Solar Powered Smart Agriculture Systems Using WSN Via IoT

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Abstract - *In this era of development in modern technology and every other aspect, wireless communication technologies,* internet of things *(IoT) network systems, and control systems have paved the way for a new method or procedure of agriculture named smart agriculture. And this new phase of farming involves the use of novel technology along with inch-scale devices and various sensors which are used to monitor crops and provide mankind an accurate knowledge about the crop and the land. Smart Agriculture can take over traditional farming practices and applies for technological advances from areas such as Wireless Sensor Networks and IoT to assist in expanding the numbers of output yields of a crop with improving efficiency and reducing the amount of stress on the farmers and their co-helpers. In this paper, a solar-powered smart agriculture monitoring system with IoT devices and sensors is presented. We can monitor the crop field conditions by using the Smartphone and will be able to take care of the necessary steps efficiently based on present conditions. Our proposed system will supply you with some valuable data(information) about soil moisture, water level, humidity, and temperature and as well as the general condition of the crop and the field to the farmers in an easily accessible manner with real-time data communication via IoT. Our team believes that this paper will establish a trademark in the upcoming future of smart agriculture.*

***Key Words*:** Wireless Sensor Network (WSN), Smart Agriculture, internet of things (IoT), Soil moisture, Human Machine Interface (HMI).

1. INTRODUCTION:

India is the powerhouse of global agriculture. Today we rank in the second position in farm output and also us almost half of the population is engaged in agriculture but the economic contribution of our whole agriculture system to our GDP is only 16% and this is so much less than a developed country [1]. This is because we are not able to make proper use of our agricultural resources due to our old traditional farming but on the other hand, the demand for our food necessities is increasing day by day because of our growing population. As we are not being able to increase our limited farmland and there are also very many skills and experiences laborers need for traditional farming. So, the time has come to replace our old traditional agricultural system with the technology-based smart agricultural system for better agricultural productivity, removing the environmental damage and reducing the whole production cost.

So nowadays internet of things (IoT) based smart agriculture has created a new dimension for technology in the agriculture sector as all the IoT devices are easy-to-use small, low-powered embedded electronics that communicate with each other to transmit all the data across the network. It will offer us a sustainable solution for smart crop field monitoring and management system which helps the farmer to monitor the conditions and their products in real-time carefully and collect crucial data about the weather, land conditions, crop conditions, etc [2]. They will monitor all the real-time data with the help of different IoT-based sensors/devices that help us to collect, analyze and process the remote data by applying cloud services, which helps us to make a better decision for that certain situation. So, by adopting the IoT-based smart Agricultural system we suddenly decrease all the labor costs and increase the quality of the produced crop.

Another promising approach that helps in solving many of the problems that farmers face in today's life comes with the use of Wireless Sensor Networks (WSN) in IoT-based smart farming. WSN refers to a group of different sensors for monitoring and recording the physical conditions of the environment and crop, then collectively pass on such data through a wireless network to a cloud location and then we analyze the data as a requirement and a proper decision [3]. It measures environmental conditions like temperature, humidity, salinity, soil moisture, etc. One of the best benefits that WSNs give in agricultural crop monitoring is that sensor nodes can be customized to the crop being monitored. It will help us to take care of the entire crop individually like while one crop will need the water but the other ones are not.

It will just be an imagination if we are not able to implement the whole smart agricultural system in all our rural agriculture and the most challenging thing that comes first in our journey is the energy resources in the agriculture field. So, to overcome this problem we are shifting our energy resources to renewable energies like Solar energy, Wind energy, Biomass energy, etc that give us energy continuously without any surveillance and load shedding problems and also alleviate the burning of fossil fuels. In this, we make our smart agricultural system

which is based on renewable energy and that help to live our whole life easier.

