Smart Farming using IoT

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***Abstract*--** **We are all aware of the fact that there is an increasing need for agriculture due to the drastic increase in the population which occupies both land area and increases the demand for food products. So we cannot completely rely on the traditional method of farming which also has various limitations. Hence we opted for Indoor farming, which is a great success. This is an idea to reflect the picture of future farming. The Indoor farming is of two major types- Green House farming and Hydroponics. In both the cases, human power is required for monitoring the parameters and taking necessary actions. This idea is focused on reducing the workload and increasing the reliability of the system electronically. The advantage of this system is that the productivity is 2 to 3 times better, time taken is 2 to 3 times lesser and saves 70 to 80% of water compared to normal agriculture provided proper pH, NPK nutrient level, Light, Temperature, Humidity is maintained. The main objective of the proposed product is that it automates the system completely and we can have an advantage of remote monitoring, data logging for various purposes and remote control of the complete system using IoT. Defect identification and control is possible from anywhere in the world and anytime. This will make a great effect in the future farming using IoT.**

Keywords— Indoor farming; Hydroponics System; Arduino; Sensors; ESP8266; HID lights; ThingSpeak; Solar panel; Battery.

I. INTRODUCTION

A. Indoor Farming

The general concept of working of greenhouse farming and hydroponics technology is almost similar, except from the case that in greenhouse farming the plants are grown in soil and in a closed glass house but in hydroponics, the plants are grown in the nutrient solution and not in the soil and placed anywhere. As mentioned earlier, the parameters such as pH, NPK nutrients, temperature, humidity, Light and level of liquids in the system should be maintained or regulated within the threshold limits for the better yield. The plants require a specific nutrient's level to be dominant at one stage of its growth and for other stages, the nutrient composition changes. The optimum level of pH should be maintained between 5.5 and 6 in average. The optimum temperature and humidity are 25 to 35 degree C and 50 to 55% approximately for best yield. The light intensity should be between 450 and 650 nm in wavelength. Thus, these are the parameters most important under consideration in these systems. The Overview of both the systems is given below.

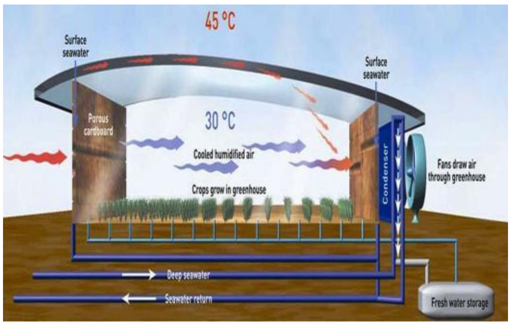

Fig. 1 Green House farming

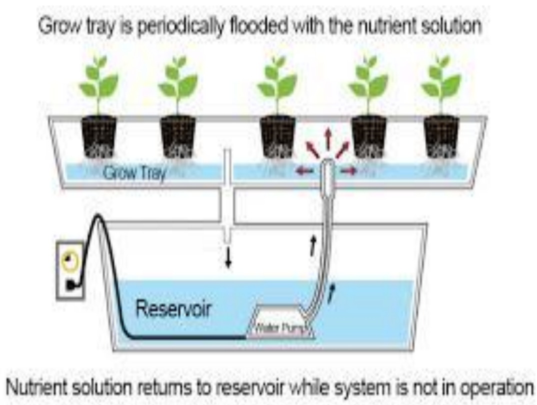

Fig. 2 Hydroponics System

II. MATERIALS AND METHODS

A. Arduino

Arduino is a opensource platform used for building electronic products. It comprises of a ATMega328P Microcontroller with 6 analog and 14 digital I/O pins. It supports serial communication. It is a embedded development board with

IDE(Integrated Development Environment) for coding. Coding can be either in Java, C or C++ language. The reason for the choice of arduino as the main board is its simplicity in size, low cost, more reliable and its wide range of compatibility with various sensors and interfacing devices.

