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Cost Effective Smart Hydroponic Monitoring and Controlling System Using IoT

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Abstract

Hydroponic System is a system in which farmers cultivate different plants without utilizing the soil. The authors have proposed IoT system that monitors and controls all parameters of hydroponic system like water level, pH, humidity and temperature through mobile application. In proposed system, the authors have used an ESP32 micro-controller that is controlled pump. The pump will draw water from a reservoir which is connected to a regular water line. If the water level of the reservoir falls down to a certain level, the system will send an SMS to the Farmer. The farmer can control the water line and make the reservoir full by mobile application. An LDR and DHT11 humidity sensor is used to control the light and temperature of the farm. In system, we also used pH sensor where pH sensor is a scientific instrument that measures the hydrogen-ion activity in water-based solutions and indicating its acidity or alkalinity expressed as pH.

Keywords

Hydroponic, Sensors, IoT, Soil-Less Cultivation, Microcontroller, Wi-Fi Module, Mobile Apps

1. Introduction

1.1. Research Background

Nowadays agriculture is largely dependent on soil and its nutrition contents. But due to global warming and globalization, the availability of soil for agricultural purpose is decreasing and this hampers the production of different plants. Also, fertilizers and pesticides are needed to use to get a better crop which is also damaging the environment. To solve these problems, hydroponics can be used in agriculture. Hydroponics is a method of growing plants without soil and instead

using mineral nutrient solutions in a water solvent. The word "Hydroponics" itself is an amalgamation of two Greek words: "Hydro" meaning water and "Ponics" meaning to work. Using hydroponics, terrestrial plants can be grown with only their roots exposed to the nutritious liquid, or the roots may be physically supported by an inert medium such as perlite or gravel [1]. The nutrients used in hydroponic systems can come from an array of different sources, including (but not limited to) byproduct from fish excrement, duck manure, or purchased chemical fertilizers. Through careful manipulation and management of the plant growing environment which includes the amount of water, the pH levels and the combination of specific nutrients, plants can be encouraged to grow faster. Hydroponics is a less wasteful approach including reduced waste, preservation of water stocks and a diminished reliance on pesticides, fertilizers and other potentially harmful materials. The net impact is an expanded surrender and progressed utilize of assets. Plants commonly developed hydroponically incorporate tomatoes, peppers, cucumbers, lettuces, and cannabis. The web of things, or IOT, could be a framework of interrelated computing gadgets, mechanical and advanced machines, objects, creatures or individuals that are given with interesting identifiers and the capacity to exchange information over an organization without requiring human-to-human or human-to-computer interaction. Implanted with gadgets, web network, and other shapes of equipment such as sensors, these gadgets can communicate and connecte with others over the web, and they can be remotely checked and controlled. These advantages of IOT have inspired scientists to use the technology in different aspects of our day to day life.

Due to limited resources, farmers need to produce more with less resource and without hampering the environment. So, more people are trying to set up hydroponics farm, since it does not require a large area and there is a very minimal need of water in the cultivation process. Using hydroponics with IOT can be an efficient way to produce maximum crops with reduced environmental impact and resources. Horticulture IOT arrangements permit agriculturists to use sensors, shrewd doors, and observing frameworks to gather and analyze data and make more educated choices. The rise of IOT has permitted ranchers to computerize the hydroponic horticulture handle to a certain degree. From keeping up the water temperature to a certain level to robotizing the supplement blending, each single handle can be done by means of this imaginative innovation [2].

1.2. Objectives

To design and develop an IOT based smart vertical hydroponic farm to solve the challenges of modern farming and to develop agriculture with minimum resource utilization.

