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# AN IOT-BASED CROP MONITORING APPLICATION IN SMART AGRICULTURE

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**ABSTRACT** The Internet of Things (IoT) plays an important role in the agriculture industry to reduce wastage and increase crop yield. Crops are necessary for the survival of humans since they may be used to provide food, feed for animals, and fuel, as well as the basic materials needed for clothing and housing. Attacks by wild animals on farms are a common problem that many farmers encounter. Standing crops are frequently destroyed by wild animals, resulting in lower yearly crop production and economic losses for farmers. This paper discusses the development of an IoT-based application for farmers to protect their crops from wild animals. When an animal enters the crop field, it produces an alarm message on the farmer's phone using Firebase Cloud Messaging (FCM). After receiving the alert, farmers can act accordingly. Farmers can acquire weather and humidity information for the following seven days by utilizing this application. Farmers may monitor field conditions and crops 24 hours a day, 7 days a week, from anywhere.

**Keywords:** IoT, Sensor, Smart Agriculture, Flutter, Firebase Cloud Messaging

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## INTRODUCTION

Agriculture is extremely important to India economy. It provides subsistence to more than 70% of the Indian people and it is the backbone of all economies, not just in India but around the world, and several countries' economic prosperity is largely dependent on crop cultivation [1]. Farms generate food for humans as well as a variety of raw materials for industry. Traditional irrigation techniques have evolved throughout time. In flow irrigation, for example, water resources like as tanks are located at enormous heights. When the channel is connected to a tank, water begins to flow down it automatically. This method of irrigation is commonly employed in flatlands. Lift irrigation is another method of irrigation in which the fields are higher than the water resources. Pumps are used to lift water from wells, tanks, canals, and rivers and irrigate the land. Ground water is being pumped to irrigate land.

According to the ‘Agriculture in 2050 Project, the world population is expected to reach -around 10 billion by 2050 [2]. To meet food demand within limited field resources, so it's urgent to improve crop productivity. The traditional method relies heavily on human instincts, which occasionally fail. As a result, a more intelligent approach to crop production is required.

### Why is IoT required in agriculture?

According to a report conducted by the United Nations Food and Agriculture Organization, global food production should be raised by 70% by 2050 to accommodate the growing population [2].

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Agriculture is the foundation of the human species since it is the primary source of food and plays an essential part in the growth of the country's economy. It also provides a big number of job chances to the people. Farmers continue to use conventional agricultural methods, resulting in low crop and fruit yields. Thus, agricultural yield can be increased by using automatic machinery. In order to increase yield, contemporary science and technology must be implemented in agriculture. We can expect an increase in productivity at a cheap cost by monitoring soil efficiency, temperature and humidity monitoring, rain fall monitoring, fertilizer efficiency, monitoring storage capacity of water tanks, and theft detection in agricultural regions using IoT.

Combining traditional practices with cutting-edge technologies such as the Internet of Things and Wireless Sensor Networks can lead to agricultural modernization [3]. The Wireless Sensor Network collects data from many types of sensors and sends it to the main server via wireless protocol. There are numerous more elements that have a significant impact on productivity. Factors include insect and pest attacks, which can be handled by spraying the appropriate insecticides and pesticides, as well as attacks by wild animals and birds as the crop matures. Crop productivity is diminishing due to erratic monsoon rainfall, water constraint, and inefficient water use.

Many techniques have been developed employing new technologies to improve traditional approaches, such as reducing agricultural waste, preventing excessive and inadequate irrigation of crops, and thereby increasing crop output. The current agricultural research trend is to boost crop productivity. This application will also help in enhancing farm productivity. In the field of IOT-based smart applications, such as Precision Farming [4], Smart Green Houses, and Cattle Monitoring and Management Systems [5], numerous types of algorithms have been developed.