1.1 Related Works:

The authors in [2] designed and implemented solar energy based on precision agriculture with the WSN via IoT architecture to meet the demand of finding highly efficient methods for smart agricultural monitoring and management system. Raghuvanshi *et al.* in [4] suggest a concept and features of the sensor world in the IoTs for agriculture to enhance the production of crops. They introduce the concept of agriculture sticks which are integrated with Arduino Technology, and Breadboard and mixed with different various sensors, and live data feed can be obtained online through mobile phones. However, some typical applications of Agriculture IoT sensor monitoring network technologies using cloud computing are discussed in [5-8]. The authors in [5] also addressed a simple IoT agriculture model with a wireless network to build sustainable smart agriculture. G.Sushanth *et al.* in [6] include the development of a system that can monitor temperature, humidity, moisture, and even the movement of animals which may destroy the crops in agricultural fields through sensors using Arduino board and in case of any discrepancy send an SMS notification as well as a notification on the application developed for the same to the farmer's smartphone using Wi-Fi/3G/4G. The authors Prathibha S.R. *et al.* in [7] implement a technology that can monitor temperature and humidity in agricultural fields through sensors using CC3200 single chip. The camera is interfaced with CC3200 to capture images and send that pictures through MMS to the farmer's mobile using Wi-Fi. The authors in [8] seek to design a product that uses low-power Bluetooth and Low Power Wide Area Networks communication modules for smart farming. MQ Telemetry Transport communication method is used in monitoring and control systems, which is an IoT-dedicated protocol, thereby improving the potential for the expansion of agricultural IoT.

1.2 Contributions:

When we first started working as a collaborative, none of us were very sure about how to move; We knew that for this to work, everyone would require to take their role within the group, but the problem was in searching what those roles should be. As we were in a very small group, everyone's full input was demanded throughout the process. After we conclave, our team has gone through various earlier related works, and we found that a maximum number of papers have been done by using different micro-controllers (Arduino NANO, UNO, etc.) which have the multiple numbers of dis-benefits like it is time-consuming to download and install software which is unable to do any complex multitasking and not compatible with the other operating systems such as Windows. By

following the above complications, we prearranged NodeMCU ESP8266 to eliminate the drawbacks mentioned prior which have integrated Wi-Fi features, are smaller in size, and have low power consumption.

Here we have also used the Blynk app for controlling the system and Thing speak to store the fetched data because it makes it a lot easier to connect both platforms rather than using separate servers, databases and clouds and it is also user-friendly.

2. SYSTEM DESIGN AND OBJECTIVE:

The system architecture consists of a NodeMCU ESP8266 board, Solar powered system, a water pump (submergible pump), a motor driver, and sensors like DHT22/DHT11 (for soil moisture and temperature checking), BC548 IC (for salinity checking), Edinburgh sensor (as a gas sensor), AVR 51 shield with MSP430 Test Code Sensor (for checking the pH level of the soil) as shown in the Fig- 1. Here we want to use the Blynk IoT app to send a notification to the user's smartphone which will show the sensor data and the threshold values of the physical parameters. It will help the user to determine the growth and increase the quantity of the crop. Our proposed system has two consecutive modes, manual mode, and automatic mode. In manual mode, after seeing the data from the app, the user has to go to the field, and then he will take the proper action for it. And in automatic mode, all the actions are done by the system automatically.
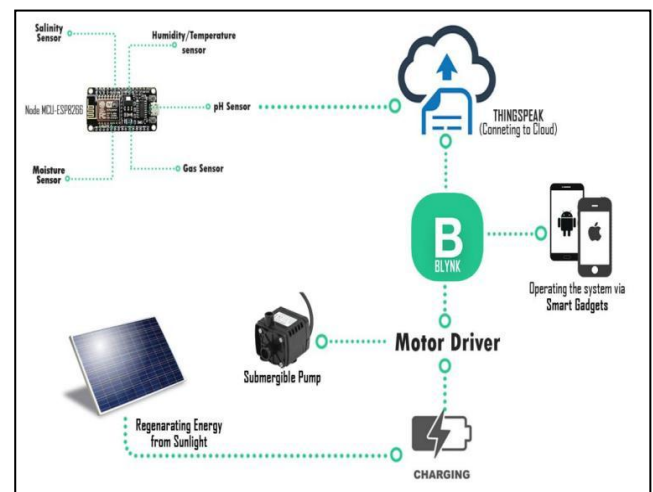

