Intelligent Farming System With Weather Forecast Support and Crop Prediction

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***Abstract*—Agriculture has been a primacy of the Indian economy. Even though it is a main source of income for a majority of the Indian population, it still stands technologically backward. To quash the problems of farmers, the proposed system helps employing a smart irrigation system in the field of agriculture. In the proposed system, we have used state-of-the-art technology to provide the water to the agricultural field based on the soil moisture value, which is detected using IoT sensor. The information received by the sensors is sent to the micro-controller. The system is activated using the mobile application, this can be accomplished with the help of ON/OFF buttons provided in the application. Also, this system when switched to automatic, it irrigates the field to a particular threshold soil moisture value when the soil moisture is low. The pump is switched ON based on the moisture content. Further, the system also provides data of the previous year's crop production in a particular area and weather forecast through an android application. This application also provides information about the latest agriculture advice, Government schemes for farmers, latest market prices, various farming tips in regional language.**

***Index Terms*—Intelligent Farming, Farming, Smart Farming, Digital Farming, Smart Irrigation System, Automation in farming, Sensor based irrigation.**

I. Introduction

In the past decades, the world has seen a proliferation in terms of intelligent devices, still the agriculture sector is far behind in terms of technology. The pace of technical improvements in the field of agriculture has been dawdling comparatively, which is impairing the condition of farmers with time. Even though 215.6 million acres of Indian land is used for harvesting crops, and agriculture contributes 15.4 percent to Indian GDP, the financial condition of farmers has not been good in India [1]. In the past couple of years, we have seen many cases where the farmers have to face miseries due to unawareness of the rain forecast or over-harvesting of a particular crop. Although the government has been consistently trying to improve the condition of farmers in the nation still the improvement has not been noticeable. The government has proposed many schemes to improve the condition of farmers like PM-KPY, PM-KISAN, etc. But till the time modern technology is not used and the efficiency of work are not improved the output of the fields will remain low. Also, as the amount of freshwater that can be used for harvesting of crops is decreasing due to the increase in water pollution, the efficient use of resources has become a necessity. The modern world is changing with technology. The implementation of technology in farming fields can help in diminishing the mass of crops that rots due to overwatering of fields. Our intended stakeholders would mainly be Farmers who solely depend on agriculture as their occupation but, it could also be used by people who possess the hobby of small-field gardening, in their respective households. The concept of Smart Farming came with the advances in computer science and technologies [2] which in-turn arrived with the advances in transmission of data from agriculture, within an overall virtual environment. [3].

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In the past two decades, there have been several researches in this field but most of them have resulted in increasing the cost of production significantly. The price comes forward as one of the main priorities for the farmers in India, considering this we have come forward with a system to ease the farming practices. The proposed system aims to ease the farming practices, by providing the farmers with an automated irrigation system, government schemes regarding farming practices, soil moisture content, suitable crop prediction, and weather forecast. The system performs a periodic check and forwards the moisture report to the farmer. The system also provides the farmer with a feature to manually turn the sprinklers on and off and an inbuilt feature of a timer is provided in the application to create a reminder of the time for which the farmer needs to irrigate the field manually. The proposed system switches from automatic to manual mode in case the weather prediction is rainy. Also, the farmers are provided with the previous year's data about the amount of each crop harvested in past years.

In this section, we have discussed the situation of farmers in India. Section II of this paper describes the current technologies and researches in this field, section III describes the proposed system techniques, further section IV describes the implementation of proposed the system, and the proposed system is concluded in section V.

II. LITERATURE SURVEY

The latest state of art reveals that some tools to automate farming practices are available in the market. The present technology provides an automated irrigation system based on the soils' current moisture value. Farming practices are a major source of livelihood in many countries like India, where 70 percent of the rural households depend upon agriculture. Introducing digitalization in farming practices can ease the work of farmers in many ways. We have studied several research papers in this domain and found that few researchers have used GSM and GPRS technology to provide smart farming solutions, while few have used wired connections with different IoT devices and microcontrollers. We first discuss research proposals using GSM and GPRS technologies: Lihua Zheng et.al. has proposed a system "Development of a smart mobile farming service system". This system uses WSN, GPS, and GIS technologies [4]. It also integrates PDA, GPRS, and Zigbee coordinator module. The data is exchanged with the host PC using GPRS. This system visualizes the farming information and offers irrigation decision based on the data in real-time. Shabadi et.al. has proposed a system "Irrigation Control System Using Android and GSM for Efficient Use of Water and Power" [5]. This system used GSM technology to control the system which ended up increasing the cost of the whole system so to over-come this we proposed a system that uses the Arduino UNO board which is combined with the WIFI module.

