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SMART AGRICULTURE SYSTEM

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Abstract - *Agriculture is the backbone of our economic system. It not only provides us with food and raw material but also employment opportunities to an abundant proportion of the population. One of the most important factors that affect the production of the crops is the controlled management of water, also known as irrigation. The traditional methods which were used for irrigation are not very efficient and thus can't cope up with the needs and demands of the farmers. Secondly, the other problem which farmers mainly deal with is the different types of diseases that infect the crops. The model proposed by us is a remotely controlled irrigation system which works via an android application that controls the amount of water to be supplied to a field based on the different factors of the soil, like the pH and moisture content in the soil, and the current weather in that area. By using the advances in deep learning and machine learning, we are able to train our model to a higher level of accuracy. With the help of image processing disease detection was attainable, and we can detect several diseases. Furthermore, a Chat-bot has been created with the help of artificial intelligence which will help the farmers to get the current market price of a particular crop in that area. In this way, we can lower a substantial amount of water from being wasted while reducing manual labor.*

***Key Words*: Agriculture, Irrigation, Disease Detection, Android Application, Deep Learning, Machine Learning, Image Processing, Artificial Intelligence.**

1. INTRODUCTION

Agriculture has been one of the most important practices from the very beginning of time for human civilization. Traditional methods that are used for irrigation, such as overhead sprinkler and chain pump, have been proven to be inefficient. These methods result in wastage of water in substantial amounts and can also promote the growth of diseases and fungus formation due to excessive moisture in the soil [1].

An automated irrigation system is essential for the conservation of the water and indirectly viability of the farm. Agriculture is the primary source of livelihood of people in India. In the past decade, it was observed that crop development in the agricultural sector has worsened. Food prices are continuously increasing because of the decline in the production of crops. It has pushed over 40 million people into poverty since 2010[3].

1.1 Objective

The main objective of the initiative is to develop a system that can help farmers or crop cultivators to take care of the farming area even in the remote places with the help of automated systems that are developed in the fate of plants. The use of a traditional watering system results in wastage of an excessive amount of water. Using a different approach will help us to reduce wastage and ensure a step towards saving water.

Detection of different diseases for different crops can be hard with changing weather patterns and varying soil parameters across different location. The android application was created with that objective in mind, which has the developed models that help us to detect various diseases.

1.2 Scope

The scope of the project is to ensure the safety and quality of the plants while providing productive tools to the user for efficient farm management. It gives the user the power of mobility with better surveillance of the farm. The image recognition software can be used to detect the diseases on the plant. The different sensors used in the project give us accurate data about the soil in the various crops are grown, giving the user a better understanding of the farm. The developed application accommodates numerous features for effective farm management.

2. SYSTEM ARCHITECTURE

Agricultural systems generate knowledge that allows researchers to consider complex problems or make informed agrarian decisions. Modelling is an essential tool in agricultural system science, as it helps researchers to extract knowledge from observations over a plant. [3]

As agriculture scientists now consider the next-generation model, data and knowledge products are crucial and are needed to meet the problems of the increasingly complex system faced by society. It is essential to take stock of this history and its lessons to ensure that we avoid re-invention and strive to consider all dimensions of associated challenges.

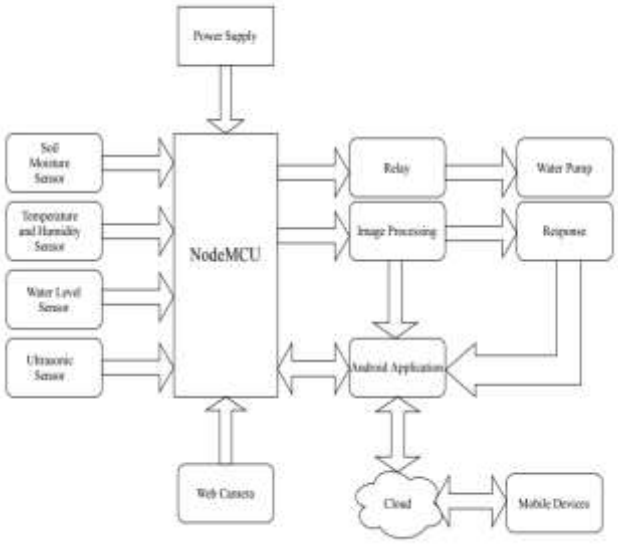

Fig -1: System Architecture

2.1 Components

2.1.1 NodeMCU

The main module which we are using in this project is NodeMCU. It is an open-source mini-size microcontroller kit and firmware that helps us to prototype and build IoT products. The name "NodeMCU" connects "node" and "MCU" (microcontroller unit). It is running on ESP8266 Wi-Fi SoC firmware from Espressif Systems and hardware based on the ESP32 32-bit. It is a WiFi-enabled chip.