1.3. Justification of Study

A conventional cultivating employment soil and takes a longer time to break

down. This increment costs and makes the plants inclined to maladies. On the opposite, IOT-based vertical planting gives way better comes about, particularly in regions with unacceptable environment and space [3]. A few of the preferences of IOT based hydroponics ranches are given underneath:

- All year-round trim production
- Elimination of rural runoff
- Reduction of utilize of fossil fills altogether (cultivate machines and transport of crops)
- No weather-related edit failures
- Less harm to the environment
- Low utilize of lands for rural reason and more arrive for living purpose
- More crops with less resources

1.4. Scope of Study

Due to climate change, the availability of cultivable land is decreasing day by day. So, an alternative way of cultivation is needed to overcome the situation. Hydroponics gives people that opportunity to cope with the environmental change. Now-a-days farmers in many modern countries are trying to cultivate using the knowledge of hydroponics. As the height of the sea level is increasing day by day, many cultivable lands of Bangladesh will be gone under water in the future. So, the land available to grow crops will be diminished drastically. Then hydroponics can be the best alternative for farmers to cultivate. Also, every year Bangladesh gets swept away with floods. In the flood affected areas, farmers cannot grow any crops and wait for the governmental help to feed themselves. Instead they can grow crops on water using the knowledge of hydroponics and support themselves during the disastrous times. In normal times, a farmer can double his profit by both cultivating his land and other watery areas he possesses. There are also some lands which cannot be cultivated *i.e.*, hilly areas. By creating small swampy area, people can grow different kinds of crops using the knowledge of hydroponics.

2. Literature Review

Vertical Cultivating into urban communities has extended. Vertical developing could be a creating vegetable vertically by unused green procedures, which joins the structure of structure and farms all together in a lifted structure interior the urban areas. This development ought to be appearing both within the rustic framework and auxiliary advancement together, in any case, small has been dispersed on the advancement of Vertical Cultivating. In this examination, development as one of the critical figure of vertical developing is talked approximately and reviewed by subjective strategy. Within the to begin with, recognizing existing and future VF amplifies in Europe, Asia, and America from 2009 to 2016. At that point a total composing looked into on developments and methods that are utilized in VF The headways advertised can be a direct for utilization advance-

ment and foreseeing creative and developing wanders of Vertical Cultivating in urban ranges. Truth be told, it can go almost as a reason for evaluating prospective cultivating and plan together. The blend of food creation into the urban districts has been seen as an affiliation with the city and its inhabitants. It whereas reduces destitution, includes sanitation, and increases coherent viability and human prosperity. The examination resources were formed from 62 interesting sources from 2007 to 2016 [4].

Hardeep Singh made and built a vertical Hydroponic apex. An apex plant, also called a window farm is a course of action of vertical hydroponics, which consolidates an A-Frame hydroponic system, hydroponic divider and falls of containers. It tends to be utilized for creating distinctive harvests like strawberry, lettuce, Swiss chard, herbs, spinach, kale, broccoli and flowering petunia. There are distinctive online sources to urge these systems, which can taken a toll around $500 or more, however you'll be able manufacture your claim apex plant for considerably less. It can moreover be utilized for creating plants interior in the event that lights are given over the apex, which is celebrated in urban domains with fair a small space for developing. The apex nursery structure portrayed here can hold 28 plants for each apex and two towers can be set in a 5-foot × 5-foot space, conveying 56 plants at one time. The arrange can be modified as shown by slant. For occasion, towers can be dangled from the top and can deplete to a solitary tank to gather the supplement arrangement. Materials recorded underneath can be found at a tool shop, with the exception of the net pots which can be acquired from hydroponic sellers or on the web. On the off chance that tower material is modified, make a point to utilize sustenance grade material [5].

The unremitting designs of growing people, urbanization, diminishing water supply, and continuing with natural alter have included to declining loads of arable arrive per person. As arrive resources for cultivation decay, procedure makers are looked with the test of viability and feeding the rapidly creating add up to people which is expected to attain around 9.7 billion out of 2050. Answers for progressing future food era are exemplified by urban vertical developing which incorporates a parcel more unmistakable utilization of advancement and robotization for land-use streamlining. The vertical property framework anticipates to basically extend benefit and reduce the biological impression interior a structure of urban, indoor, climate controlled tall structures. It is ensured that such workplaces offer various potential focuses of intrigued as a idealize and green wellspring of food, nearby biosecurity, opportunity from vermin, dry spells, and reduced utilization of transportation and petroleum subsidiaries. In this article, the issues included are evaluated beside potential focuses of intrigued and obstacles. Potential consequences are recognized for thought by approach makers and to energize assist budgetary examination [6].