Another work proposed by Pavithra et.al. describes a GSM-based irrigation system that uses water from a storage tank [6]. The system comprises a three-water-level indicator (low, medium, and high) and uses an ARM7 microcontroller that is a Reduced Instruction Set Computer (RISC) and multiple soil moisture sensors. The proposed system is built keeping in mind the idea to keep the production cost minimal [6]. Later, Mahadik et.al. has proposed a system which determines the saline content of soil and water, it helps the farmers to manually turns ON/OFF the motor using GSM so that use of water resources can be done efficiently [7]. Some of the proposed research work using other technologies include A wireless application for automating drip irrigation with the help of soil moisture sensors proposed by Dursun et.al. [8]. In the proposed work, irrigation decision is made based on soil moisture values but extend to this, the proposed system provides several features such as crop suggestions, weather forecasting, and news related to agricultural schemes. Later, Yoshikawa et.al. proposed a system based on the wireless sensors and the low-cost wireless controlled irrigation that works on real-time monitoring of the water content in the soil. It works on the solar-powered energy and aims to prevent the moisture stress of trees and increase the efficiency of the use of freshwater resources [9]. Arun. C. et.al. has proposed "Agricultural Management using Wireless Sensor Networks - A Survey" [10]. They proposed a system that turns the pumping motor ON and OFF by detecting the moisture content of the earth [10]. The implementation involves the use of a high-end PIC microcontroller, low-power multi-channel nRF905 transceiver chip. The system monitors the flow of water in real time with the sensors that send the data to the monitoring room and the further process is carried out. [10]. Similarly, R.Vagulabranan et.al. has proposed a system of automated irrigation mechanism using an Arduino board ATmega328 microcontroller, which switches the pumping motor ON and OFF on the bases of the comparison between soil moisture value detected using soil moisture sensors and the database values [3]. Another system supports Smart Irrigation by automatically irrigating the field if the soil moisture is below the threshold limit and send a message to the farmer. The system uses an Arduino-Uno microcontroller based on ATmega328 and an LM393 comparator that converts analog data to discrete [11].

Wenju Zaho et.al. has designed the Smart Irrigation System Based on LoRa. The data exchange is done via the cloud through LoRa gateways using wireless transmission. This system can be controlled remotely by mobile application [12]. Later, Dasgupta et.al. has proposed a system "Smart Irrigation: IOT-Based Irrigation Monitoring System" which detect humidity, temperature, amount of pollutants like PM2.5, PM10, etc. in the soil and compare all these factors to the past records in the dataset in order to predict whether the field should be irrigated or not, this would help in detecting the amount of water to be released in the field [13].

Later, Wolfert, Sjaak, et. al. proposed a system that shows how the information and communication technology can be used in the cyber-physical farm management cycle [14]. State-of-the-art technologies such as the Internet of Things and Cloud Computing are used for development and introduce more robots and artificial intelligence in smart farming. With the help of the phenomenon of Bigdata, large volumes of data with a wide variety that can be captured, analyzed, and used for decision-making [14]. The above-mentioned systems use multiple technologies that would be helpful in the proposed system. But the use of the technologies in the above system increases the manufacturing cost of the system significantly. Pricing of a system related to farming matters a lot in countries like India where the condition of the majority of farmers is not prosperous. By referring state of art, we observed that there is a need for an efficient irrigation system that must display soil moisture values, crop suggestions, weather forecasts, and also automatically switch the motor ON/OFF by considering soil moisture values along with manual controlling of a water pump. To the best of our knowledge, no such system exists with all integrated features. We propose a system that includes all of the above stated essential features of an irrigation system to make it work intelligently. **The major contribution of the proposed work is:**

A. The proposed system provides one stop solution for farmers that resolves their problems with ease of use facility. The proposed system includes following features:

*1) **Crop harvesting options:** The proposed system will provide the farmer with appropriate crop choice for the field.:*

*2) **Prevent excessive watering:** This feature will turn off the irrigation system the moment the soil moisture value reaches to the threshold limit.:*

*3) **Ease of watering:** The proposed system allows the farmer to turn ON/OFF the irrigation system with the help of WIFI network.:*

*4) **Weather forecast:** This feature provide the farmers with the weather forecast of the same day and next two days with details such as humidity, temperature, etc.:*

*5) **Rain forecast**: The system will shift from automatic to manual in case if the weather forecast is rainy in order to prevent the over watering of the field.:*

B. **Digitalization:** The use of technology will result in digitalization of the sector providing a further ground for development in the field and easing the farming practices.