Fig -1: Proposed Architecture for Solar Powered Smart Agriculture System Using WSN Via IoT

2.1 Objective:

The objectives of the smart agriculture policy are to enhance the quality of life for farm families and communities and to increase the production of human food. Designed an agricultural system that is based on

renewable energy (Solar energy) and that help to live our whole life easier, it is a system that will supply some valuable data about soil moisture, water level, humidity, and temperature and as well as the general condition of the crop and the field to the farmers in an easily accessible manner with real-time data communication via IoT. To assist in expanding the output yield of a crop while enhancing efficiency and diminishing the amount of stress placed on a farmer.

3. METHODOLOGY:

The methodology for the development of solar power-based smart agricultural systems using the sensors and microcontroller (WSN) via IoT is presented here aiming to increase the quality and quantity of the crop while optimizing the human labor used.

The proposed system would be done with multiple operations.

3.1 Data Collection

First of all, once turning on the device the motor is going to be connected to NodeMCU, and then the Soil moisture, humidity, temperature, gas, pH and salinity sensor using the system work automatically can be determined by the respective sensor values.

3.2 Diagnostics

The sensor values or the data are analyzed by the system and then all the actions are taken either automatically or manually by the user.

3.3 Decision Making

After the detection of the problem by the system, the microcontroller unit can send the data via the cloud to the Blynk IoT app when the system mode is set to manual mode. From the user's smartphone, then receive a pop notification from the system. And in this notification user can see the sensor data. Once checking this condition, then the user can take relevant action.

3.4 Actions

In this section, the user takes a desirable step to go to the field or it can happen automatically also. If the user sets the operation of automatic mode, then the system can take sensor data and calculate them. If the value determined is desirable for irrigation, then the water pump (submergible pump) will be turned on using a motor driver. On the other hand, if the value isn't desirable for water irrigation, then the system remains turned off and similarly, the rest of the sensors will operate consequently.

Here we use a solar board that is directly connected to the battery, when the power of the battery is not sufficient then the stored power is generated via the battery to run the whole system. In this proposed model we are also using NodeMCU instead of other micro-controllers (Arduino NANO, Arduino UNO, etc.) and other devices which are capable to fetch the data from the cloud, as we wish to use an adequate number of components so that it would be a clean and simple way to represent.

4. SYSTEM OVERVIEW:

A satisfactory project always needs a well-structured and organized system that provides adequate information so that the bookworm has a suitable sense of the capacity of the system, what it can do, what it can interact with as well as any special needs. Designing a comprehensive project system overview requires detailed knowledge of the system or the ability to get that information from different people familiar with the system.

Here we categorized components into two different sections:

4.1 Hardware Specification

In the Internet of Things, hardware comes in many forms, whether the underlying processors control the phones, the sensors collecting information from the physical world, or the edge machines processing and analyzing the data. At the heart of any wired venture is IoT hardware and the technical capabilities of these boards have only become more important as the Internet of Things has developed. But, because of the sheer number of design boards and modules in the room, choosing the right IoT hardware for a project can be daunting. In this article, we will look at different aspects of IoT hardware and see how these devices communicate data to the internet.

4.1.1 Components Required:

4.1.1.1 Salinity Sensor

Salinity Sensor is a sensor that precisely measures the total amount of dissolved salt present in an aqueous solution. The Salinity Sensor measured the conductivity of a solution with a high ion concentration. Here we use the Salinity Sensor BC548(BJT) which shows in Fig-2, to detect the salt water is present or not in the field.