Adjustment of Hydroponic Frameworks and Fancy Species. Vertical nurseries are another strategy for seeing nurseries and of implanting them in sudden zones interior the urban communities. The plants create with or without sub-

strate for root advancement, *i.e.*, in hydroponic systems or are created soilless. Not at all like rural yields such systems include of various species with different necessities and are obligated to complex environmental conditions. The physical and physico-concoction fertigation course of action is depicted by EC, pH and oxygen substance. Moreover movements of temperature, light and stickiness ought to be considered. The arrange of the hydroponic systems ought to conclusion up balanced to different improvements. A few hydroponic reusing systems for utilize in vertical developing are proposed [7].

The progression of modern development for food era is fundamental to bolster man's necessities for survival. The utilization of farmlands for food era and mechanical purposes goes past the passing on restrain of the soil. The examination chose the materialness of Vertical Cultivating utilizing Hydroponic Innovation to onion era in Nueva Ecija, Philippines. The nation is known as the onion capital of Southeast Asia. The examination evaluated the innovation's supportability and ampleness to onion the country is known farmers. By utilizing test methodology, assembly, and Centered Gather Talks (FGD), the examination built up its common sense. Three periods of field tests were driven in Eminent 2016, May 2017 and July 2017 utilizing the Vertical Cultivating and Hydroponics Innovation and Single Calculate Examination of Fluctuation. The results illustrated that there's noteworthy differentiate within the improvement of onion bulb each week and the fittingness and resemblance of the advancement to conventional The examination induced that the VFH development is palatable to most onion farmers aside from the portion of the cost of starting hypothesis which needs government gift for the standard onion cultivator to benefit of this unused and down to earth advancement in onion era [8].

The Vertical Cultivating is the impelled degree of agribusiness advancement where this must be cleaned when there's blocked off of arrive and diverse prerequisites for the perfect structure of developing mode, this is the other way or approach within the moved level and this paper deals the method, gathering technique, water the officials and collect advancement and yielding strategy. Besides, a few of standard limitless resources are utilized, for example, windmill, sun arranged and so forward, where these are not just like the conventional green method, a parcel of diverse hones must be for the extraordinary yielding procedure [9].

The apex was expecting to go supplement wealthy water through two hydroponic systems, stream and supplement film framework at that point return the water back to the store. The apex will develop 5 unmistakable plant collections. Appraisals have been done on the rise, system sort, and collect sort to choose the foremost productive [10].

Really, to control biological components of the vertical hydroponic nursery, the sensors, for case, Electrical Conductivity (EC), Potential of Hydrogen molecule (pH), Discuss temperature, Relative dampness, Water temperature, and Broken down Oxygen (DO) fair as lighting system will present on the vertical

hydroponic systems. All things considered, the think estimation of sensors is dealt with by the microcontroller to screen and control a motor, a humidifier, a water siphon and a ventilator [11].

Qatar, with a people of 2.17 million, directly has destitute created grounds and agricultural potential for autonomy. The elemental issue is the desolate soil and brutal environment, which can be ordinary in Middle-Eastern Inlet areas. A country with fair 1.6% of arable arrive and may barely convey its very possess food would got to spend to moment food to fulfill the wants of the people. An anticipated degree of 11 billion USD has been gone through on imported sustenance within the year 2014 alone. A making country like Qatar, which country is on a very basic level a leave, would have to be think of an reply that would empower them to provide their exceptionally claim fresh food, indeed with a pointless soil. This errand proposes to utilize a gigantic scale vertical-even hydroponic soilless developing development and extraordinary to rapidly display the advancement of soilless developing and how it exceptionally well may be utilized for tremendous scale food era in Doha, Qatar. The Service of Environment of Qatar as of late made the National Food Security Program to address the nourishment deficiency in Qatar. One of the primary parts of the program is to use different hydroponic frameworks to develop crops for sustenance creation. A few thoughts for the task has been made, however none of them uses both vertical and level direction of planting [12].