Fig. 3 Arduino

B. Sensors used

In this project the sensors used are Soil moisture sensor, Ultrasonic sensor, Level sensor, pH sensor, Light sensor, Humidity sensor and Temperature sensor (DHT11), Air Quality sensor and EC sensor.

The soil moisture sensor is used in case of a Greenhouse farming to test the moisture level of the soil used. Ultrasonic sensor here, is used to measure the water level in the main tank and level of nutrient solution in the intermediate tank. Level sensor is used to measure the level of nutrient solution in the PVC arrangement. Light sensor is used to measure the intensity of light inside the system. Temperature and humidity sensor is used to measure temperature and humidity of the system environment. Ph sensor and EC sensor is to measure the ph and the amount of main nutrient levels such as NPK (Nitrogen, Potassium, Phosphorous) in the nutrient solution. The air quality sensor is an additional sensor for determining the quality of air in the system environment.

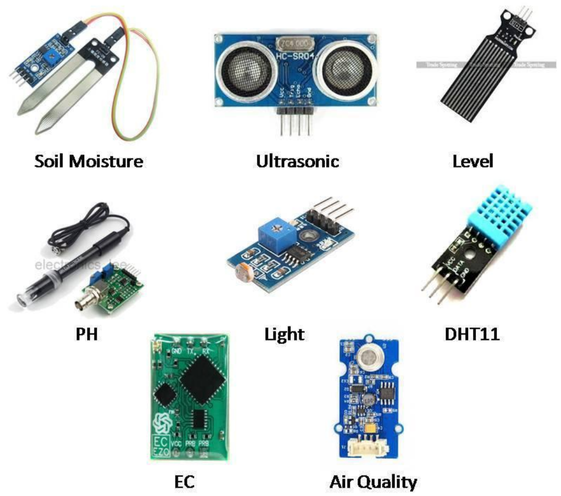

Fig. 4 Sensors

C .Other Accessories:

The other accessories includes the relay channel for making contact between higher voltage and lower voltage, a pump for pumping nutrient solution which usually be present in the system, HID lamp or Glow lights for lighting source, ventilation fan to maintain humidity and temperature, RTC (Real Time Clock) to make the system act or trigger a response based on the needs, and a mobile phone/tablet/computer to monitor and to establish a remote control of the overall system. 9V batteries are used to power the product. The most important hardware is the internet connectivity module. To make the product cheap, ESP8266 is used as a WiFi source.

Fig. 5 Other accessories

III. WORKING

All the sensors and the Wifi module, ESB8266 is interfaced with Arduino to establish network connectivity. If the water level in the water tank is sensed less by the ultrasonic sensor, appropriate amount of water if filled to it. EC sensor senses the NPK levels in the intermediate and accordingly nutrients are pumped to exact levels to satisfy the plant's needs. pH sensor measures the pH level of the intermediate tank and balances it by adding pH up solution or pH down solution according to the measured level. Once this is done, the level of nutrient solution in the PVC arrangement is sensed using level sensor and appropriate amount of water is pumped from the intermediate tank. This is regarding Hydroponics. In case of Greenhouse farming, the moisture level is sensed by soil moisture sensor and accordingly the nutrient solution is pumped to the system. Temperature and humidity sensor senses the temperature and humidity of the surroundings, if there is an increase in temperature or humidity, ventilation fans are turned on automatically to maintain it. Light sensor monitors the light intensity of the system and maintains this by the use of HID lights or glow lights which provides equivalent amount of sunlight energy even during night time. The plants require a specific nutrient's level to be dominant at one stage of its growth and for other stages, the nutrient composition changes. RTC (Real time clock) is used as a reference for all the timings especially in determining the stage of growth of plants to shift the nutrient composition condition in the code. Since a variety of plants are used in these systems, number are switches are provided for selection of the type of plant so that a particular part of the code which is holding the plant's threshold limit checks, gets executed and thereby eliminating the problem of usage of the system for one type of plant alone.

