A system may be as tiny as having one on your room bench using Carassius auratus and growing herbs to a bigger system in your yard with silver perch growing lettuces, tomatoes, herbs etc. Aquaponics system is formed from a tank containing the fish, and one or additional grow beds for vegetable production. The fish provide nutrients to the plants that are in a very grow bed and also the plants clean the water of the nutrients. Then the water travels through the tank making a recirculating system. The fish water is pumped up to the grow bed/s, using a system of pipes.

The grow bed is often packed with gravel, clay pebbles or water. The fish water feeds the plants of that there's an enormous range to decide on from to plants like tomatoes, cucumbers, lettuce and inexperienced ivied vegetables, the water then returns to the tank ideally by gravity. The water that comes back to the tank is clean and prepared to be used by the fish, then the cycle continues. Aquaponics is appropriate for the variety of fish like lungfish, Bass, Jade Perch, Golden Perch, Silver Perch, and Murray Cod if you're in Australia all of that are nice to eat as well. Genus Tilapia is that the most typical fish used in an aquaponics system outside of Australia. Thus we've established that water is recirculated through the system, and you'll add a little quantity of water to catch up on what's lost by evaporation, and transpiration by the vegetables. Thus, Aquaponics uses solely about 100% of the water needed for ancient horticulture or fish farming. Aquaponics is that the way forward for home horticulture and business food production for any country.

Aquaponics may be a balanced, self-contained ecosystem that works. No chemicals are added or for that matter are often added to the vegetable a part of the system as that will cause your fish to die. Garden pests are often eliminated by exploitation of nontoxic pest removal strategies.

Nitrification is the method that drives most aquaponic systems. Nitrogen is one in all the foremost vital plant elements, however making it available depends very closely on the flexibility of system microorganism to add gas to ammonia and nitrite that are both harmful, to produce nitrate that may be a comparatively benign type of nitrogen that's plant available [2], [3]. This method of oxidation is known as nitrification, and it serves a variety of secondary functions within the system also, including acidification of the system water.

Some of the foremost common issues with aquaponics include an increase in the temperature of the tank water, maintaining optimum pH for the plants to grow, a frequent check of ammonia content within the tank, identifying and removing the unhealthy fishes. Certain tropical fishes would need ideal temperatures for his or her growth, therefore requiring a technique to manage the temperature [4]. The pH levels within the tank drop to a pH level of 7.2 because of the characteristics of the fish wastes and plants grow in more acidic surroundings with pH levels 5.8 – 6.0. The build-up of ammonia within the system might prove fatal to the fishes and hence has to be balanced. Profits are very unlikely just in case of an outbreak of any diseases to the fish and hence wants endless observance. Therefore, any slight glitches from the threshold values of any of the parameters might be costly for the users [5]. Finally, a stable backend to keep up all the information collected to investigate and predict is also required. Therefore, we've combined along the technologies that will resolve the above issues.

II. Literature Review

R. Hussain in his paper "Control of Irrigation Automatically By Using Wireless Sensor Network," proposed in *International Journal of Soft Computing and Engineering, Volume-3, Issue-1,* March 2013 discussed about an automated precision agriculture system to promote the use of smart irrigation techniques with various modern technologies and new ideas that are integrated to construct the farm in a technical manner for precision agriculture [1].

The system is mainly relying on sensors and microcontroller. Based on the sensor output which is placed on the farm, farm parameters are measured and the output value is given to Arduino. Using the threshold values decision is taken and requirements are notified to the user using the web server. Online farming allows the farmer to view the farm status and live video of the farm using remote devices.

This system is found to be feasible and cost-effective for optimizing water resources, energy efficient, reduction in fertilizer cost for agricultural production and minimize environmental impacts. This system has potential to attract the farmers to implement precision agriculture to effectively utilize the available land resources.