Fig-2: BC548 IC(Salinity Sensor)

4.1.1.2 Humidity and Temperature Sensor

DHT11 is a Humidity and Temperature Sensor that detects the Humidity and Temperature of the crop field environment. DHT11 sensor can measure a humidity value in the range of 20-95% of relative humidity. The Sensor data contains integral and decimal parts for both Humidity and Temperature. The sensor is shown in Fig-3.

Fig- 3: DTH11(Humidity and Temperature Sensor)

4.1.1.3 PH Sensor

Fig-4 shows the MSP430 Test Code Sensor which is used for detecting the pH of the water. We use the pH Sensor because it helps to measure the acidity or alkalinity of the groundwater. When the pH value dips below seven the water is acidic and if the value is above seven then the water is alkaline.

Fig-4: AVR 51 shields with MSP430 Test Code Sensor

4.1.1.4 Gas Sensor

Here we use the Edinburgh gas sensor as FIG. 5 to detect the different types of gasses that are present in the field. Gas sensors are mainly used to detect toxic or explosive gasses and measure gas concentration.

Fig-5: Edinburgh sensor

4.1.1.5 Soil Moisture Sensor

The soil moisture sensor is the most sensitive to the environment usually used to observe the moisture of the soil in the crop field. The moisture sensor can be used to measure the moisture of the soil when the soil is dehydrated and in that case, the module gives a higher output, otherwise, the output will be low. Here we used Grove-Soil Moisture Sensor which is shown in Fig- 6.

Fig-6: Grove-Soil Moisture Sensor

4.1.1.6 NodeMCU

NodeMCU is a microcontroller that has an in-build WIFI module. NodeMCU can send the data via the cloud to the Blynk IoT app. It is shown in Fig-7.
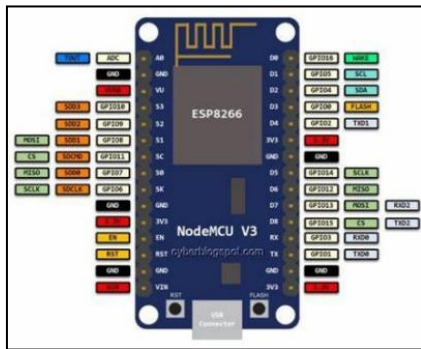
Fig-7: Node MCU ESP8266

4.1.1.7 Motor Driver

We have used L298N dual H-Bridge IC as a motor driver module to pump water for irrigation in the crop field. It can drive DC motors having a voltage range of 5V - 35V, with a peak current of up to 2A. It is shown in Fig-8.
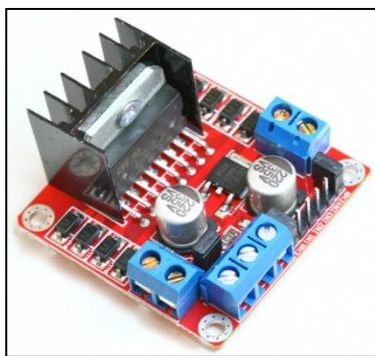

Fig- 8: L298N Motor Driver

4.1.1.7 Solar Panel

Here we have used D165X165 mono-crystalline solar panel as Fig-9 which consists of photovoltaic and the power is stored in a rechargeable battery. Although the initial cost of solar installation is higher than the conventional source of electricity it is suitable for the rural area which is why the solar system is used as a power supplier rather using another conventional source.

Fig-9: D165X165 mono-crystalline solar pane

4.2 Software Specification

This paper provides an outline for IoT Software. IoT is about [Internet + (Sense and Communication)]. Things of things are connected through the internet. Let's take the example of the Mi fitness band- To use this band, a user should install the Mi-fit app to connect to a phone. Band calculates total hours of sleep, the number of calories burned, heart rate monitoring, and sleep analysis. Users can see all the information on mobile phones. Every device, area, software, and sensor is connected, and we can access it through a phone or computer.

