Smart Cultivation System using IoT

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Abstract Agriculture plays an essential role in this world. In addition to other nations, India makes up the majority of the world's contribution to agriculture and its linked industries. Eighty-one percent of its farmers are tiny and marginal, providing a source of income for seventy-two percent of its rural households. However, modern agriculture faces many complex challenges, including how to cope with climatic conditions, soil erosion, poor irrigation techniques & poor quality, etc. To overcome these problems, IoT sensors like Soil moisture sensors, Ultrasonic sensors & Bosch's BMP280 environment monitor sensors are used. These sensors allow us to predict temperature, altitude, humidity, soil moisture, atmospheric pressure, etc. Using mobile applications and statistics of the most-in-demand crop at a specific time of year can be analysed. The primary seasonal plants are split into two broad groups, for example, crops sown at the start of the winter season are known as Rabi crops, and crops sown at the start of the monsoon season, are known as Kharif crops. Each crop needs a particular set of climatic conditions to grow well. The goal of the project is to present a Smart Cultivation System that is based on the Internet of Things (IoT). This system will help farmers get real-time data for effective environmental monitoring, which will help them increase production and product quality.

1 Introduction

Today, agriculture is fundamental to the world. India, along with other countries, contributes the majority of the world's output in agriculture and related industries. Seventy-two percent of its rural households depend on the revenue generated by its eighty-one percent tiny and marginal farmers. Agriculture in India is a major geographical problem. 49% of the people in India depend on agriculture. India's total land area is broken down into 141 million hectares of net sown land and 195 million hectares of gross cropped land. The contribution of agriculture to India's GDP, income distribution, and wealth is 14%. It provides needs like human food and animal feed. It provides a substantial supply of raw materials for India's agricultural-based industries. Due to the country's broad relief, varied climate, and varied soil conditions, a variety of crops can be cultivated there. All tropical, subtropical, and temperate crops are grown in India, while the majority of the nation—about two thirds—is devoted to growing food crops. Every crop needs a specific set of climatic conditions to grow well. Certain crops, though, can coexist with those that require the same climatic conditions. The

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principal seasonal plants are separated into two main groups, including Kharif crops, which are sown at the start of the rainy season, also known as the monsoon, and Rabi crops, which are sown at the beginning of the winter season.

However, there are numerous difficult issues that modern agriculture must address, such as how to deal with changing weather patterns, soil erosion, inadequate irrigation practices, poor product quality, etc. IoT sensors like soil moisture sensors, ultrasonic sensors, and Bosch's BMP280 environment monitor sensors are employed to solve these issues. These sensors allow us to forecast a variety of variables, including temperature, altitude, humidity, soil moisture, and atmospheric pressure. Information on the crop that is most in demand at a specific time of year can be researched via mobile applications. The project's objective is to demonstrate a smart cultivation system based on the Internet of Things (IoT). This technology will enable farmers to efficiently monitor their surroundings and obtain real-time data that will help them increase output and product quality.

2 Literature review

IoT-based agriculture monitoring and prediction was proposed by R. Saini and M. Saini. 2020 Sixth Global Meeting on Framework, Equal, and Dispersed Registering (PDGC), The industry with the greatest potential for global expansion at the moment due to the growing population is agriculture. The primary goal of the agriculture industry is to boost farming production and quality without constant physical supervision in order to meet the world's fast growing need for food. In addition to the expanding population, the climate situation presents the agriculture industry with major challenges. The purpose of this research article is to present an IoT-based smart farming model that uses clustering to solve the issue. Each type of sensor used in this method—soil moisture, humidity sensors, rain detection, and air pressure—is used for a particular function. The data will be gathered and automatically analysed on the cloud.

Despite having greater land for agriculture, India's plant productivity isn't higher than the average worldwide. Low plant yields might happen for a variety of reasons. A technologically advanced agricultural support framework is required for productivity increase. The integrated agricultural monitoring system described in this research uses smartphone apps and the Internet of Things. With the help of this technology, farmers may remotely check the pH of the soil, the temperature of the surrounding air, the duration of leaf wetness, and the soil moisture on their farms. By quickly analysing the weather and soil conditions in a specific place where the plant is located, the device offers new insights to impact decision-making. The technology is used and tested in the fields of Islampur, Maharashtra. The suggested instrument is a cost-efficient farming method.

India's economy and population survival both depend heavily on agriculture. The objective of this project is to create an embedded system for soil monitoring and irrigation that will substitute mobile applications for manual field inspection. The technique is recommended as a way to help farmers increase agricultural productivity. Numerous sensors are used to test the soil, including pH, temperature, and humidity sensors. Farmers can cultivate the crop best suited for their soil based on the findings. The field manager receives the sensor values over the Wi-Fi router, and the mobile application suggests a crop. Automatic irrigation is employed in hot weather conditions. The field manager receives an email with pesticide recommendations along with a cropped photograph that was taken.