III. PROPOSED TECHNIQUE

The proposed system will provide ease to farmers in terms of irrigation, by providing an automated irrigation system, weather prediction, and notification regarding new government policies. The proposed system suggests the farmers about crops that are suitable for a particular region and the amount in which they were harvested last year for better results. Fig.1. highlights the features of the proposed system.

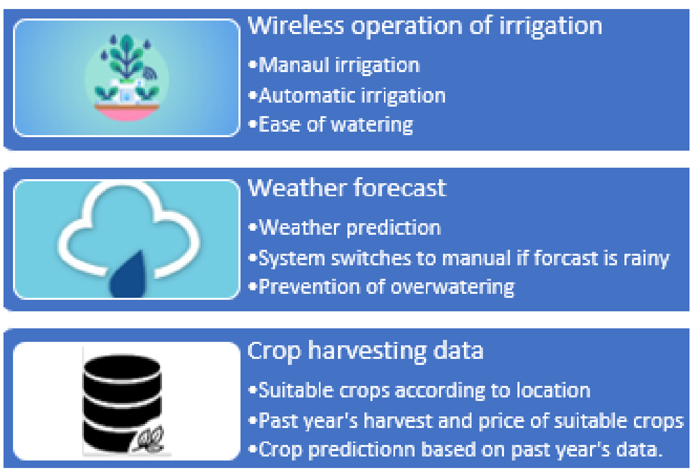


Fig. 1: Features of the Proposed system

The system also provides a feature of switching the irrigation system from manual to automatic. The intelligent farming system aims to introduce automation and digitalization in the field of farming by providing the farmers with the latest weather predictions and suitable crops for their field using past year's data and records. The proposed system will switch the system from automatic to manual in case the prediction for weather is "Rainy". This is done using an Application Program Interface (API).

Also, the proposed system provides the farmers with the data of past years' crop harvest and the government's suggestion regarding the crops that should be grown in the area, this is done using prediction analysis technique based on the past year's data. Hence stabilizing the production of crops and thereby decreasing the crop wastage and major fluctuations in the price of crops.

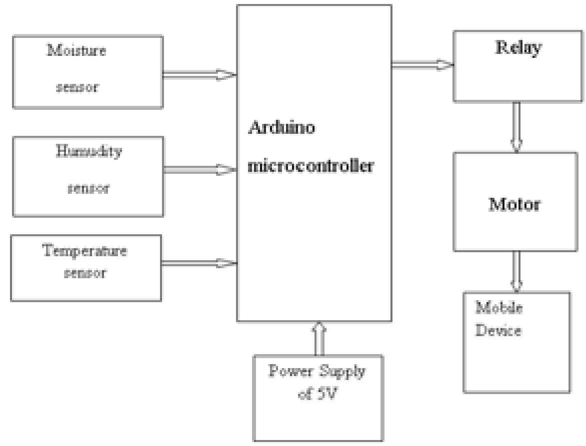


Fig. 2: System Architecture

The soil moisture sensors is being used to detect the soil moisture from the soil and then it is compared with the threshold value that has been set. The threshold value is to be decided based on the agricultural database in the system that has been built based on the type of soil and crop. The soil type of the farm is detected based on the GPS location of the field that farmers have selected for crop harvesting. Fig.2. shows the basic architecture of the proposed system. The soil moisture sensors shown in the architecture are used to detect the moisture from the soil and send the information to the micro-controller and so is be the function of temperature sensor and humidity sensor. The processing and decision-making tasks are performed in the micro-controller and the signal is sent to the relay to switch the water pumps on/off. We now explain the overall working of the proposed system. Figure 3 shows the level 0 DFD of the system i.e. the interaction of farmer and the admin with an intelligent farming system.