Hydroponics is the technique of growing plants without soil, its make quality food in limited land. Soil based agribusiness is as of now standing up to distinctive challenges, for case, urbanization, cataclysmic occasion, natural alter, purposeless utilization of manufactured substances and pesticides which is depleting the arrive productivity. In this article distinctive hydroponic structures viz. wick, back and forward development, drip, deep water culture and Supplement Film Method (NFT) system; their errands; points of interest and limitations; performance of different harvests like tomato, cucumber, pepper and verdant greens and water conservation by this methodology have been talked almost. Some preferences of this strategy are less creating time of yields than standard creating; circular the year era; irrelevant ailment and aggravation event and weeding, spraying, watering and so forward can be murdered. Monetarily NFT strategy has been utilized all through the world for compelling creation of verdant fair as diverse vegetables with 70% to 90% save stores of water. Leading countries in hydroponic development are Netherland, Australia, France, Britain, Israel, Canada and USA. For compelling utilization of trade hydroponic development, it is basic to develop negligible exertion frameworks which are anything but troublesome to work and keep up; requires less work and lower in common course of action and operational expense [13].

The vertical cultivate may be a world-changing progression whose opportunity has arrived. Imagine a presence where each town has their claim neighborhood food source, created within the most secure way conceivable, where no

drop of water or particle of light is wasted. Smart developing makes a gigantic commitment for food supportability for 21st century. Erecting a property that's in closeness to the common populace which it serves by openness of less costly, characteristic, ailment free harvests adjacent proceeding the limited customary assets [14].

All through the a long time, standard developing for collecting with the utilization of soil sets aside longer exertion to crumble making it slanted to illnesses and expensive. Hydroponics system implies creating plants without soil with superior results, especially in districts with space and condition unsatisfactory. Trade Hydroponics is the up and coming advancement that creates plants through a sit out of gear media instead of typical soil. This system has no opposing results for condition or quality on yields. Alternately, it gives superior supplement worth and grants controlling the supplements by implies of supplement course of action. Its essential point is to save water, progress nature of yields keeping absent from the opposing impacts of pesticides and components impacting nature of soil and save arrive. This paper gives an outline about the financially savvy execution of Hydroponics for little ranchers in India [15].

3. Methodology

This project is about hardware and software application based. It has followed some features and presented its own methodology with its own strategy.

Following **Figure 1** shows a diagrammatic representation of different phases of this project methodology.

4. Design and Development

4.1. Circuit Diagram

The main aim of this project is making an advance IOT base hydroponic System. To make this project authors are designed following **Figure 2**.

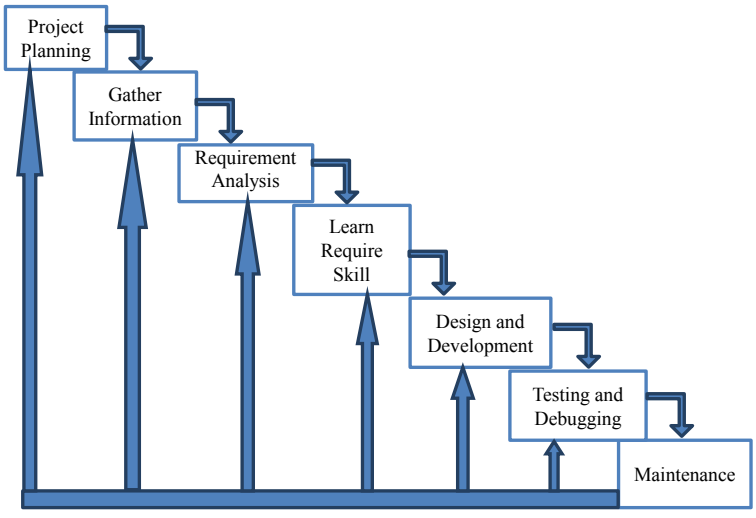

Figure 1. Diagram of proposed methodology.