Both firmware and prototype board design are open source. The firmware uses the Lua scripting language. All the different IoT components and sensors are connected to it. NodeMCU is inexpensive and has WiFi capabilities making it very feasible in different IoT projects.

2.1.2 Soil Moisture Sensor

The Soil Moisture Sensor senses the moisture content of the soil and passes the information to the NodeMCU module. They measure the volumetric water content within the soil. As we all know that the direct gravimetric measurement of free-soil moisture requires removing, drying, and weighing of a sample, soil moisture sensors measure the volumetric water content indirectly by using another property of the soil, like dielectric constant, interaction with neutrons or electrical resistance, as a proxy for the moisture content. Soil moisture sensors typically ask sensors that estimate volumetric water content.

2.1.3 Temperature and Humidity Sensor

DHT11 could also be the foremost commonly used temperature and humidity sensor. It's a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and thermistor, which is meant to carry air and supply a digital signal to the communications pin (no analog input pin). DHT11 is effortless to use. The sensor comes with live temperature as an 8-bit microcontroller for output temperature and humidity values as hardcore NTC and serial data.

2.1.4 Water Level Indicator

Water level indicator helps to measures the water level in the soil. It is a sensor that relays information back to an impact panel to point whether a body of water features a high or low tide level. Some water level indicators use a mixture of probe sensors or float switches to sense water levels. The purpose of the water level indicator is to manage and gauge water levels in a field. If the sensors report high level of water in the field then there is no need to turn on the pump.

2.1.5 Ultrasonic Sensor

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. It uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The sensor determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse. It is similar to how radar measures the time it takes a radio wave to return after hitting an object. It is used for checking the water level in the field and can also be used for intrusion detection.

2.1.6 Web Camera

The Web Camera is being used for capturing images of the leaves of the plants for disease detection. The inbuilt camera of the mobile phone is used to lower the additional cost and to avoid external cameras which are expensive, fragile and hard to install. Portability is attained by using Cameras from mobile phones.

2.1.7 Power Supply

Provide an electric supply to the motors and other components. The NodeMCU has to be powered via an usb port. For powering on the components much power is needed. The minimum power needed can be generated from most of the chargers and power banks available.

2.1.8 Relay Module

A relay is an electrically operated switch. The relay module consists of a set of input terminals for single or multiple control signals and a set of operating contact terminals. The relay module is a separate hardware device used to control a variety of external devices and for remote device switching. The relay uses an electromagnet to switch electric appliances mechanically. With it, you can remotely control devices over the Internet or any network.

Using a relay with the ESP8266 is a great way to control the water pump remotely. Devices can be remotely powered on or off with commands coming from ClockWatch Enterprise delivered over a LAN or a WAN. Relay acts as a switch between electrical load and NodeMCU.

2.1.9 Water pump

The water pump is used to release water into the field. The water pump works in synchronization and on the command of the Relay module.

3. TECHNIQUE

With the headway in technology and the surge in growth of the smartphone industry, smartphones are now more common than never. Over the past several years, we have continued integrating smartphones into their daily lives. Thus, creating an android application was just not only a viable option but also a greater mean to achieve portability. The main idea is to promote portability while keeping in mind the convenience and easy usability of the application.