IoT is an innovative technology that represents the direction of computers and communication in the future. Every business, including smart cities, smart homes, and smart traffic management, is using IoT. IoT may be applied in various industries and has a wide range of potential applications. The application of IoT in agriculture is covered in this essay. The Internet of Things facilitates better agricultural management, resource management,

cost-effective agriculture, increased quantity and quality, crop monitoring, and other tasks. The proposed model employs numerous IoT sensors, including air temperature, soil pH, soil moisture, humidity, and water volume sensors. The essay provides examples of the hardships farmers face as well as the common farming techniques they employ today. The proposed model is a simple architecture of IoT sensors that collect data and send it over a Wi-Fi network to a server, where the server can take appropriate action based on the data.

3 Proposed method

3.1 Problem statement

Lack of information, high adoption costs, security concerns, and other issues are the major obstacles for IoT in the agricultural sector. Identifying the soil characteristics that are suitable for agriculture is one of the most important steps. It is essential to take into account both the soil characteristics and the current environment when deciding which crop is best suited for growing on a specific soil. The creation of a wireless sensor network-based decision-making system capable of managing a broad spectrum of agricultural tasks and provides valuable farming data such as soil temperature, humidity, and moisture content.

3.2 Objective

Real-time data collection, analysis, and distribution are the main goals of an IoT-enabled smart agriculture system. This project aims to provide users with reliable and recent data on soil moisture content, ambient temperature, and humidity. According to the circumstances at hand, it enables individuals to reach wise decisions and perform the appropriate actions. The project helps the user make an early choice about the type of crop that should be grown in a certain area and improves the general efficacy and efficiency of agricultural harvesting activities.

3.3 Architecture diagram
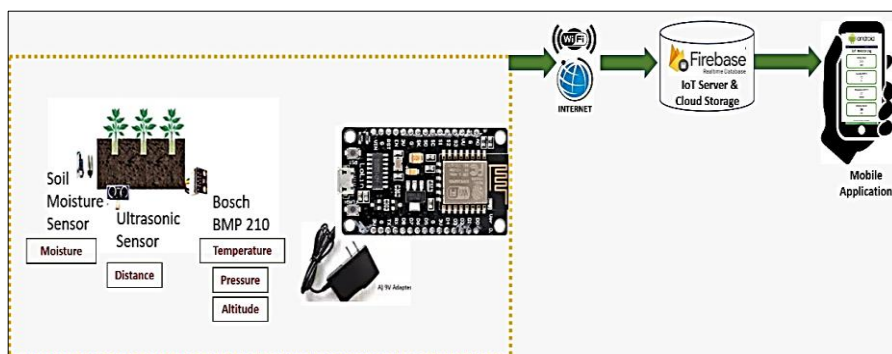
Fig. 1. Smart cultivation architecture diagram.

The project's fundamental ideology can be understood from figure 1. Sensors like soil dampness sensor, Bosch's bmp280 sensor and ultrasonic sensor are associated with ESP 32 board and identify the qualities. Once the sensor finds the values, they are saved in firebase via internet or WiFi connections. A mobile app is developed to make it simple for farmers to access the sensor and read the values it detects. The mobile app is made with Kodular.

3.4 Hardware and software components

3.4.1 Microcontroller ESP32

A cheap and energy-efficient solution with Bluetooth and WiFi is the ESP32 Microcontroller. It replaced the ESP8266, a cheap WiFi microcontroller with constrained features. A power-on-board module, a coordinated receiving wire, an RF balun, a power intensifier, and low-commotion enhancers are among the features of the ESP32. Our ESP32 module needs instructions in order to interact with the sensors and send collected data to the mobile application. A well-known integrated development environment for programming the esp32 is the Arduino IDE.

3.4.2 Soil moisture sensor

Soil moisture sensors can estimate how much water is in the soil horizon by monitoring the soil's water content. Many factors, such as soil types including sandy, clay, loam, and sandy loam, have an impact on the moisture content of the soil. Salts, which incorporate iron, manganese, calcium, phosphorus, nitrogen, and sulphur, are a typical component of soil. The temperature is another factor.

3.4.3 Bosch's BMP280 sensor

The BMP280 is a combined digital pressure and temperature sensor with high precision and low power consumption. It is based on the BMP180, but with a few extra features and improvements. It is designed to be used in a variety of applications, such as weather forecasting, altitude measurement, and indoor navigation. The pressure measurement range is 300-1100 hPa, and the temperature range is -40 to 85°C.