What happens if the system has failed in automation and after few hours the plants gets spoiled? There comes an added and the most important concept of Internet of Things (IoT). All the sensors' data are sent to the cloud service from which we can monitor all the data. The cloud services used for the prototype are ThingSpeak and Microsoft Azure because of their ease of use and security.

Thus this is the overall automation with remote monitoring and control of the system which makes it more reliable and takes this to the concept of
"Smart Products".

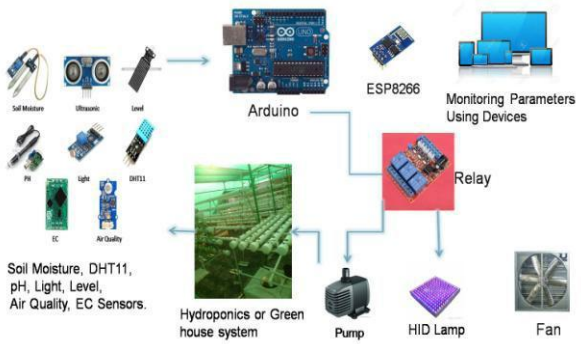

Fig. 6 Indoor Farming Schematic Representation

Solar Powering

To make the system more reliable and to contribute to the environment safety, green energy is used for the complete operation of the system. A solar panel is used to convert the light energy into electrical energy. The charge controller is connected to the output of the panel which regulates the power and also acts as a switch to protect the battery from overcharging issues. Thus a battery gets charged and supplies the DC loads (HID lights). An inverter is used in case of AC loads (Ventilating fan, Pump).

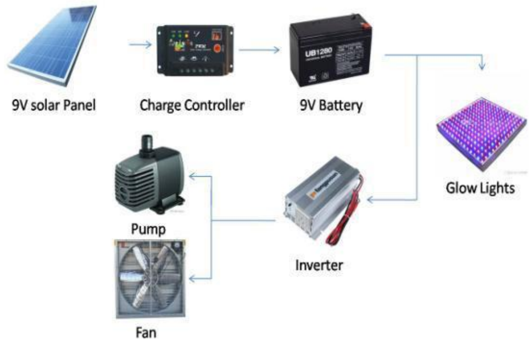

Fig. 7 Solar Powering Circuit

IV. ADVANTAGES

Work load is greatly reduced in both the systems because of full automation. The system can be monitored and controlled anytime and from anywhere using IoT. Data logging is done in order to identify which part of the system is malfunctioning based on the deviations from the previous data and hence it will be easier for defect detection which is a great advantage. System uses green energy, therefore there is no pollution. Error detection and remedy is easy. The most important advantage is the impressive cost effectiveness of the overall product. The product can be used for a number of crops and not limited by one. Hydroponics grows plants with 2 to 3 times of better quality, 2 to 3 times faster and saves around 70 to 80% of water when compared with traditional agriculture and hence the advancement made in this system will have a great effect in the market.

V. RESULTS

Based on the proposed concept, a working prototype model was formed using the main board arduino. The sensors are connected to the general purpose input output pins(GPIO) of the main board. The connectivity module, ESP8266 requires a 3.3V supply from the arduino. Most of the sensors are analog except ultrasonic. The output trigger is always digital and this acts as an input for the relay. The main board and the relay is given a 5V supply. Supply from the solar powering circuit is connected to the relay to activate the pumps, HID lamps, Ventilating fans etc on reception of the output signal from the arduino which is generated based on the output of sensors. Thus this helps in automating the system by regulating the parameters under optimum level for better yield.