However, nowadays, the most common problem that many farmers experience is attacks by wild animals on their farms. These attacks aren't limited to a single location. It can be found in many parts of the country with various types of wild animals. Farmers are spending their evenings defending their farms,

which is causing them a lot of anxiety. Since so many years, wild animals have been attacking the crop, and protecting this crop field from wild animals has become a severe challenge. The animals face a shortage of water and food due to which they move towards the farmlands and often destroy standing crops which results in a significant loss of crops and annual income for farmers, when wild animals invade a farm, a warning system is required to protect crops from wild animal damage [6].

There has been an idea to develop a IOT based smart application to protect the crops from animals and also gathering all the information about current whether. By using this application farmer can get the information about their field if animal enters their fields to harm the crops. It will be also reducing the efforts of farmers like they can know about next seven days' weathers information, humidity, temperature etc. Android application developed using Flutter Framework, Raspberry pi 3B+ used to detect to farmland activity, Firebase Database used to store the data and Firebase cloud messaging used to send the alert message on former phone.

## RELATED WORKS

Deepak Murugan et al., [7] in this paper, PIR sensors are installed to detect any movement and, as a result, switch on a camera when motion is detected. When such intrusions occur, a message is automatically generated, and the cameras are turned on, which capture an image and begin recording video for a period of time. The video is then stored on the SD card as well as on the cloud, which is Dropbox, where the landowner can view it on any smart device and access it later. The Raspberry Pi board is used to connect all the sensors and components.

Manish Kumar Dholu et al., [8] discuss about IoT for Precision Agriculture Application. The main goal of the article is to detect all of the necessary agricultural characteristics and make the proper decisions about how to run the actuator. This strategy, however, falls short in terms of boosting the mobile app's utility, such as appending alarms if a specific parameter is not properly regulated. The suggested system combines alarm and warning messages with sensor data and sends them via email and SMS.

A. Montes de Oca et al.,[9] describe Drone monitoring: The trending disruption of scientific advantage has nearly transformed the introduction of farm drones. Drones, both on the ground and in the air, are utilized to assess agricultural monitoring. Drone is equipped with a camera and is used to watch our field. If any animals enter the field, the drone sends a message to the farmer's phone, who receives the information.

G. Sushanth et al., [10] describe Smart Agriculture System based on IOT. The development of a system that uses sensors on Arduino boards to measure temperature, humidity, moisture, and even animal activity in agricultural fields, and, in the event of any discrepancy, sends an SMS or even an application notification made for the same purpose to the farmer's smartphone via Wi-Fi/3G/4G. The method, however, is lacking because ongoing internet connectivity is necessary. This can be avoided by modifying the system so that ideas are sent to the farmer by email and SMS rather than a mobile app. In the proposed system, which is developed.

Girish Bekaroo et al., [11] discuss about Agriculture Monitoring with Drones and Satellite Data: Drones have been used for precision agriculture monitoring at smaller scales in recent years, and satellite data has been used for land cover classification and agriculture monitoring at larger scales for the previous few decades. Precision agricultural monitoring on a wide scale is a difficult endeavor. In this research, a method for precision agricultural monitoring is described, which involves the classification of sparse and dense fields using freely accessible satellite data (Landsat 8) and drone data. Drone usage must be reduced over time; hence an adaptive categorization system is created that uses picture statistics from the specified location.

Agale et. al. [12] work is to develop an automated irrigation and crop security system using IoT technology. The system collects and analyzes real-time sensor data such as temperature, humidity, soil moisture, and PIR (Passive Infrared Sensor) to monitor and control irrigation and crop security operations. The key findings of the research include water savings, improved crop quality, 24/7 surveillance, and a 92.24% accuracy rate in testing a prototype of the system. However, in this approach we can use the camera module to capture the image detected by the PIR sensor.