3.4.4 Ultrasonic Sensor

An ultrasonic sensor is a device that determines an object's distance using ultrasonic sound waves and converts the sound's reflection into an electrical signal. Ultrasonic waves travel more quickly than audible sound. The transmitter and receiver are an ultrasonic sensor's primary two parts. In calculating the distance between an object and the sensor, a sensor measures the amount of time between the transmitter emitting sound and making contact with the receiver. The formula for this computation is $D = 12\ T \times C$, where D is the distance and T is the time.

3.4.5 Arduino

The word "Arduino" describes both the software that is used to programme an open-source electronics board. Based on C and C++, the Arduino programming language was created. It aims to make electronics more approachable for creators of interactive environments or objects, including artists, designers, hobbyists, and others. The Arduino IDE will pre-process the code to prevent some unwanted errors, but other than that, it will be written in C and C++. This electronic platform has connections, LEDs, microcontrollers, and a lot more. The Arduino UNO, Red Board, Lily Pad Arduino, Arduino Mega, and Arduino Leonardo are just a few of the many variations of Arduino boards available on the market. A text editor for programming, a text console, a message area, a toolbar with buttons for common operations, and a number of menus make up the Arduino Integrated Development

Environment (IDE). It uploads programmes and communicates with the Arduino hardware. Each Arduino board can be used with the free and open-source Arduino Software (IDE), which makes writing programmes and uploading them to the board simple.

3.4.6 Kodular

A free online toolset for creating applications for mobile devices. It frequently provides a drag-and-drop online Android app builder so that anyone may create any app without writing a single line of code. The procedure for building a Kodular application is simple. The client creates a portable application by moving the options shown on the left half of the screen into the centre of the Versatile screen and positioning them as needed.

3.4.7 Firebase

Firebase facilitates the development of top-notch apps, the growth of your user base, and higher earnings. Each feature can be used independently, but their combined performance is better. The Firebase Realtime Data set is a cloud-enabled NoSQL data set that facilitates real-time information matching and storing between clients.

3.5 Modules and descriptions

3.5.1 Data collection

Gathering the necessary project-related data is the first step in any project's creation. The information in this project is about crops, the best times to plant them, the best soil for them, and the states they are most commonly grown. Rice, paddy, sugarcane, cotton, groundnut, and other crops are among the Kharif crops. From June to July, these crops are planted, and from November to December, they are harvested. Contrarily, Rabi crops like cone, sugarcane, barley, and oats are sown in October or December and harvested in April or June.

3.5.2 Connecting sensors

The next step is to find out what sensors could be used in the project and how they will be used. This project uses the ultrasonic sensor, the Bosch BMP280 sensor, and the soil moisture sensor. The ultrasonic sensor determines the tank's water level, the soil moisture sensor determines the soil's moisture content, and the Bosch BMP280 sensor determines the atmosphere's temperature, pressure, and altitude.

3.5.3 Implementation and mobile app creation

With the help of the Arduino IDE software, it is now time to write some codes to put the project into action after gathering the necessary data.The board module used in this project is esp32. A port connects the board to all of the necessary sensors. The board is connected to the system when the code is compiled and uploaded. The values that the sensors detect will be displayed on the serial monitor. Farmers or users can quickly view the values that the sensors have observed by developing a mobile application. The mobile application was created with Kodular Creator. The Firebase real-time database, which also aids in delivering the data to the user and syncing data for them, maintains the sensor-detected information.

4 Results and discussions

The primary goal of the initiative is to implement IoT-based smart farming by making use of the best sensors, informing farmers about the condition of their crops, and offering stimulation when necessary. This strategy boosts crop productivity by using IoT technologies. Using factors like soil moisture, Bosch's BMP280, and ultrasonic sensors, the soil contents are identified, including its precise soil moisture level, altitude, pressure, temperature, and water level. These qualities have a significant role in determining the appropriate soil conditions. The developed hardware kit for the suggested model is shown in Figure 2.
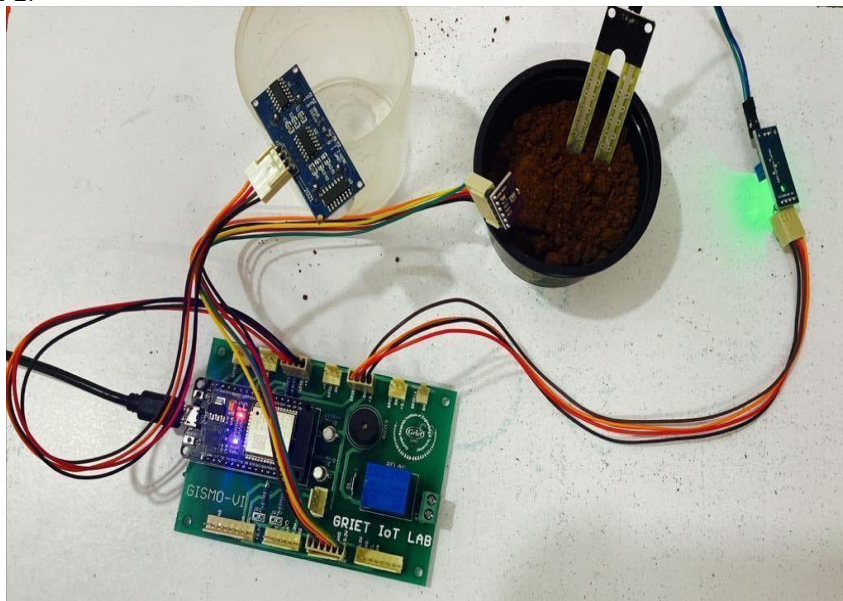

