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Identification of Soil Features Suitable for Barley, Maize and Sugarcane Cultivation using Precision Agriculture

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Abstract. Agriculture plays a crucial role in a nation's economy by significantly contributing to its Gross Domestic Product (GDP). Improved methods of farming not only benefit farmers by lowering their workload but also boost crop yields. Identifying the optimal soil for each crop is essential for producing harvests of the highest quality and quantity. Precision farming in agriculture uses Internet of Things (IoT) technology to ensure the most efficient use of available resources to increase crop yields and reduce operational costs. It reduces instances of crop failure and aids in averting catastrophic losses. Variations in soil temperature and soil moisture have the most significant influence on crop yield. The Soil Moisture Sensors calculate the soil's total volumetric water content. Using the BMP280 absolute barometric pressure sensor, it is possible to get accurate temperature and air pressure measurements. In the paper, the primary purpose of precision agriculture usage is to determine the optimal soil characteristics for the production of Barely, Maize and Sugarcane crops.

1 Introduction

Agriculture and related industries are without a doubt India's principal source of income. This is particularly prominent in rural areas of the country. Agriculture is the growing and harvesting of plants for various uses. Sustainable agriculture is vital for global rural development, along with rural employment, food security, and eco-friendly practices including biodiversity preservation, soil conservation, and natural resource management. India has seen the blue revolution, the yellow revolution, the white revolution, and the green revolution in agriculture and related areas. In order to be successful in the agriculture business, it is vital to consider a number of key elements or qualities. Water is a vital component of agricultural productivity and a need for food security. Irrigated agriculture accounts for around 20% of the world's farmland yet produces 40% of the world's food. When compared to rain-fed agriculture, the productivity of an irrigated field is at least twice that of a rain-fed field, opening up new possibilities for crop variety and expansion. Irrigation is essential to maintain high agricultural yields and continue crop production in

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dry places. As a significant source of production, irrigation provides an excellent replacement for monsoons in Indian agriculture. Productivity is affected by a number of other factors. As a result, agricultural automation is necessary to address these challenges. It has been used in research, but farmers are not offered it as a commercial commodity to help them recoup their costs. The use of automated machinery in agriculture has the potential to boost output.

The Internet of Things (IoT) is spreading rapidly in many industries, including manufacturing, healthcare, and automobiles. It provides a variety of food production, distribution, and storage options that may increase India's food supply per capita. Sensors that provide information on the state of soil nutrients, moisture levels, and other factors that may be utilized to progressively increase crop yields. When assessing the viability of a crop in a certain place, climate is one of the most significant considerations to take into account. Climate has a considerable effect on the potential yield of a crop. Climate accounts for over fifty percent of crop variation. The three most significant climate influences on crop growth, development, and yield are solar radiation, temperature, and precipitation. The temperature range necessary for the maturation of a plant's productive components is separate from that required for flowering and the production of flowers. Flowering and flower development need a somewhat narrower temperature range. In two unique ways, temperature regulates the germination of seeds. Temperature affects the germination rate of seeds and might cause a plant to fall dormant.

2 Literature survey

Due to the rising population, agriculture is now the industry with the most global growth potential [1]. In order to meet the rapidly rising demand for food, the agriculture sector's key task is to increase farming productivity and quality without continual physical supervision. In addition to the growing population, the climate situation poses significant difficulties for the agricultural sector. The objective is to provide a smart farming model based on the that uses clustering to address the problematic situation. Each type of sensor is used for a specific purpose, including soil moisture, air pressure, rain detection, and humidity sensors. The data will be gathered and automatically analysed on the cloud. Crop management, the gathering and automatic interpretation of useful data are all components of smart agriculture. The goal of this study is to show how the IoT may be used to monitor climate, soil conditions, humidity, temperature, and water delivery to fields. This study describes an IoT-based Smart Farming System that integrates various sensors and a Wi-Fi module to produce a live data feed that can be accessed online. Its drawback includes, expensive and poor internet connectivity.