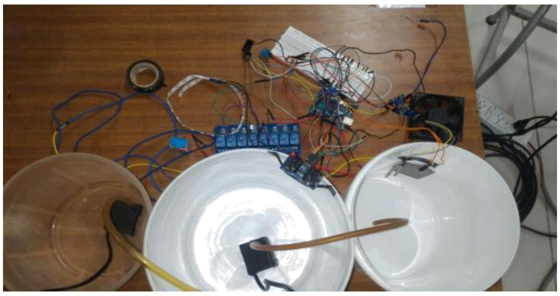

Fig. 8 Prototype setup

The following is the real time values of the sensors obtained at the Microsoft Azure dashboard. Creation of the dashboard is done with required amount of data logging parameters, six in this case. Coding is done in such a way that the ESP8266 establishes a link between the product and the Microsoft Azure Cloud service. Thus all the sensors values are obtained with time stamps as in SCADA. If we need a secured data logging, Microsoft Azure is good but it costs you for usage.

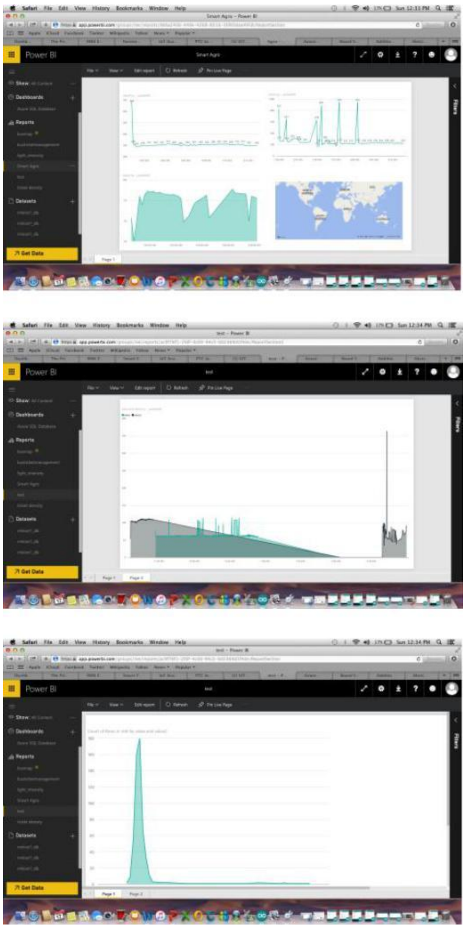

Fig. 9 Microsoft Azure Dashboard

The following is the real time values of sensors obtained at the ThingSpeak dashboard. This is the easiest of all cloud services. Creation and customization of the dashboard is very simple. An API key will be generated for the project and this will be used as a reference for the sharing of data through ESP8266. This cloud service is free of cost and more user- friendly.