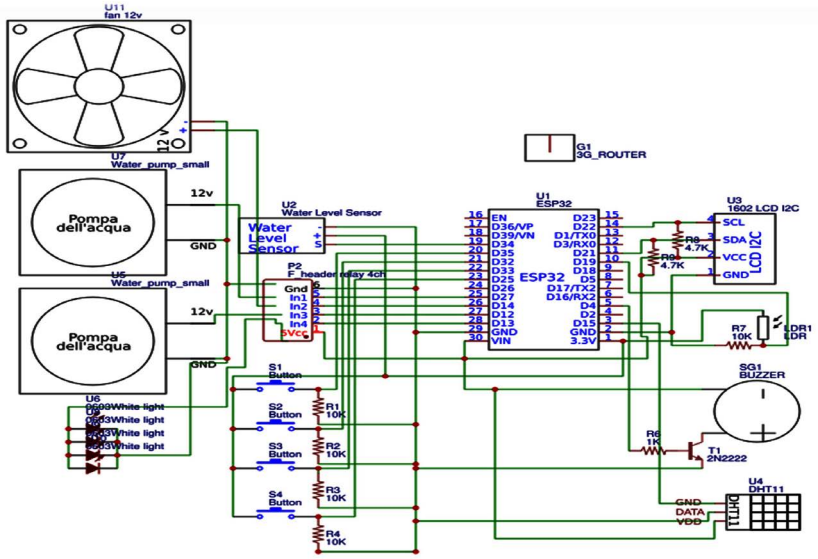

Figure 2. Circuit diagram of proposed system.

Description of Circuit Diagram

Firstly, on the circuit an LCD is connected to ESP32 microcontroller. SCL and SDA of the LCD 12v system are connected to ESP32 through data pins D22 and D21 respectively. Two resistors R8 (4.7 K) and R9 (4.7 K) are used here for pull up. Secondly, an LDR is connected to data pin D19 of ESP32 board and a resistor R7 (10 K) is used for pull down. Thirdly, there is a buzzer in the circuit for alarm system. The negative pole of the buzzer is connected to the ground of ESP32 through VIN pin and positive pole is connected to D4 pin of ESP32. The D4 pin has been pulled down by a resistor R6 (1 K). For the buzzer, a T1 2N2222 amplifier is used to amplify the sound. Fourthly, a DHT11 censor is used in the system which is connected to ESP32 through D15 pin. Fifthly, there is a water level censor here which is connected to D34 pin of ESP32 board. The negative pole of the water level censor is connected to the ground of ESP32 through a GND pin and positive pole is connected to 3.3 V pin of ESP32. Sixthly, there are 4 buttons (S1, S2, S3 and S4) used in the system for the controlling of different devices *i.e.*, S1 for fan, S2 for nutrient pump, S3 for lighting system, and S4 for water pump. These 4 buttons are connected to ESP32 through 4 pins: S1 through D35, S2 through D32, S3 through D33 and S4 through D25. To pull down these pins, 4 resistors are used: R1 (10 K) for D35, R2 (10 K) for D32, R3 (10 K) for D33 and R4 (10 K) for D36. Seventhly, a 4 channeled (ln1, ln2, ln3 and ln4) relay is used in the system which is connected to ESP32 through 4 pins: ln1 through D27, ln2 through D14, ln3 through D12 and ln4 through D13. Two pumps, one fan and a lighting system are connected to the relay each of which has a potential of 12 V.

4.2. Block Diagram of Proposed System

Description of the block diagram

There are three main parts in the below **Figure 3** of a vertical hydroponics

farm: sensor interface, microcontroller and hardware. In the sensor interface section, there are four sensors: pH sensor, water level sensor, air temperature and humidity sensor and light sensor. This sensor interface section is connected to ESP32 microcontroller through GPIO port. A four-channeled relay is also connected with the ESP32 microcontroller. Hardware section consists of a fan, a nutrient pump, a lighting system and a water pump. The hardware components are connected to the four-channeled relay as an output. There is a display connected to the ESP32 microcontroller. By using a router gateway, data can be stored in a cloud server. By using a mobile application, the data can be shown on the display and the owner can control the hardware components with his/her mobile phone.