Fig. 2. Project setup.

ARK, which represents Agriculture for Rabi and Kharif Crops, is a Kodular-based app that was made with farmers in mind. The user is given access to a user interface so they can monitor the condition of their crop. When a user first launches the app, screen1 is displayed. When he selects the ARK button, screen 2 appears. This panel has buttons for seasonal crops, soil moisture, water level, temperature, pressure, and height. For instance, screen 3 will open if the user clicks on the "soil moisture" button, allowing them to see the current soil moisture level and choose whether the motor is ON or OFF. The user can see screen 5 and see the current atmospheric temperature by clicking the "temperature" button.

Likewise, screen 8 displays a few examples of yields that are grown during a specific season when the customer selects the "Seasonal Crops" button. Crops including rice, maize and other similar crops are grown from June to December, whereas wheat, oats, and chickpeas are grown from December to June. Applying IoT technology to agriculture to address crop quality issues, pesticide needs, farm management issues, and weather issues. It represents a step toward raising output in terms of both high quality and profitability. Intelligent livestock tracking is achievable when an innovative farming solution is incorporated into your agricultural enterprise. Additionally, geofencing makes it easier for farm managers to know where their livestock is at all times. The tool can begin to analyse a location's soil and meteorological conditions. The technology is very accurate and efficient in getting current information on soil moisture and meteorological conditions.
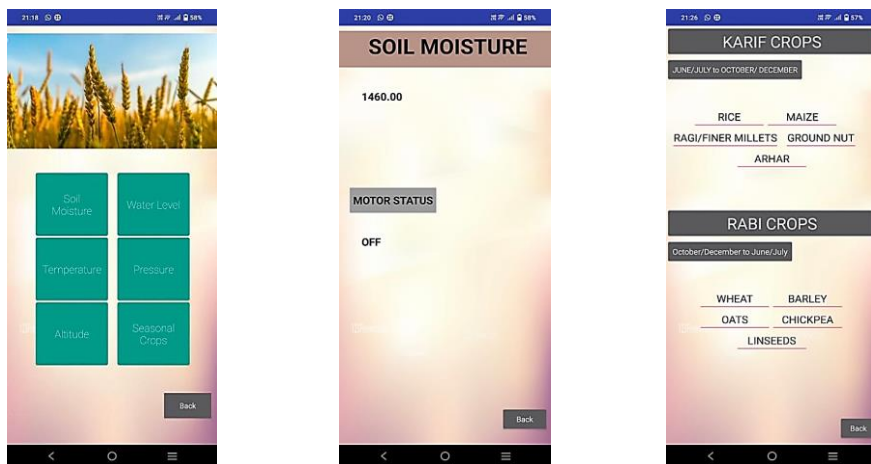
(a) Screen 2. (b) Screen 3. (c) Screen 8.

Fig. 3. Mobile application.

5 Conclusion

Agriculture is the economic backbone of every nation. In order to meet the basic needs of humanity, agricultural production has been improved in both quantity and quality thanks to modern technologies. To ensure the successful harvest of any nutrient-rich crops, analysis and monitoring of a wide range of environmental variables, including pressure, humidity, soil moisture, and water level, is required. This process depends heavily on the Internet of Things and other sophisticated technology. This documentation offers an in-depth comprehension of how soil qualities based on the internet of things effect agricultural productivity. Several low-cost smart technological developments are being looked into in the agriculture sector to improve farmers' traditional farming methods and way of life. The initiative's main objective is to streamline monitoring and eliminate the need for farmers to constantly check on their crops. One solution to this is intelligent agriculture. Modern sensors and analysis tools are used in precision agriculture to increase crop yields and generate reliable results. Farming has traditionally been used to increase output, reduce labour costs, and ensure effective management of irrigation and fertiliser. With the aim of increasing resource productivity, precision agriculture is a cutting-edge innovation and field-level management technique.

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