Agriculture uses the IoT technologies a lot these days [2]. a project that leverages the Internet of Things (IoT), where all information can be accessed and managed at the touch of a finger, to reduce water consumption in the agricultural sector. A few sensors were used in the system development, including the soil moisture sensor to measure soil moisture, the humidity and temperature sensor to track early symptoms of temperature changes, and the pressure sensor (BMP 280) to gauge surrounding pressure. These sensors are interconnected and connected to a Wi-Fi module (Node MCU) to increase the sensitivity of the irrigation system. The gathered information will be transferred to the cloud and presented as graphs on the app and website. The app's features include displaying sensor readings and controlling the water pump in case of an emergency. In conclusion, the project was able to achieve all of its goals in terms of water usage, low project costs, labor efficiency, and dependability. It drawbacks are;

- Expensive
- Inaccurate Results

- Possibility for wrong Analysis of Weather Conditions

The Internet of Things (IoT) is a network of shared physical items that, with an Internet connection, may communicate with one another [3]. Smart agriculture increases crop productivity by reducing waste and making effective use of fertilizer. A system is created to manage irrigation and monitor crop fields utilizing sensors (soil moisture, temperature, humidity, and light). Wireless transmission is used to send sensor data to a database on a web server. Data is encoded in JSON format and stored in the server database. If the field's moisture and temperature drop below the critical point, the watering is automated. Along with watering, light intensity management can be automated in greenhouses. Farmers' cell phones receive the notifications on a regular basis. Farmers may check on the state of their fields from anywhere. In places with limited water supplies, this system will be more practical. This system is 92% more effective than the standard method. Its drawbacks lies at expensive. An integrated agricultural monitoring system powered by Internet of Things and smartphone applications is described in this paper [4]. With the help of this technology, farmers are able to remotely monitor the soil moisture, length of leaf wetness, soil pH level, ambient temperature, and humidity on their properties. By quickly assessing the weather and soil conditions in a particular place where the plant is located, the technology delivers new insights to affect decision-making. The technique is used in the fields of Islampur, Maharashtra, and tested there. A cost-efficient and productive agricultural method is the advised tool. Its drawbacks are as follows.

- Poor internet connectivity
- Inaccurate Results
- Possibility for wrong Analysis of Weather Conditions

3 Proposed method

Identifying the properties of the soil that are suitable to agriculture is one of the important Aspects. To identify which crop is suitable for cultivation on a certain soil, it is important to take into account both the soil's characteristics and the current environment. To develop an efficient decision support system using a wireless sensor network that manages a variety of agricultural operations and delivers pertinent farm data about soil temperature, humidity, and moisture content.

The increasing water level is a result of weather conditions. It is damaging to agriculture since farmers face several diversions. Farmers use the smart phone application SoilCheck for both Automatic and Manual water level management. Agriculture is a very labour-intensive industry. We have used precision agricultural methods to determine the best soil for Barely, Maize and Sugarcane cultivation. Using IoT, a network of sensors is created that handles multiple agricultural processes and provides data about altitude, temperature, humidity, and soil wetness. A soil moisture sensor is used to determine the volumetric water content of the soil. Soil moisture sensors may not monitor soil moisture rapidly. Instead, they see changes in a distinct soil characteristic related to water content. One kind of sensor that is used in the process of determining the volumetric water content of the soil is known as the soil moisture sensor. The removal, drying, and subsequent weighing of soil samples are required for direct gravimetric measurements of soil moisture. These sensors determine the volumetric water content by replacing the moisture content with electrical resistance, neutron interaction, dielectric constant, and other soil characteristics. Absolute barometric pressure sensors, such as the BMP280, are very useful in mobile applications. Due to its diminutive size and low power consumption, it is used in battery-powered gadgets including GPS modules, mobile phones, and watches. Based on Bosch's proven piezo-resistive pressure sensor technology, the BMP280 boasts a high degree of accuracy and linearity, long-term stability, and outstanding EMC resilience. A vast array of device operating options maximizes versatility. Optimizing filter performance, resolution, and power consumption. Using this Atmospheric Sensor Breakout, model number BMP280, to detect temperature and barometric pressure is the smallest, least cheapest, and most space-efficient method. The sensor data is stored on the firebase and sent to the farmers through SoilCheck. Based on the ideal value readings and the current data readings, the farmer evaluates if the soil is appropriate for the desired crop. When the soil is ready, the application sounds an alarm to notify farmers.

As seen in the architecture diagram shown in Fig 1. Initially, the best values for Barely, Maize and Sugarcane crops were determined by perusing many study publications. These optimum values are kept as the threshold values for the sensor readings. Using SoilCheck, the user can assess if the soil is suited for the selected crop. Barely, Maize and Sugarcane are the crops focused upon. Users may choose the crop they want to produce before comparing the ideal and present readings to get the best reading for crop development. The Soil Moisture sensor is used to monitor the soil's water content, whilst the BMP280 sensor analyses the area's air pressure, relative humidity, and temperature, in order to validate the soil characteristics that have been considered. The sensor's readings are stored in the firebase and shown through the mobile application- SoilCheck. The present measurement is compared to the threshold readings defined for each crop to determine whether the soil is suitable for the chosen crop. The user is informed whether or not the current measurements surpass the threshold value and whether or not the field is appropriate for growing the selected crop. For the implementation of the project there are 3 Modules that should be worked on. They are,

1. Data Collection and User Interface Module
2. Reading Sensor Values Module
3. Notification Module

3.1 Data collection and user interface module

To identify the exact best reading of the Barely, Maize and Sugarcanecrop based on the factors considered, a comprehensive literature analysis was done. For the user's convenience, a mobile application has been built via which they can quickly access the readings and determine whether or not their soil is appropriate for cultivating the chosen crop.