The images of the plants and the leaves will be captured by using the cameras of mobile phones. These images will be sent for processing. The processor will determine the health of the plants by the machine learning and image processing modules built in the application. The leaf disease is identified by the image processing technique using the Python OpenCV library module. OpenCV means Open Computer Vision is created by Intel for CV applications. The 4GB RAM & 300GB ROM with Intel i3 processor-powered PC is used for CV processing. First, the CV module Capture image and process the image to identify the leaf disease.[7]

SocNet Communication:

It is used to interact with the same or different machines. A network socNet is an internal endpoint for sending or receiving data at a single node in a computer network. The term "socNet" is also used for an internal endpoint of local inter-process communication (IPC) and the term "port" is used for external endpoints at a node.[5]

Serial Peripheral Interface:

In embedded systems, the Serial Peripheral Interface bus (SPI) is an asynchronous serial interface specification used for short-distance communication. A master-slave architecture with a single master is used by the SPI devices to communicate in full-duplex mode. The master device originates from the frame for reading and writing. Through selection with individual slave select (SS) lines, multiple slave devices can be supported.[5]

By using the above system, water is passed to the plants as and when required. With a single tap of a button, water can be pumped through the relay into the field.

3.1 Hardware and Software Specifications

The experiment setup is carried out on a Mobile device which has the following hardware and software specifications

Table -1: Hardware Details

Processor	NodeMCU (ESP8266)
Soil Moisture Sensor	YL- 69
Temperature and Humidity Sensor	DHT11
Ultrasonic Sensor	HC-SR04
Image Recognizer	Mobile Phone Camera
Motor	Relay Motor
Pump	5V DC Water Pump

Table -2: Software Details

Operating System	Android KITKAT
Programming Software	Android Studio
Database	Firebase
Model Training	TensorFlow Lite Deep Learning Model-Convolutional Neural Network (CNN)
Cloud Platform	Google Colab

3.2 Sample Data Set Used

There are three classes/diseases: Bacterial leaf blight, Brown spot, and Leaf smut, each having 40 images. The format of all images is jpg. [8]

Table -3: Sample Data Set

Data Set Characteristics:	Multivariate	Number of Instances:	120
Attribute Characteristics:	Integer	Number of Attributes:	N/A
Associated Tasks:	Classification	Missing Values?	N/A

3.3 Evaluation Matrix

There are a lot of pattern algorithms, descriptor algorithms and distance algorithms that are available in the OpenCV library module. Feature extraction is applied to the input image after completing the pre-processing, color conversion and de-noising where these techniques are used to improve the Classification & Segmentation of input image.

Machine learning is a niche technology that is dominantly used for many applications in our industries. Machine learning algorithms are statistical algorithms which are performing some mathematical operations in order to specify the image class or category to apply classification. In feature extraction, the image features are converted into vectors to specify the class type. With the input feature vectors are matching or mapping with the train features then it being classified.

4. IMPLEMENTATION

There are multiple factors which play a part in generating maximum yields like soil condition, varying weather patterns and current market prices.

User Friendly Interface

The User Interface (UI) for the application is made, keeping the farmer in mind. The UI is made simple and easy to navigate by providing all the necessary information about Farming, Irrigation and Agriculture to the farmer. More pictorial representations are used rather than textual format so that the user has a better understanding of the UI and how to use the application.

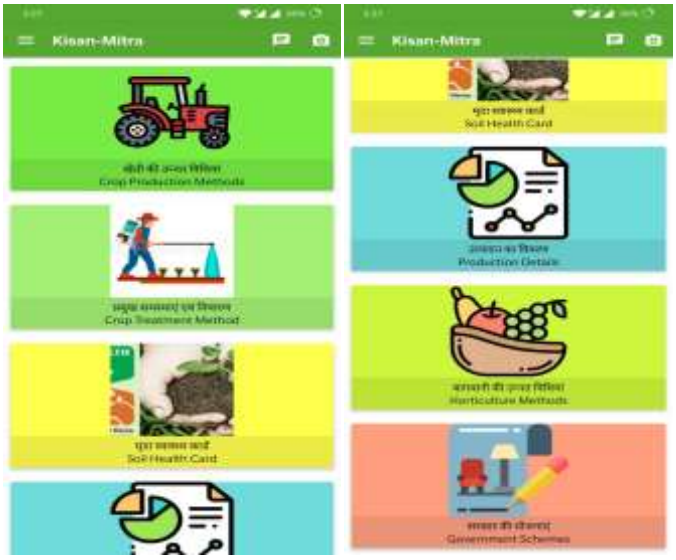

Fig -2: Main Screen UI (a) **Fig -3**: Main Screen UI (b)

Fig -4: Dashboard UI

Multilingual Support

Multi-lingual support is added so that the user can understand all the features of the application in his/her native languages. The most 4 spoken languages in India are added, the user may select any of these languages.