Ashifuddin Mondal et al. [13] proposed smart farming method based on the Internet of Things (IoT) is to improve farm productivity and quality of farming without continuous manual monitoring. It aims to automate farming operations, monitor environmental conditions such as temperature and soil moisture, and take necessary actions based on these values without human intervention. The goal is to achieve high precision crop control, collection of useful data, and automated farming techniques. It reduces the human effort and cost of farming to a certain extent. However, more biotic parameters such as fungi, monera etc. can be considered for better the productivity of the crop.

Ryu et. al.[14] approach aims to provide smart farming systems for end users by integrating IoT devices, such as sensors and controllers, into the farm. The system consists of three main components: connected IoT devices, an IoT gateway called &Cube, and an IoT service platform called Mobius. The Mobius allows for the registration of devices and provides REST APIs for monitoring and controlling the connected farm. The connected farm system enables farmers to remotely monitor and control their farm, as well as share their knowledge and experience with other farmers. The document also presents a service scenario that demonstrates the advantages of the connected farm system. Overall, the document highlights the potential of IoT technology in improving agricultural productivity and providing innovative farming services.

## SYSTEM DESIGN

Raspberry pi 3B+, low-cost temperature and humidity sensors, Flutter Framework for Android application development and Firebase database are used in this work. It will continuously monitor the farmland and when any animal entered in the farmland then raspberry will generate a signal and send it on the server. We use some sensors and its data are stored on the database. In work an android application developed such a way that if raspberry

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send signal on database, then an alert message is generated and shows to farmer and also by using this application, we can control speaker which set in field, shows humidity and temperature [17][18].

A nylon rope surrounds the farmland and is plugged at one of the corners. If any animals enter the farmland, the nylon rope will unplug, and the Raspberry Pi will sense a little current and then it will generate a signal on database and that signal is also detected by android application after the detection android application will generate an alert message on former phone with the help of firebase cloud messaging (FCM) and an automate speaker which is operated by application through raspberry pi, will turn on. After the alert message Former will get the information that any animal had entered in their field and now, he can take necessary action regarding his requirements. The automated speaker also will controllable by application. The work flow system design is shown in Fig.1 [19][20].

### Raspberry Pi

The Raspberry a credit card size little processor that have various functions. It is uses in various fields like home automation, voice command applications, application of force system and surveillance systems etc. Raspberry Pi 3B+ Model is shown in Fig.2.

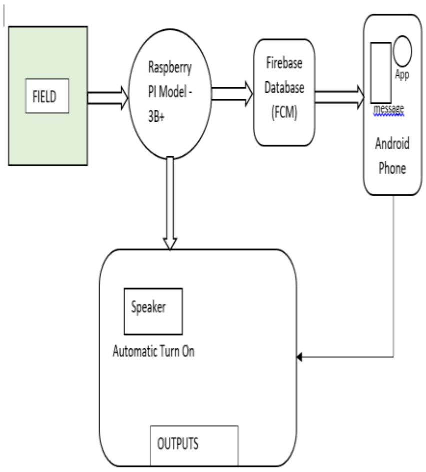


Fig 1: Work Flow System Design

The many components of the Raspberry Pi are listed below, along with their varied functionality. SD Card Slot for installation of operating system and other applications/software. The SD card Memory size should be near about 16GB.Micro USB Power Port which provides 700mA at 5A. When HDMI port is not used then RCA video out is connected with display. The use of this port is to carry out the signals of audio and video otherwise they are called as A/V jacks. When HDMI is utilised to obtain stereo audio, digital audio is obtained. Analogue RCA Connection is utilised here. Ethernet Port by which raspberry pi get connected with internet. It is also usable for updating and sharing new software easier. It has 40 pins in which 28 pins are GPIO (general purpose input output) pins. The real world is interacted with via GPIO pins.