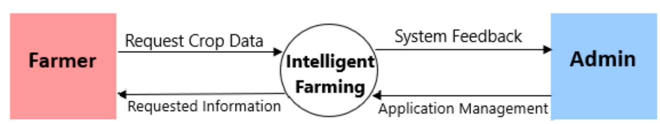


Fig. 3: DFD Level 0

Figure 4 and figure5 shows the details with the help of DFD level 1 and 2. DFD Level 1 describes the interaction of the farmer with the intelligent farming application and the use of different features like crop suggestion, weather prediction, and automatic irrigation via an application. Whereas DFD Level 2 describes the further elaboration of the above-mentioned features.

IV. IMPLEMENTATION DETAILS AND RESULT ANALYSIS

The development in irrigation practices using wireless communication facilities allows the sharing of real time information with the user and such services have huge potential in the market. The proposed technique is implemented on

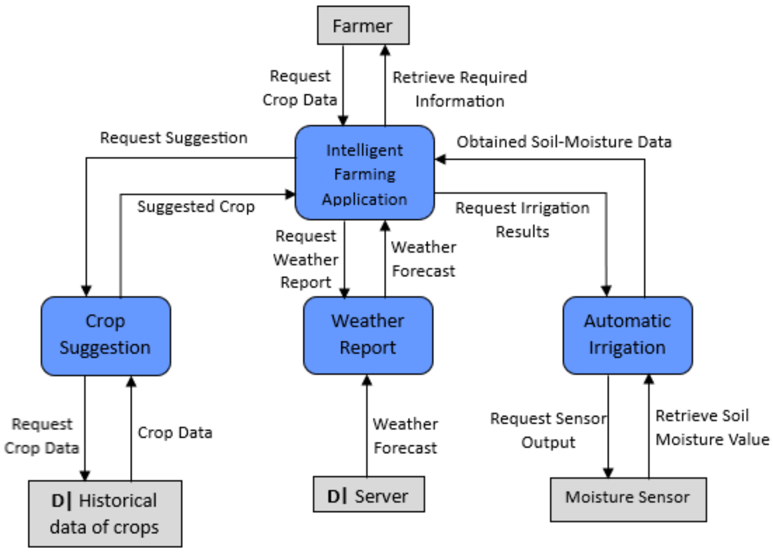


Fig. 4: DFD Level 1

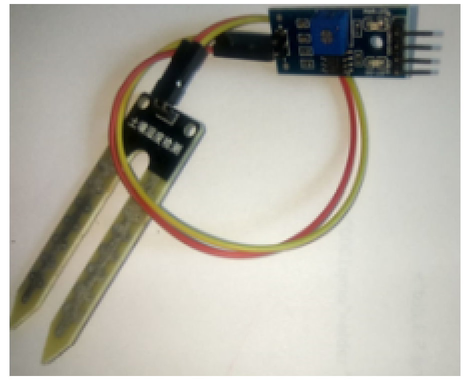


Fig. 6: Soil moisture sensor

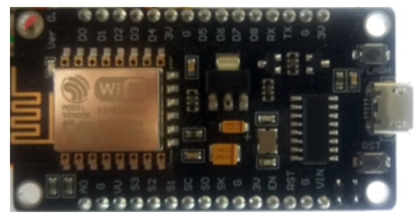
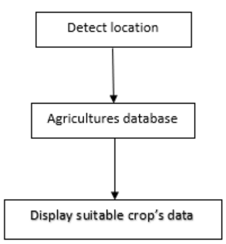
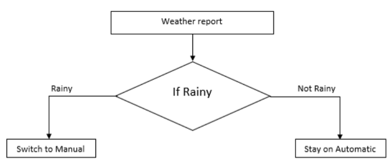


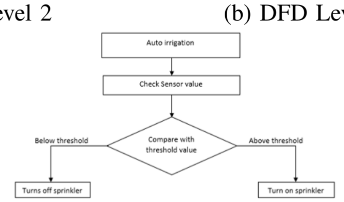
Fig. 7: ArduinoUno esp8266



(a) DFD Level 2



(b) DFD Level 2



(c) DFD Level 2

Fig. 5: DFD level 2.

an Arduino microcontroller and Windows 10 64-bit Operating system, Intel(R) Core (TM) i5-7200U CPU @ 2.50GHz 2.71GHz, x64-based processor, 8.00 GB RAM. Description of the components used in the proposed model: Fig. 6 shows the soil moisture sensor used in the proposed system. The soil moisture sensor measures the dielectric permittivity of the soil i.e. the water content in the soil using capacitance. It creates a voltage according to the measured dielectric permittivity of the soil and averages the measured value of the entire sensor.