By providing the freedom of choosing the language in which the application will run, we are able to deliver excellent support and assistance to the user. Illustrations and animations are developed according to guidelines of HMI principles.

Text-to-speech API's and voice to text conversion (voice search) is added so that the application is able to assist the user in all circumstances.

Fig -5: Language Selection **Fig -6**: Hindi Language Representation

Soil Fertility Test

Farming cannot be done if the soil is infertile. So, checking the fertility and suitability of the soil beforehand becomes a priority. According to the location of the user's farm, a list of nearby soil testing laboratories is displayed where the farmer can go and get his soil tested.

For a naive insight about the soil health, the provided IoT mechanism can be used in which different sensors like the pH and soil moisture sensors can be used to understand about the health of the soil. Thus, the farmer can decide which crop to grow with respect to the current soil condition.

Fig -7: List of Laboratories where the farmer can get his soil tested

Production Analysis

Now that the soil has been tested for fertility, it is of utmost importance to select the appropriate crop for production in the farm, keeping in mind the various factors such as suitable weather conditions, the soil type required and the demand for it in the previous years. We display the previous years analysis for a specific crop in the selected region through the application.

Fig- 8: Selecting Region

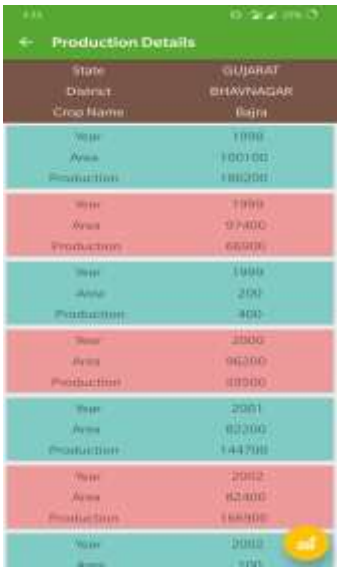

Fig -9: Displaying Analysis

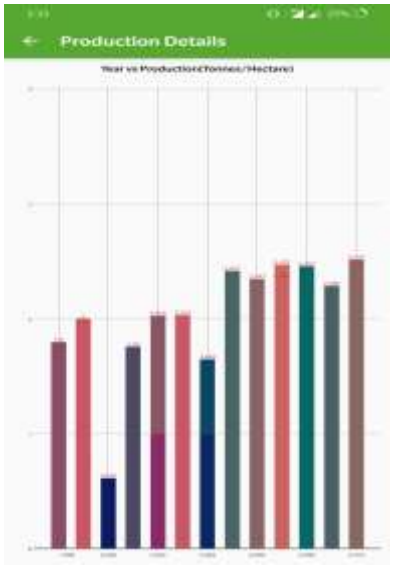

Fig- 10: Graph Analysis

Crop Production Techniques

A step-wise instructional and informative manual regarding the important crops helps the farmer to get all of the details about his crops at his fingertips, right from the soil type, the weather conditions and the water requirement for that specific crop. The Multi-lingual support and the Text-To-Speech API makes it very convenient to get acquainted with.

Fig- 11: List of Crops

Fig- 12: Informative Manual

Horticulture Methods

We also promote different horticulture methods in our application for better farm management.

A step-wise instruction manual for a naive farmer with the multi-lingual and text to speech support helps to get a bird's eye view for efficient farming.

Fig -13: Horticulture Crops **Fig -14**: Mango Crop Details with Multilingual Support

Disease Detection

The application is integrated with a handy camera which the farmer may use to click photos of the crop which the user wishes to diagnose. The image is then processed by Image Processing algorithms (IP). After processing Convolutional Neural Networks (CNN) a class of deep neural networks, is used for analyzing visual imagery. CNN along with AI is used to classify the different plant disease.

If accidentally the user clicks the photo of something else other than the plant then a class called "background" is invoked which means that the image captured may be wrong or the camera was out of the frame and the infected area of the plant was not captured accurately.