4.3. System Architecture of Proposed System

Description of the system architecture diagram

The below Figure 4 shows Voltage is given by adaptor in hydroponics and automated control system. Automated control system is connected with hydroponics system. The input of automated control system is shown by the output of hydroponics system. The router get way connected is connected with automated control system we can control hydroponics system and given instruction by smart phone through cloud server.

4.4. Work Flow Diagram of Proposed System

The following Figure 5 shows working flow diagram of proposed system.

5. Result and Discussion

5.1. Device Prototype

After completing the connection of all devices (Water level sensor, pH sensor, DHT11 Temperature and Humidity sensor, LCD Display, LDR) with the Arduino IDE, authors are taken a image by the mobile phone that shows in following Figure 6.

5.2. Mobile Application View

The authors design mobile application according to following Figure 7 where showing device id that is unique to identify the IoT device. The above mobile application also shows current information of Humidity, temperature and pH. The user can switch off or on according to Humidity, temperature and pH value.

5.3. Readings Real Time Data from Sensors of Proposed IoT Device

In following Table 1 shows real time sensor data.

5.4. Graphical Representation of Real Time Sensor Data from Hydroponic System

The following Figure 8 shows measurement of different sensors data.

Table 1. Different sensors data.

Types of Sensor	Date: 17/08/2019	Date: 31/08/2019	Date: 08/09/2019
Water level sensor & nutrient	3	2	1
pH sensor	5.59	5.92	5.70
Temperature sensor	27.55	26.59	26.55
Humidity sensor	26	20	25

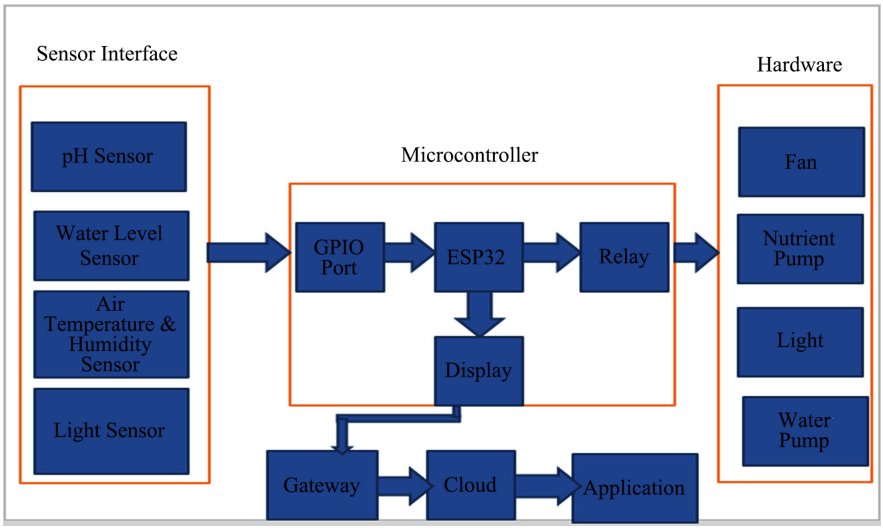

Figure 3. Block diagram of proposed system.