3.2 Reading sensor values module

Using sensors, the soil is analyzed depending on the user's chosen crop to decide whether or not it is appropriate for cultivation. Soil Moisture Sensor and BMP280 sensor were used in order to determine the appropriateness. Soil Moisture sensor was used to monitor the soil's water content,whereas BMP280 sensor was utilized to measure atmospheric pressure, humidity, and temperature. Once readings are collected from the sensors and uploaded to the firebase, the farmers may access the information through the application, which shows the values on the firebase. Further, sensor readings are compared with the ideal value for the chosen crop, deducing that the soil is acceptable for crop production.

3.3 Notification module

If the current readings are found to tally with the optimal values then it means that the soil is suitable for cultivation. In this case the farmer is notified and as well on the application he is alerted with the message stating that his soil is suitable for cultivation.

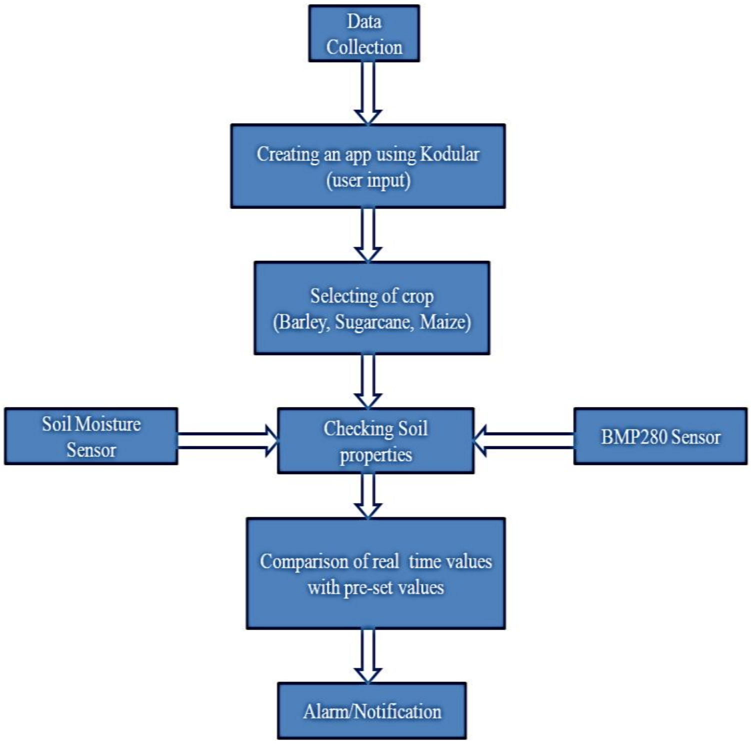

Fig. 1. Architecture diagram.

4 Results and discussions

The values of Barely, Maize and Sugarcane crops farmed in different regions of India are included in the statistics compiled. The largest significant producers of Barley in India are Rajasthan, Uttar Pradesh, and Madhya Pradesh. About 78% of India's total Barley production is produced in these three states. However, Andhra Pradesh (20.9 %), Karnataka (16.5 %), Rajasthan (9.9 %), Maharashtra (9.1 %), Bihar (8.9 %), Uttar Pradesh (6.1 %), Madhya Pradesh (5.7 %), Himachal Pradesh (4.4 %) produce the most maize in total. Approximately 80% of India's total production is contributed by these eight states. The largest significant producers of Sugarcane are Uttar Pradesh, Maharashtra and Karnataka. About 80% of India's total Sugarcane production is produced in these three states. Various research on Barely, Maize and Sugarcane were consulted to determine the optimal value ranges for these three crops. When considering factors suitable for Barley cultivation, it is found that the soil moisture content should be approximately in the range 35 to 45 percent. Temperature should range from12°C to 25°C. The suitable atmospheric pressure found is always under 10 atm. Humidity of area to be approximately in range 90 to 97.7 percent. The readings have been analysed and taken from various research papers and articles (Source [7]).