A Google Colab model known as TensorFlow Lite (TFlite) is used in the building of model which converts the Machine learning (ML) model into a deployable format for android phones. Using these models also decreases the memory space and time required for processing these images by different Artificial Intelligence (AI) processes We have used CNN models of the deep learning class for classifying the images based on different types of diseases.

We then converted this model by TensorFlow Lite so that it can be efficiently used on an android phone. As these deep learning models are enormous in size and require a lot of memory to run, it won't be feasible on a mobile phone. TensorFlow Lite converts it into a smaller format which supports mobile hardware. To avoid internet usage, all the database is stored locally on the mobile. The user just needs to click the picture of the diseased area of the plant and the application will take care of the rest.

The process in brief, the image is then sent for pre-processing and then it is pushed as an input for the AI model which gives the output as the class of the plant and the disease which is then used to get information from the knowledge base. All the relevant data is then displayed on the mobile of the user. Disease Detection of the leaves is possible by that system proposed above.

The application also provides symptoms of the disease which will help the farmer to ensure that the steps he/she is taking are appropriate.

The disease detection model is very beneficial for the farmer as it helps the farmer to catch early disease symptoms, recognize current infections and also give remedies on how these diseases can be treated.

For training this model, we have downloaded a public dataset of 54,305 images of diseased and healthy plant leaves collected under controlled conditions. These images cover 14 species of crops, including apple, blueberry, cherry, grape, orange, peach, pepper, potato, raspberry, soy, squash, strawberry and tomato. It contains images of 17 basic diseases, 4 bacterial diseases, 2 diseases caused by mold (oomycete), 2 viral diseases and 1 disease caused by a mite. 12 crop species also have healthy leaf images that are not visibly affected by the disease.

Fig -15: Common Rust Plant Disease Detected

Fig -16: Healthy Leaf Detected

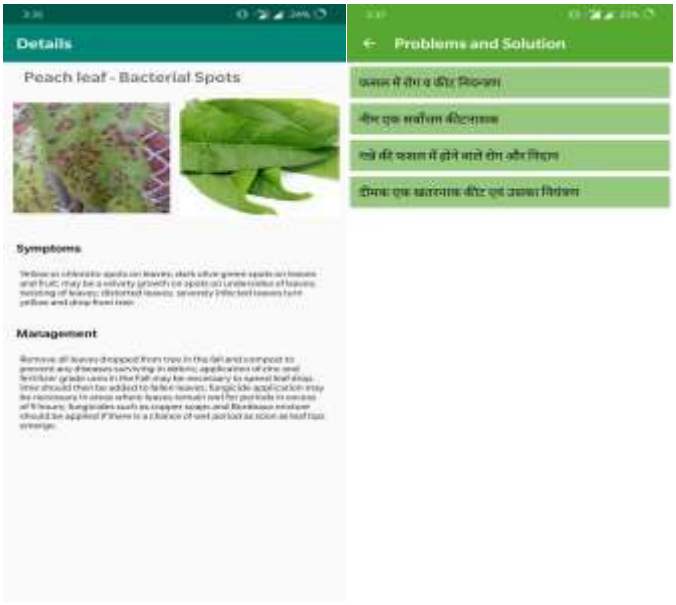

Fig -17: Bacterial Spots Disease **Fig -18**: Major Problems in Description with Symptoms Crops and their Solutions and Management Techniques

Organic Fertilization Methods

The application also suggests some natural ways and methods to reduce these diseases, promoting the use of eco-friendly and natural chemicals like manure and biomass over synthetic chemicals and fertilizers.

To avoid the harmful effects of pesticides, a stepper manual to prepare manures/ fertilizers from easily accessible and naturally occurring biodegradables with the multi-lingual and text to speech support will help to minimize the expenditure of pesticides.

Fig -19: Methods to Create Natural and Organic Fertilizers with Multilingual and Text to Speech Support

Weather Forecast API

The varying and unpredictable weather condition creates a lot of problem for the farmer. We have developed a user-friendly weather forecast with the inspiration from human and machine interaction and understanding human psychology. The weather is displayed on the mobile via an API. If the weather is Clear and Sunny on a particular date, the background for that element of the interface will be displayed as Orange—likewise, Blue for the rainy day. So, even a naive user can understand the weather conditions accurately.