Joe-air Jiang, the author of "Becoming technological advanced - IOT applications in smart agriculture," has proposed precision agriculture system to optimize water resources, fertilizer, pesticide, insecticide and labor work. The proposed system in *APAN 38th meeting,* 11-15 August 2014 is well suited for a farmer to cultivate in geographically isolated areas [6]. The precision agriculture system implemented was found to be feasible and cost-effective for all types of farmland and crops. The system leads to maximum productivity, minimum investment and less impact on the environment.

This system consumes only 25% of water than traditional methods of irrigation. The system gives the information about the crops grown in the soil and soil moisture content in the farm. Besides the monetary savings in water use and fertilizers, the importance of the preservation of this natural resource for the next generation justifies the use of this kind of precision agriculture system.

The limitation of this aquaponics architecture is that it requires constant management of aquatic life and the adjoined farm which sometimes becomes cumbersome. It is also necessary to constantly monitor the grow media and the water conditions manually moreover there are some plants which when grown are not profitable in aquaponics.

III. System design

The proposed system contains the following sensing elements – temperature sensor, pH sensor, gas sensor, ultrasonic sensor, Passive IR sensor, water sensor and humidity sensor. The temperature and pH sensors are placed within the tank that monitors the temperature and pH levels. These sensors are necessary to observe the system at all times. Just in case of any variations within the data, an alarm is given to the farmer to check the aquaponics setup. Variations principally occur because of abnormality within the original setup. The fishes should be prevented from getting infected, however, if any fish is infected by a specific sickness, the sickness would spread rapidly among the other fishes within the tank. The entire block diagram of the system is shown in Fig.1.

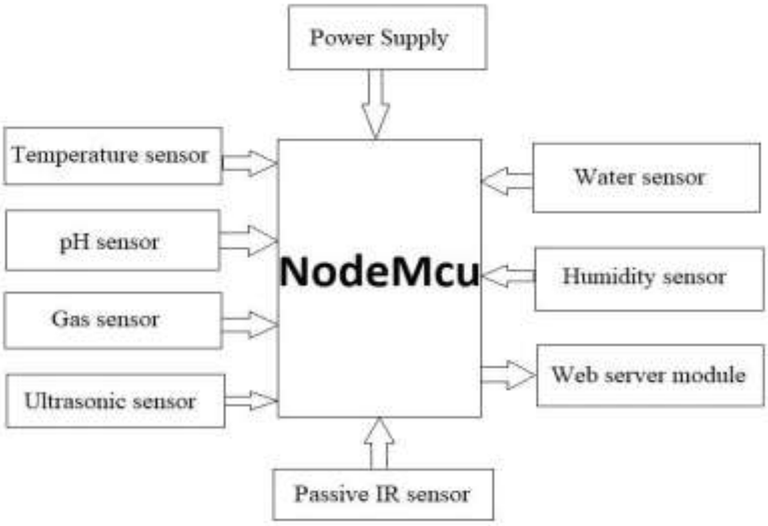

Fig. 1. Block diagram of the complete system

3.1 NodeMcu
NodeMcu is an open source IoT platform. It provides the ability to load larger programs compared to Arduino with onboard WIFI and support for many sensors.

3.2 Temperature Sensor & Humidity Sensor
A temperature sensor is exactly what it sounds like – a sensor used to measure ambient temperature. The DHT11 is a basic, digital temperature and humidity sensor. This particular sensor has three pins – a positive, a ground, and a signal. This is a linear temperature sensor. Temperature Sensor provides information about the current temperature of the aquaponic farm surrounding. Keeping track of this can help managing temperature when the aquaponic farm is implemented in a greenhouse. Humidity sensor helps keep track of humidity, thereby enabling the user to make sure adequate moisture content in the environment is available.

3.3 pH Sensor
It us SEN0161 sensor sued for detection of ph. ion concentration thereby determining the Ph value of the water so that it can be maintained at an optimum level.

3.4 Gas Sensor
It is a MQ11 sensor device used for detecting harmful gases and their proportion in air. It possesses both analog and digital outputs out of which the digital outputs can be used for a precise measure.