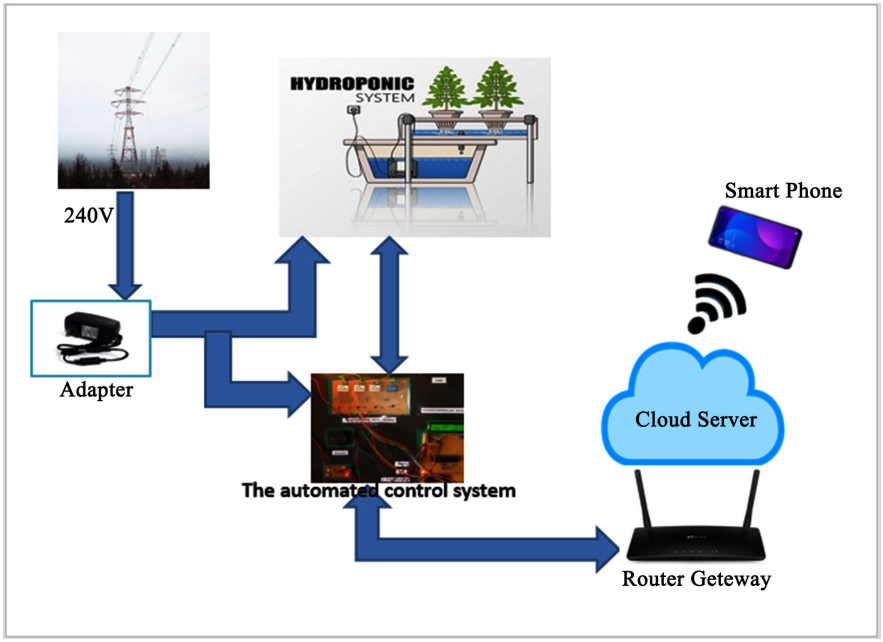

Figure 4. System architecture of proposed system.

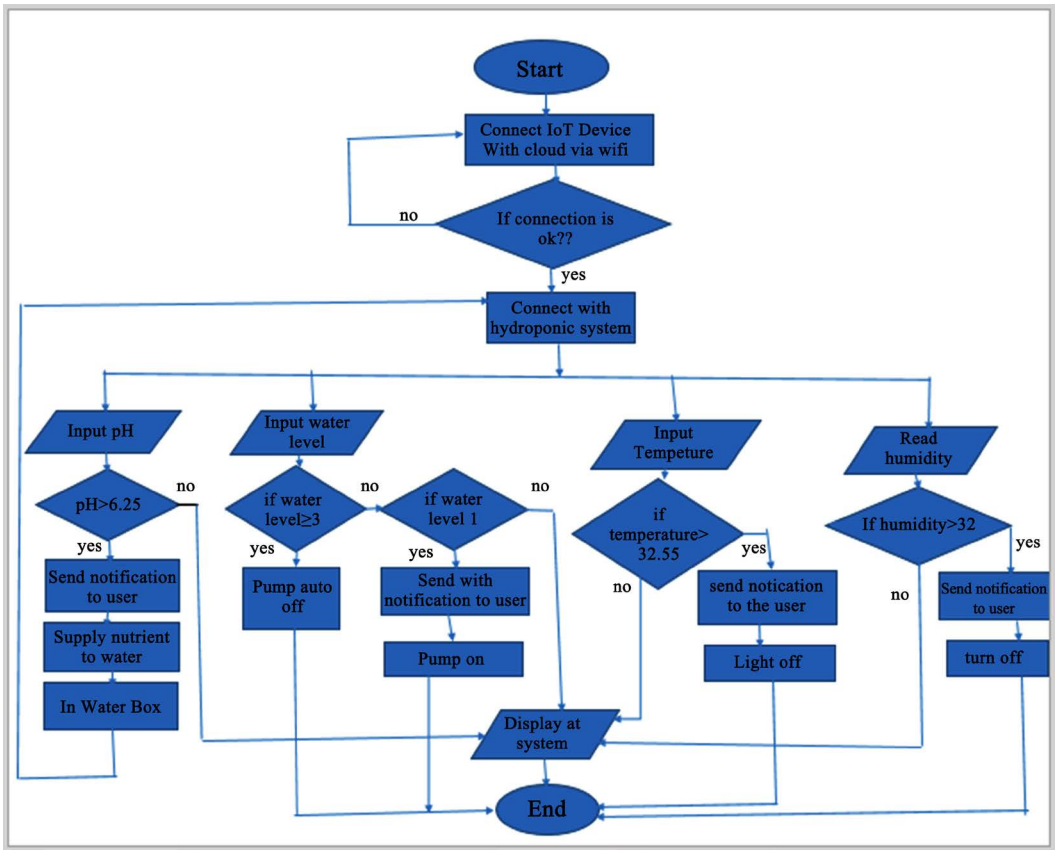

Figure 5. Work flow diagram of proposed system.