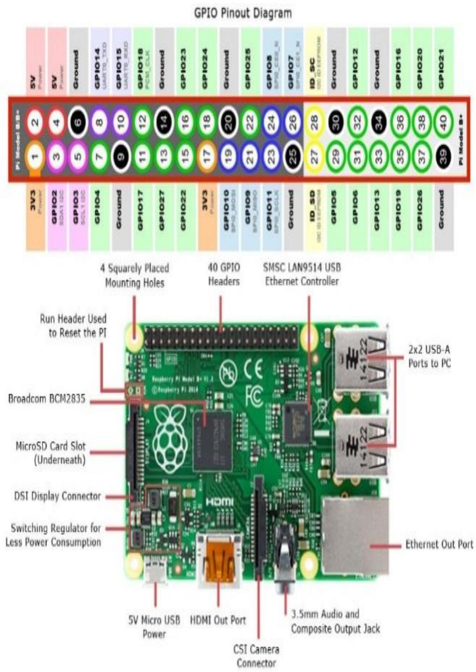


Fig 2: Raspberry Pi 3B+ Model [15]

### DHT11 Temperature and humidity Sensor

The utilized sensor is the DHT11 which is ultra-low-cost digital temperature and humidity sensor. Humidity refers to the sum of water vapor in the air. The humidity is calculated because the relative humidity fluctuates as the temperature changes. Before and after irrigation, the temperature and humidity change. The quantity of tiny droplets of water in the air increases after irrigation. This results in a drop in temperature, which raises the relative humidity of the environment. The user is frequently reminded of temperature and humidity readings so that from afar, he or she can monitor field conditions. Greenhouses can also benefit from the temperature and humidity sensor. DHT11 temperature and humidity sensor is shown in Fig.3.

**Flutter Framework**

Flutter is a framework which is use for develop cross-platform and high-performance mobile

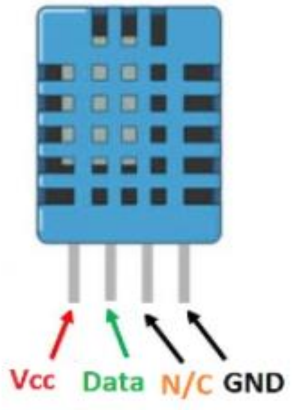


Fig 3: DHT11 Temperature and humidity Sensor [16]

applications. It is developed by Google as open-source plate-form. Flutter applications are not just accessible with Android and iOS, but Flutter is also the application-level framework for Google's next-generation operating system, Fuschia. In flutter dart is use as a programming language. To write applications in flutter developers use dart which is created and managed by Google. It's widely used at Google and has proven to be capable of creating vast web applications. Flutter enables stateful hot reloading while developing, which is critical for reducing development time. When application is in running in VM then if we want to see changes in running application on VM after change or update in code. We inject updated code into running dart VM without changing in inner structure, keeping every action and transaction.

**Firebase Database**

Firebase is a Google platform by which developers can create, manage, and scale their work simply. It helps developers to create their application more quickly and securely. No programming is required on the Firebase side. We can use Firebase database in many fields like web development, android app development, IOS development etc. It provides you cloud storage to storing the data. It uses NoSQL as a database to store data. The working of Firebase Database is shown in Fig.4.

Firebase work as a backed application development software which provide feature for developer to

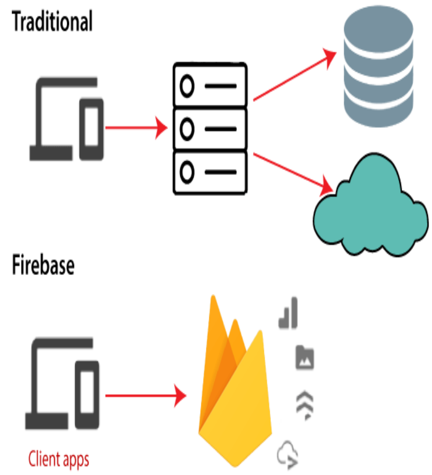


Fig 4: Firebase Database

develop Android App, web App and IOS application. Firebase offers various features for reporting and repairing app errors, collecting analytics, and developing marketing and product experiments. Firebase offers three core services: a real-time database, an API, and a mobile app. user authentication, and hosting. With the help of the Firebase, we can use these services IOS SDK allow us to create apps without writing any server code.