3.5 Ultrasonic Sensor
It is a basic reflective sensor based on the principle of SONAR which basically transmits and receives the 40000 Hz frequency wave to measure distance.

3.6 Passive IR Sensor
It is HC-SR501 sensor used for detecting IR (infrared radiation), perfect for measuring IR changes in environment.

3.7 Water Sensor
It is an Arduino compatible sensor capable of identifying water level based on its electrical conductivity.

3.8 Web server module
The Block diagram of the web server based online system is shown in Fig. 2. The sensor measures all the data and load onto the microprocessor NodeMcu. This data is then uploaded to the web server and saved to the online database. The farmer can access all the data on the remote device after successful authentication. The user can access from anywhere in the world.

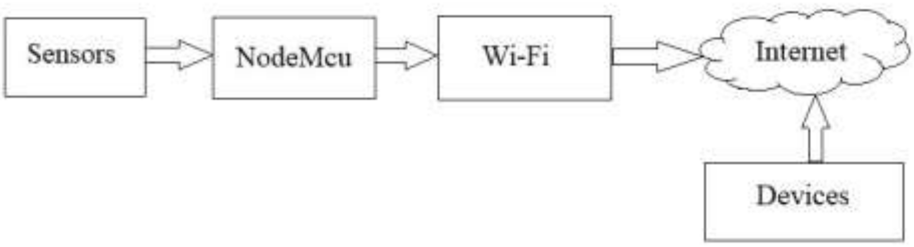

Fig. 2. Web server based online system

IV. Software Design

The flowchart for the system proposed in the paper as well as software design is shown in Fig. 3. Software design proposed for the system includes two parts: design embedded system, microcontroller programming. Initially, we need to set up the aquaponics system and embedded system. The microcontroller receives and reads all the data. Using these threshold values, one can automate the system accordingly. The microcontroller will read all the data and will load the data to the web server via the internet. The information would be saved online in the database. This information would also help the farmer to analyze the data and take necessary future actions. Before the farmer can access the data, the farmer will have to authenticate to the server after the authentication he will be able to view and access all the farm status and data.

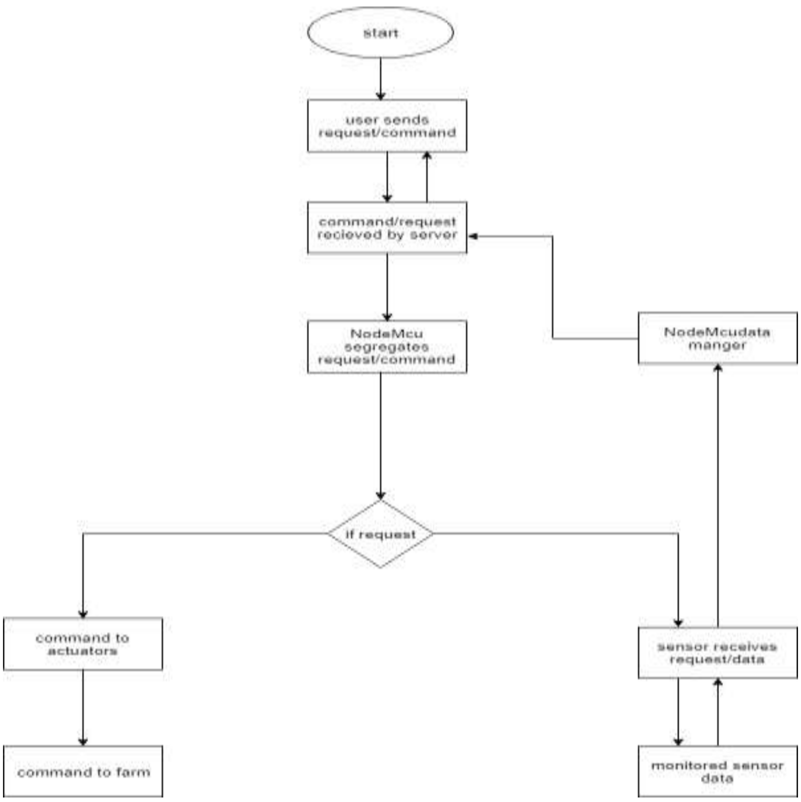

Fig. 3. Flowchart of the system

V. Implementation plan

We brainstormed on various ways to integrate the components and make a final design. Layout design Fig. 4. was constructed on the basis that it can be easily accommodated in small space like balconies of houses.