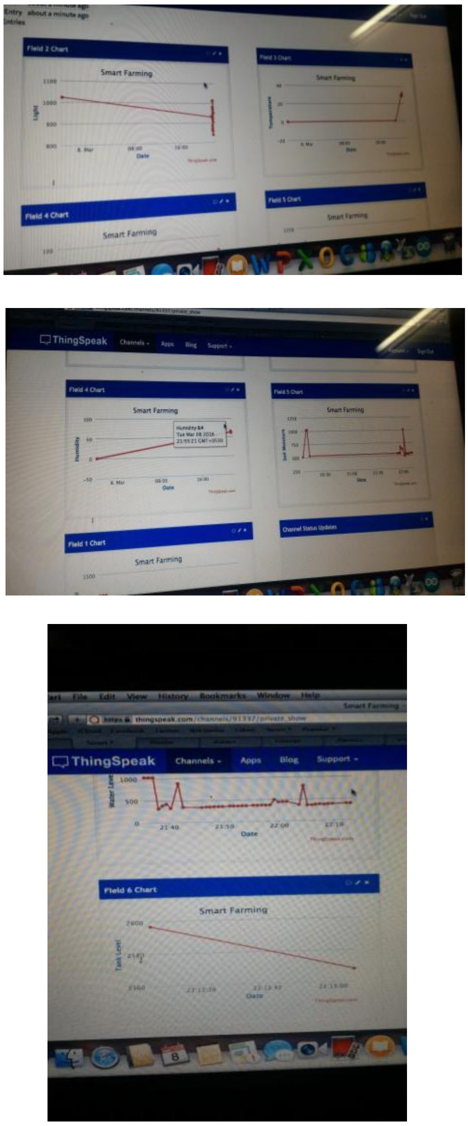

Fig. 10 ThingSpeak Dashboard

The following is the additional feature of ThingSpeak. It is an a mobile android app version of ThingSpeak. It is available in Play store, once downloaded, it asks for API key and its done. All the datum will be available in your hand even if you are miles away from your system.

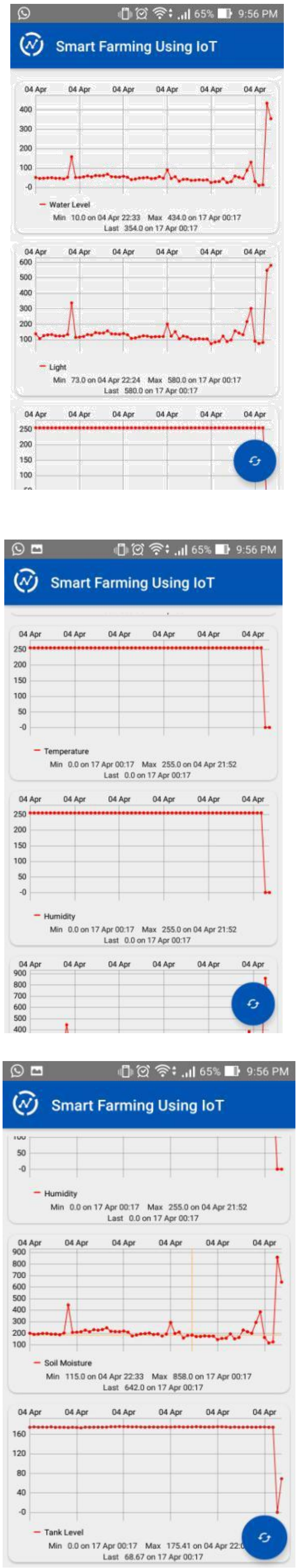

Fig. 11 ThingView MobileApp Monitoring

Even if the user is away from the system for several days, the system acts perfectly, that is the system is a perfect stand alone one and you can crosscheck if the system is working properly with your Laptop or Mobile phone and control it. If any of the parameters deviates from the threshold limits of defect range, it can be easily recognized that the particular part of the system is malfunctioning from the dashboard. Hence it can be taken care of and restored easily that is, defect identification of this big system and its rectification is very easy since every parameter has an individual monitoring. Thus, these are the two most important highlights of the product.

VI. COST ANALYSIS

The traditional hydroponics setup for a 10x10 sq m will cost around 1 lakh rupees including the manual pH meter and manual Nutrient meters and other accessories excluding solar setup. But the setup alone will cost only 70 thousand rupees. But for my proposed product of same area, the cost is

TABLE 1: Cost Analysis of the product

Name of The Component	Price in Rs
Hydroponics Setup	70K
Sensors (Ultrasonic, Light, DHT11, Level)	600
pH and EC meters	15000
Solar Powering Circuit	8000
Other Accessories	2000
Relay, ESP8266	700
Total	96300

Thus, the overall product’s cost is less than the traditional one with many advantages like, complete automation, data logging, remote monitoring, remote control, and solar powering. The solar powering can be optional which brings down the products price greatly. The massive difference in the price is due to the pH and Nutrient meters that is provided with the traditional setup. In this product, a simple low cost sensor is used but it does not give the actual value. With greater calibration, calculations and conclusions, the accurate value is obtained with very minimal permissible error. This is the greatest effort in bringing down the cost of the product. I hope, this will be a good step forward in improvising the field of farming in the future.

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