Fig.7 shows the image of the ArduinoUno esp8266 that is used in the proposed system. The microcontroller provides 32 pins including 17 GPIO pins, 4 ground pins, and 3 3volt output pins.

Firebase Cloud Messaging (FCM) is used to deliver the notification to the user. FCM provides a reliable data connection between the server and the devices. It is a battery efficient method to deliver notifications to the user on iOS, Android, and the web at no cost. Firebase is a cloud service supplier and backend as a service company. Firebase provides a special platform for building mobile and web applications. It can update and build applications in real-time. Firebase stores data in JSON format [13]. Notification messages are integrated with Google Analytics for Firebase, giving the user access to detailed engagement and conversion tracking.

Table 1 shows the reading of the soil at different points of time. The reading number 1 to 4 has been taken while the system was working in an automatic state whereas the reading 5 has been taken by keeping the system in manual to increase the water content in the soil and then shifting it to automatic.

TABLE I: Sensor Values

Reading No.	**Sensor Readings**			
	Sensor 1	***Sensor 2***	***Sensor 3***	***Sprinkler Status***
1	1024	1024	1024	ON[a]
2	956	923	934	ON[a]
3	754	834	650	ON[a]
4	453	498	478	OFF[a]
5	6	0	12	OFF[a]

a

In this proposed model, we have taken the threshold value limit of 500. The threshold value decides sprinkler status. A binary value of 500 is set because it's a general case value for almost all the crops, i.e. a state at which the soil is neither too moist nor to dry, this limit is not adequate for the plants that require stagnant water for instance rice. This means, if the reading of the sensor exceeds threshold value, sprinklers will be turned On. The threshold value is calculated using Eqn. (1)

$$(\Sigma_i^n S_i)/n = \tau \tag{1}$$

Where, S_i *is reading of* i^{th} *sensor and* n *is number of sensors.*

The above formula will help the system in deciding the moisture vale for multiple circumstances and also the average soil moisture value of the field.

Decision making statement for independent use of sensors: if (Sensor_value is greater than 500) set sprinkler pump pin to HIGH else set sprinkler pump pin to LOW

A. We have designed the mobile application for the proposed model:

Fig.8 and fig. 9 are the screenshots of the important features of the proposed system.

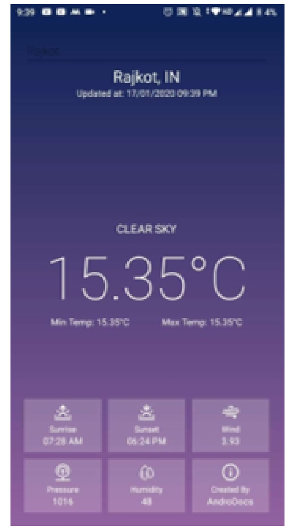


Fig. 9: Weather report

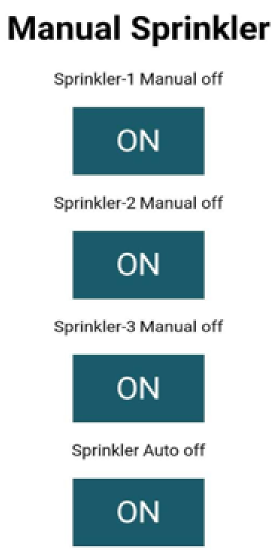


Fig. 8: Result and control shown on server

User can select any one of the options available. The firs three buttons are turn the sprinkler on and off where as th fourth one is to switch between automatic and manual mode of irrigation.