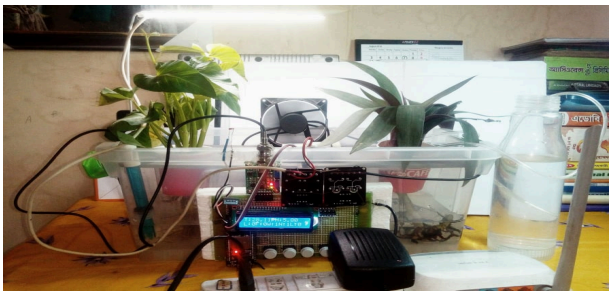

Figure 6. Prototype of proposed IOT device.

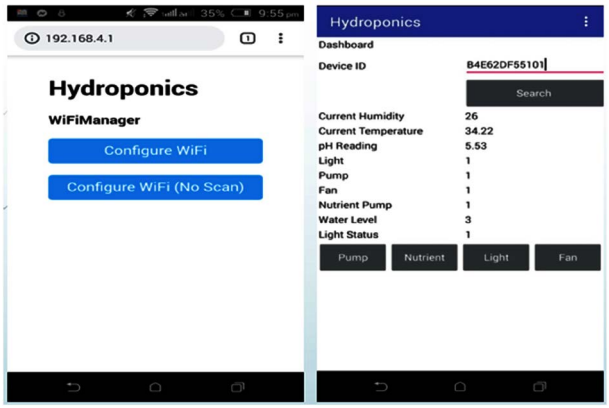

Figure 7. IoT device information via mobile apps.

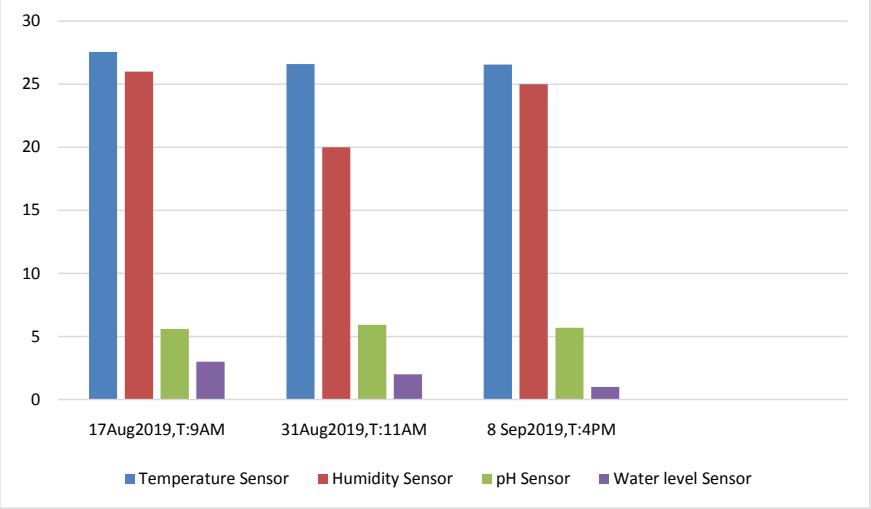

Figure 8. Showing graphical view of real data.

6. Conclusion

6.1. Conclusions

Hydroponics can give people the ability to grow crops in any areas with a less expensive and efficient way which has a low impact on the environment. And using hydroponics with IOT can definitely make the cultivation more convenient for the farmers by turning every process in the farm automated and precise. In this project authors have developed a vertical hydroponic system using the concept of IoT. The authors proposed that IoT device can control and monitor Hydroponic system. The proposed hydroponic system can work smoothly on each environmental factor and system has been showed good performance under the setting condition.

6.2. Limitations

Nutrient sensor could be used for mixing water and nutrition.

6.3. Future Works

In future authors will use nutrient sensor for better quality of water in hydroponic system. The water in a hydroponic framework must be supplement improved. Supplement enhanced water ought to be closely observed to guarantee that supplement levels are not as well moo (repressing development) or as well tall (possibly toxic).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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