When checking for factors suitable for Maize cultivation, it is found that the soil moisture content should be approximately in the range 30 to 70 percent. Temperature should range from 12°C to 35°C. The suitable atmospheric pressure found is always under 10 atm. Humidity of area to be approximately in range 60 to 80 percent. The readings have been analysed and taken from various research papers and articles (Source [5] and Source [6]).

When checking for factors suitable for Sugarcane cultivation, it is found that the soil moisture content should be approximately in the range 30 to 70 percent. Temperature should range from 27°C to 38°C. The suitable atmospheric pressure found is always under 10 atm. Humidity of area to be approximately in range 45 to 65 percent. The readings have been analysed and taken from various research papers and articles (Source [8] and Source[9]). Precision agriculture is used to discover the soil characteristics ideal for barley, maize and sugarcane cultivation. Utilizing Internet of Things (IoT) technology, this system enhances agricultural production via smart farming depending on soil conditions. Regularly, the network server collects and transmits sensor data, which is then analysed and recorded in Firebase to display via SoilCheck. The setup of the project for testing is depicted in Fig 2. The ideal growing conditions for Barely, Maize and Sugarcane are determined by the moisture and humidity of the soil, as well as the temperature, atmospheric pressure, and altitude of the area. These features contribute to the process of establishing the environmental conditions that are most favorable for agricultural output. These factors are essential in determining the best possible conditions for the soil. These data are derived with the assistance of the Soil moisture sensor and the BMP280sensors. The maximum moisture capacity of the soil may be measured using a soil moisture sensor, which is helpful for controlling irrigation. The parameters obtained during the process are shown in the below Figure 3. The data shown on the serial monitor is likewise stored in Firebase and displayed there. Firebase provides real-time readings. The Firebase Real time Database enables the development of robust, collaborative apps by offering safe database access directly from client-side code. Even when the user is not connected to the internet, local data storage and real-time events continue to occur, resulting in a responsive experience. The real-time data that we have obtained from the sensors can be seen in Fig 4.

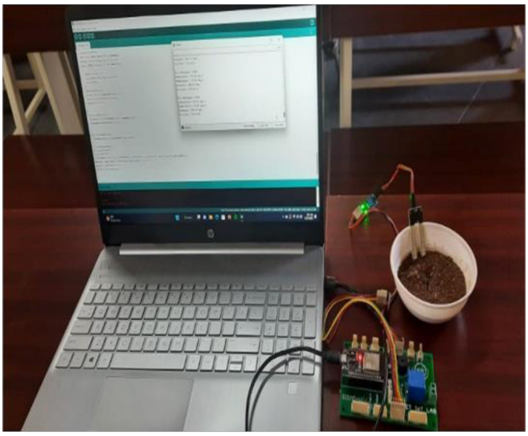

Fig. 2. Project setup.

The measured parameters such as soil moisture, humidity, atmospheric pressure, temperature and altitude are displayed in an application. When the parameters are equal to the preset values then the farmer receives an alarm with a notification 'Suitable for cultivation'. When the parameters are not equal to the preset values then the farmer receives a notification 'Not Suitable for cultivation'. When farmers click on Barley, the application compares the displayed values with the preset values of Barley. If the values are matching then it automatically rings an alarm and sends a notifier stating that the soil is suitable for cultivation. The Barely, Sugarcane and Maize readings page as chosen by the user is shown in Fig 6,7 and 8 accordingly.

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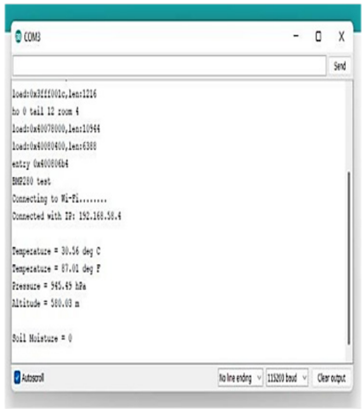

Fig. 3. Arduino serial monitor output.

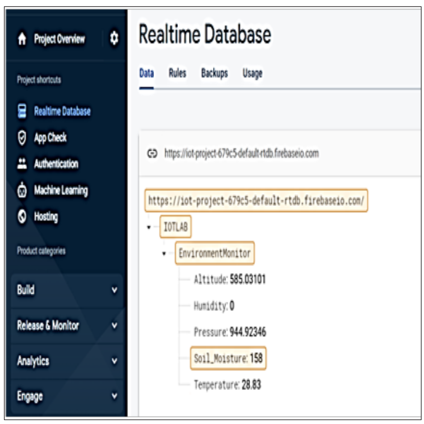

Fig. 4. Firebase display.