B. Crop harvest prediction using prediction analysis:

The proposed system provides the user with the quantit of each crop that was harvested in past years, and also witl the prediction of the quantity of each crop that would b harvested this year. This is performed using a predictio analysis technique using machine learning. To perform the prediction value analysis we used SARIMAX algorithm in python [15]. SARIMAX stands for "Seasonal AutoRegressive Integrated Moving Averages with eXogenous regressors". It's one of the methods available in Python to model and predict future points of a time series [16]. In order to predict the quantity of each crop that would be harvested we trained a system based on records of forty-one years (1949-1989) and tested the system against the value of seventeen years (1990-2006). Although, there are some difference in the predicted values, more precise systems and more data can be used in order to quantify the values of crops that would be harvested in a particular year. Which can be used by both the farmers and the Ministry of Agriculture Farmers Welfare. This feature will help the government authorities to send suitable crop suggestion to the farmers and stabilize the production of crops and maintain a balance between the demand and supply of the crops so that the inflation in the crop price can be maintained and the condition of farmers can be improved subsequently. Fig. 10 shows the crop prediction analysis of rice production for the year count on the x-axis from 1990-2006 and the quantity in tons on the y-axis. The blue line in the prediction graph shows the test value and the red line shows the predicted value.

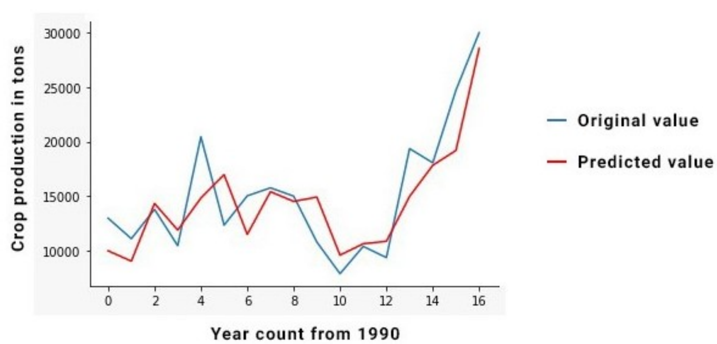


Fig. 10: Prediction analysis of Rice (1990-2006)

V. COMPARISON WITH EXISTING WORK

Table 2 provides the comparison of the proposed system with the work proposed by Krishnan et. al. [17]. Fuzzy Logic-based Smart Irrigation System using Internet of Things state-of-art and represents the new features that can help to ease the work of farmers. The work proposed by Krishnan et. al. focuses on irrigation using IoT and GSM, this would increase the cost of the system significantly. Therefore, the proposed system uses Wi-Fi to operate the system.

TABLE II: Comparison of proposed technique with [17]:

S.No	Krishnan, R. S. et.al. [17]	PROPOSED WORK
1	The system is based on automatic irrigation.	Provides both automatic and manual control of sprinklers, so that the farmers can also operate the system manually with a touch button.
2	Does not provide past year's data.	Provides Past year's crop production data, so that farmers can give a better thought to what kind of product they need to harvest.
3	Does not provides the user with weather prediction.	Provides weather prediction, so that farmers can get to know the future weather and set their farming practice schedule accordingly.
4	Switches off power at the time of rain.	System switches from automatic to manual automatically, in case weather prediction is rainy. This feature saves the crops form over-watering.
5	No timer used.	Provides timer-based irrigation, so in case farmers want to irrigate the field manually for a particular time they can set a timer for that amount of time.
6	GSM based system.	Wi-Fi based system. As the system is Wi-Fi based this would reduce the technology cost for farmers in case, they are in the range.

VI. Conclusion

The existing system works by collecting moisture data from the field using moisture sensors, then this data is sent to the server-side and on this data further processes are conducted based on this data. The final output of this system is displayed to the user after getting processed by the server-side. Thus, after analyzing the existing systems, we conclude that the proposed system will not only aid the farmers but will also help them to digitalize their farming practice and in turn help them to yield the best from their practices without being dependent on the climatic conditions. The proposed system will automate the farming practices, provide the farmers with weather prediction, and the suitable crop for harvesting based on the past year's data. The proposed system will not only help the farmers in irrigation practices but will also improve the condition of the current farming practices. The proposed system provides a feature of automatic and manual irrigation to the farmer. The system also provides suggestions of a suitable crop to the farmer based on their location and its last year's crop harvest quantity. It also provides a prediction of the quantity of each crop that are going to be harvested this year based on the previous year's data using prediction analysis. Also, the system provides a feature of the weather forecast and in case if it is "Rainy" the sprinklers will switch from automatic to manual mode this would prevent the overwatering of field saving them from getting rotten and increasing the efficient use of water. The proposed system also provides farmers with updates and notifications regarding the latest government schemes related to farmers and farming. Thus, the system will ease farming practices and might improve the condition of farmers economically. The future work and developments might improve the proposed system and be more fruitful to the farmers and studies related to the proposed work.

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