4.2.1 Components Required:

4.2.1.1 Arduino IDE Software

Arduino IDE is a software application which is shown in Fig 10 that enables C program to compile and upload to the Arduino board. It is programmed to work with additional types of microcontrollers. Once after compiling and uploading the code, the required action is executed. In this paper, NodeMCU Devkit acts as one of the microcontrollers which fetch the data from the sensors. An ESP8266 The JSON object is imported to complete cross-compatibility between Arduino IDE and NodeMCU framework.
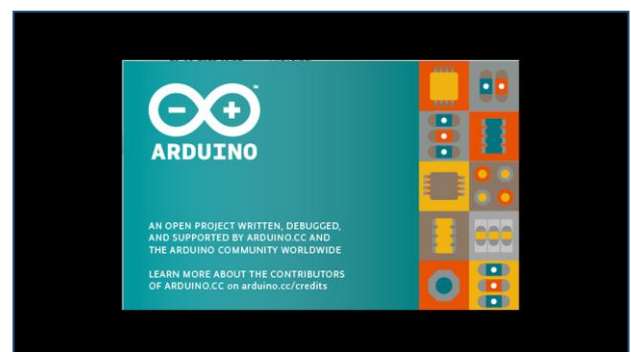

Fig-10: Arduino IDE

4.2.1.2 Thing Speak IoT Cloud platform

Thing Speak IoT which is shown in Fig-10 is used for data visualization. The data sensed by the sensors is redirected to the cloud with the help of microcontrollers. The Data is visualized in the form of graphs and meter gauges.

Fig-11: Thing speak IoT Cloud Platform

4.2.1.3 Blynk IoT Application

Blynk is an IoT platform which is shown in Fig-12, for IOS or Android smartphones that are used to control Arduino, Raspberry Pi, and NodeMCU via the internet.

This application is used to create a visual interface or human-machine interface by assembling and supplying the appropriate address on the available devices.
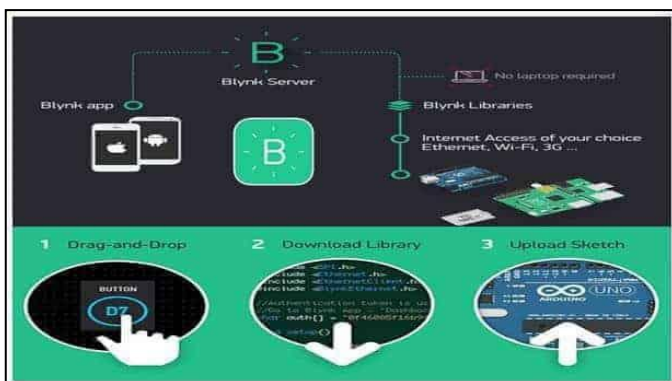

Fig-12: Blynk IoT Application

5. ADVANTAGES AND DISADVANTAGES:

5.1 The advantages of our proposed system are:

5.1.1 Increasing Productivity Rate

It will help to increase the productivity rate of the crops, and also increase the quality of the food. So, this type of system is very helpful in raising the income of the user because in rural areas most of the people are completely dependent on agriculture for their livelihood.

5.1.2 Reduce Harmful Emissions

Here we use the gas sensor, which will detect the increasing rate of unnecessary amounts of any gases which will be harmful. So, it gives us the great benefit to avoid harmful emissions.

5.1.3 Sensors

Various types of sensors are used in the system which will help to detect the desirable number of physical parameters which is needed to grow and increase the quality and quantity of the crops.

5.1.4 User Friendly

Our system is very user-friendly, the user can control the whole system and check the all details using his smartphone.

5.1.5 Using Renewable Energy

We use a solar panel in our system to reduce pollution besides using fossil fuel in the battery.