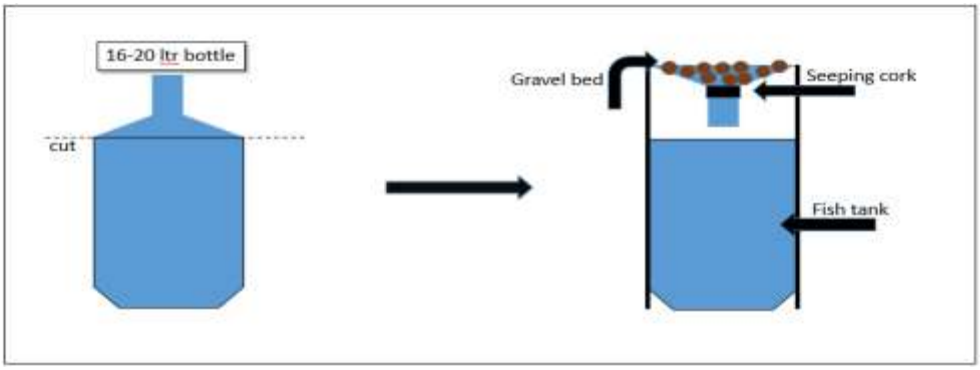

Fig. 4. Architecture of the proposed system

Interface plays a major role in the interaction of a user with the system. If the interface is simple and easy to get acquainted with then it is considered as the best interface. So we decided to design a simple interface where we will provide all the necessary data and an analyzed report about the status of the system and if any action is required to be performed or not. Also, there will be simple options to trigger the motors if the user feels necessary. Majorly this phase will deal with the front-end development of the Interface. After designing the core of the project i.e. the Backend will be constructed. The code or logic behind the proper functioning of the system will be majorly developed in Arduino IDE & Firebase.

In the Implementation phase, the motors and the sensors are embedded in the system and the microcontroller is programmed to get the data from these sensors. First of all, the architectural design is built then the plants and fish are introduced into the system. Plants require some initial time to grow after that fishes and plants make an ecosystem in which they live in a symbiotic relationship where the nitrate waste of fishes is consumed by plants and the water is purified by the plants as the nitrate levels are reduced and water becomes favorable for fishes.

VI. Conclusion

In comparison to industrialized agriculture, automated sustainable agriculture uses about 30% less energy per unit crop yield. The proposed system promises economic stability for farmers to lead a better quality of life. The concept of the connected farm with aquaponics is soon to be a reality. A green, smart, user-friendly infrastructure which provides autonomous decision making and control is the need of the hour. The proposed Microcontroller based automated farming system using wireless technique is a real-time feedback control system which monitors and controls all the activities of the farm efficiently. The various other salient features of this project are:

1. It can be implemented in gardens or nurseries even in balconies with minimum cost and resources. Also helps in proper utilization of the available resources and helps in avoiding wastage of electricity and water.
2. Can be easily configured and scaled up to work on larger fields.
3. Provides a user-friendly interface hence will have a greater acceptance by the technologically unskilled workers. The system is more compact compared to the existing ones, hence is easily portable and low cost.

Advancements in sensor technology and control systems allow for optimal use of resources. Our aim is to design and develop newer techniques that will allow garden automation to flourish and deliver to its full potential. Thus it can be concluded that the proposed project will lessen labor, conserve water, increase crop yield, provide maximum automation and benefit the society by adopting the fast-growing IoT (Internet of Things) to implement newer and sustainable ways of farming.

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