Fig -20: Weather API Based on Foundations of HMI

IoT

Automated Irrigation system and farm health-check mechanism using the concept of IoT. All the different sensors will send their data to the NodeMCU module which will display values from all the different sensors in the Application and on Google Firebase.

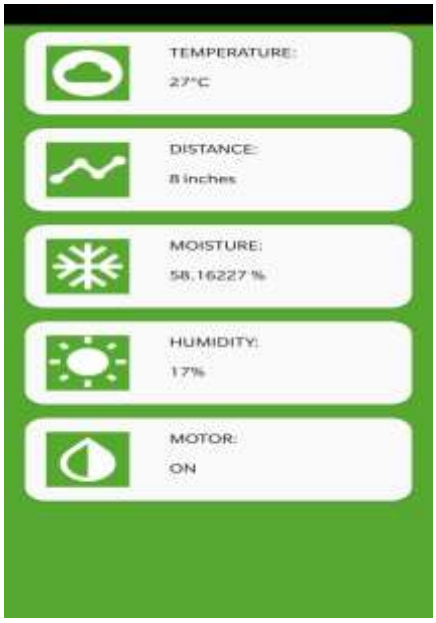

Fig -21: Sensor Information Representation from Firebase Database

Chatbot and Helpline Service

A 24*7 personal assistant is included. The Chatbot will be able to get the daily market prices of different crops in a specific region. So that the farmers can get justified prices from the merchants. This Chatbot is scraping data from the web about the current market price of the crop and displaying for the user. The Chatbot is able to give suggestions to the user so that the user is not required to type the whole sentence. The user just needs to type the name of the crop, and then the Chatbot will ask the question of which state the rate of the crop is to be found out. Furthermore, the Chatbot gives the minimum, maximum and average price of the commodity which is being searched in that particular region on that particular date.

A Kisan helpline Number has also been provided on the dashboard of the application. So, if the farmer needs any help regarding farming or concerning his farm, he can directly call the helpline center.

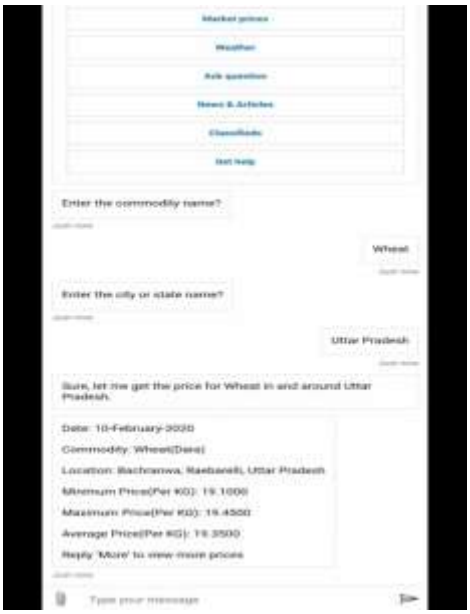

Fig -22: A 24*7 Chatbot to Assist the Farmer

Government Aid and Assistance

Initiatives by the Government will help farmers to get valuable resources. Centers and websites are put up by the government in order to help the farmers and sustain agriculture. The government provides information about recent reforms and subsidiaries to the farmers. Different tools needed for irrigation and Machinery are available at a reduced cost. Seeds, fertilizers and equipment needed for farming are available at a reduced price. Various loan schemes and farmer-friendly programs are made available by the government.

In our application, we provide the most reliable and authentic sources available across various platforms so that the farmer knows about the initiatives taken up by the government.

Fig -23: Government Schemes **Fig -24**: Scheme Details

5. CONCLUSION

In this paper, the Smart Agriculture System Live Monitoring of Temperature, Soil Moisture and Humidity using NodeMCU and disease detection using Machine Learning and Image Processing have been proposed. This information can be transmitted to the application using the cloud database. Weather Forecast is available in the application with the use of API. The application also advises the best practicing methods for agriculture and horticulture. Real-time prices of the crops can be obtained by using the chatbot feature of the application. Farmers should perceive the potential of the IoT marketplace for agriculture by putting in sensible technologies to extend the fight against productions. With the population growing at a pace, the demand can be met if the farmers, implement agricultural IoT solutions.

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