5.2 The disadvantages of our proposed system are:

5.2.1 Cost

This system is very high in cost.

5.2.2 Weather

In the case of agriculture, most of the procedure is dependent on weather conditions. This is a natural phenomenon, which is not controlled by any type of technology.

5.2.3 Challenges in Spreading the Knowledge

It is a big issue because most of the agriculture fields are situated in rural areas and most of it is controlled by farmers, who don't have the proper knowledge about the technologies. So, we have to spread the knowledge and facilities about this type of system.

6. CONCLUSION AND FUTURE PLANS:

In this study, we proposed an efficient and highly productive IoT-based smart agriculture system that is operated by solar energy. Here we used many types of sensors like salinity sensors, pH sensors, soil moisture sensors, humidity and temperature sensor, etc. That will help us to understand the physical parameters of the field and also the crop. Here we are using a microcontroller

(Node MCU) to make a connection between the circuit, the motor driver to control the water flow from the pipe, the battery, and a solar panel. We are distributing the power by a battery via a solar power system. For obtaining the data related to the crops and the field we are linking the Blynk application to Thing speak (collecting the data from the cloud) and then the user (farmers) can easily access the information and also take efficient care of the food production. In this way, we can upgrade our whole agricultural system which will be reducing farmers' production costs, and labor costs and increase the whole production quantity and quality without having any skilled persons.

In near future, we can use any type of renewable energy besides solar energy as a power source. We can also implement this type of system in the Greenhouse method of harvesting crops. We will be focusing to compact the number and variety of sensors to fetch more data (information), particularly regarding pest control management and integrating GPS modules for predicting weather forecasts to enhance the demand for this agriculture IoT system.

REFERENCES

[1] Rahul Wagh, Dr. Anil P. Dongre, "Agricultural Sector: Status, Challenges and it's Role in Indian Economy", Journal of Commerce & Management Thought, Vol. 7 (2), pp 209-218, 2016. DOI:10.5958/0976-478X.2016.00014.8

[2] Mohammad Samunul Islam, Golap Kanti Dey, "Precision Agriculture: Renewable Energy Based Smart Crop Field Monitoring and Management System Using WSN via IoT", in Proc. IEEE Int. Conf. on Sustainable Technolories for Industry 4.0 (STI), Dec. 2019.

[3] Sebastian Sadowski and Petros Spachos, "Solar-Powered Smart Agriculture Monitoring System Using Internet of Things Devices", in Proc. IEEE 9th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), Nov. 2018.

[4] Durgesh Raghuvanshi, Apurva Roy, and Dr. Vaibhav Panwar, "IoT Based Smart Agriculture System", Int. Journal of Research in Engineering and Science (IJRES), Vol. 9 (6), pp: 12-16, Jun. 2021.

[5] Mahammad Shareef Mekala, Dr P. Viswanathan, "A Survey : Smart Agriculture IoT with Cloud Computing", in Proc. IEEE Int. conf. on Microelectronic Devices, Circuits and Systems (ICMDCS), Aug. 2017.

[6] G. Sushanth, S. Sujatha, "IOT Based Smart Agriculture System", in Proc. IEEE Int. Conf. on Wireless Communications, Signal Processing and Networking (WiSPNET), Mar. 2018.

[7] Prathibha S. R., Anupama Hongal, Jyothi M. P., "IoT based Monitoring System in Smart Agriculture", in Proc. IEEE Int. Conf. on Recent Advances in Electronics and Communication Technology (ICRAECT), pp. 81-84, 2017.

[8] J. Bauer, and N. Aschenbruck, "Measuring and adapting MQTT in Cellular Networks for Collaborative Smart Farming", in Proc. 42nd IEEE Conf. on Local Computer Networks (LCN), Singapore, pp. 294–302, 2017.

BIOGRAPHIES
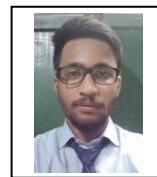
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