Fig. 5. Soil check homepage.

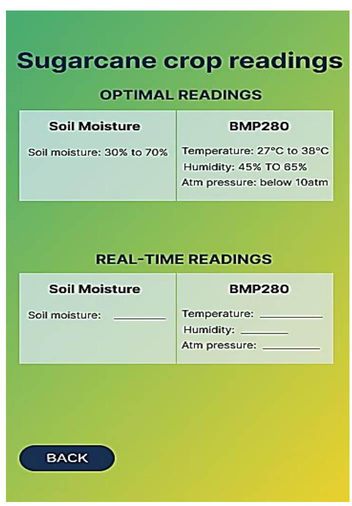

Fig. 6. Notification of Sugarcane crop.

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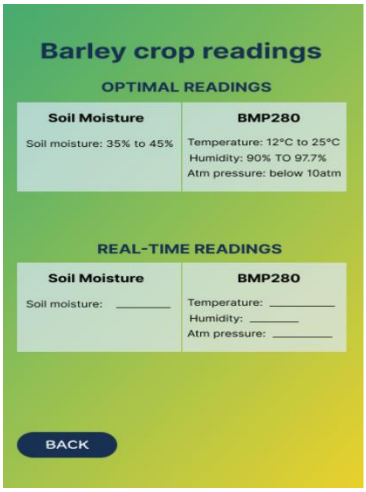

Fig. 7. Notification of Barley crop.

Fig. 8. Notification of Maize crop.

5 Conclusion

Precision agriculture technique is used to identify the optimal soil for Barely, Maize and Sugarcaneproduction. Using the Internet of Things, a network of sensors is constructed that manages several agricultural operations and provides data about altitude, temperature, humidity, and soil moisture. The system designed collects environmental data such as temperature, soil moisture and humidity through a wireless sensor network, with the sensor node to understand the farm's characteristics and the monitoring apparatus. The Soil Moisture sensor monitors the soil's water content, while the BMP280 sensor analyses the area's air pressure, relative humidity, and temperature in order to validate the considered soil properties. Through the Soil Check application, the farmer is presented with the sensor's data. On the basis of the farmer's selection of crop, the optimal value readings and the live data readings from sensors of the specific crop are compared, and a conclusion is produced on the crop's suitability. When the readings matched, the application sounded an alarm to alert farmers that the soil is ready to be tilled. For future developments, the range of crops available to be cultivated can be expanded to give farmers a variety of alternatives. Integrating a camera in farmland so the farmer may monitor his field in real-time would enhance agricultural practices. Hence reducing the likelihood of crop theft and agricultural destruction.

References

1. Mohit Kumar Saini, Rakesh Kumar Saini, *Agriculture monitoring and prediction using Internet of Things*, in Proceedings of the 2020 Sixth International Conference on Parallel, Distributed and Grid Computing (PDGC), (2020)
2. Nurulisma Ismail, Sheegillshah Rajendran, Wong Chee Tak, Tham Ker Xin, Nur Shazatushima Shahril Anuar, Fadhil Aiman Zakaria, Yahya Mohammed Salleh Al Quhaif, Hussein Amer M. Hasan Karakhan and Hasliza A. Rahim, *Smart irrigation system based on Internet of Things*, in Proceedings of the Journal of Physics:

Conference Series, vol. 1339, International Conference Computer Science and Engineering (IC2SE) 26–27 April 2019, Padang, Indonesia, (2019)

3. P. Rajalakshmi, S. Devi Mahalakshmi, *IoT based crop-field monitoring and irrigation automation*, in Proceedings of the 2016 10th International Conference on Intelligent Systems and Control (ISCO), INSPEC Accession Number: 16429444, (2016)
4. Manoj A. Patil, Amol C Adamuthe, Dr. Anantkumar J. Umbarkar, *Smartphone and IoT Based System for Integrated Farm Monitoring*, Book: Techno-Societal, (2018)
5. Maize Water Management, https://www.ikisan.com/tg-maize-water-management.html
6. Maize, https://farmer.gov.in/m_cropstaticsmaize.aspx
7. Barley Section-4, Plant growth and physiology, https://grdc.com.au/
8. Weather Conditions Suitable for Sugarcane Crop, https://indiaagronet.com/communi ty/specificfa rmers/Weather%20conditions.htm
9. Sugarcane - Soils And Climate, www.ikisan.com/ap-sugarcane-soils-ndclimate.html