## IMPLEMENTATION OF THE MODEL

This work is mainly divided in three parts, first one is development of Android Application using Flutter framework and second one is collecting field data using raspberry pi and sensors and third one is weather forecasting up to Seven-days.

**Android Application using Flutter framework**

As we seen above about flutter framework, using this framework we created an android application and it connected with the sensors through firebase database. It also displays all the information about whether and sensors. It is further divided into some modules.

**Programming Language**

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In this application we are using dart programming language to implement whole logic of flutter framework.

**Whether API**

We are using weather Application Program Interface (API) from OpenWeatherMapAPI to get all weather information. We get temperature, humidity, air wind and weather-related information for next seven days. This information will display on app and after seeing which the farmer will be able to easily decide whether to irrigate or not.

**User Interface**

To design all the display screen of application we are using flutter. In this we are designed an attractive user interface to display the all information of related work. Home screen is divided into two parts on the first part we will show all API data and in second part we will show all the sensor data. Design a popup screen to generate alert message.

**Collecting field data using raspberry pi and sensors**

In this Module we connect all types of sensors, firebase database, raspberry pi and android application to each other for gathering the data. Fig.5 show collecting of field data using raspberry pi and sensors.

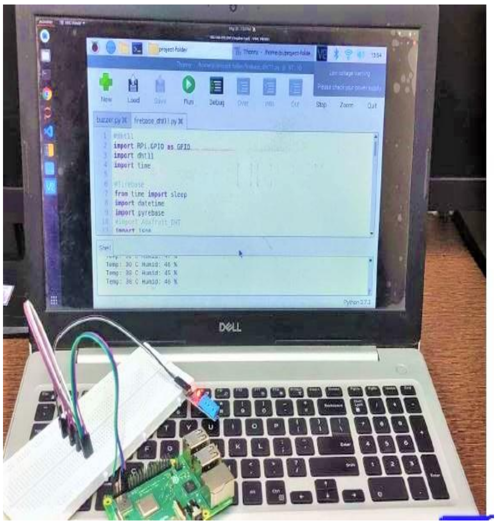

Fig 5: Collecting Field Data

**Raspberry Pi**

In this work, we are using raspberry 3B+ with 2 GB ram to interact with farmland and generating signal on server when animal entered in field. There are 40 pins in raspberry pi I which 28 GPIO pins. We use GPIO pins to measure temperature and humidity.

**Coding in Raspberry pi**

We use python language to write the code in raspberry pi to connect sensors with raspberry. Sensors predict data from field and this data will send on firebase using raspberry pi.

**Sensors**

Sensor is an electronic device, unit, machine, or subsystem whose function is to detect events or changes in its environment and transfer the data to other electronics, most commonly a computer process. A sensor is always used with other electronics. We are used current sensor to predict to current flow, Humidity sensor to predict Humidity of soil and temperature sensor to measure the temperature of field environment. Sensors are handled by raspberry pi. Architecture of proposed model is shown in fig.6.

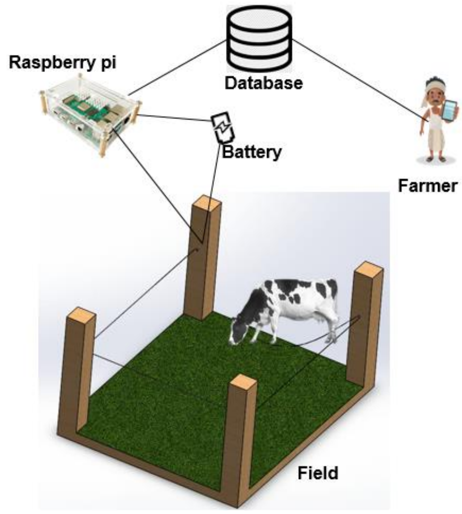


**Fig 6:** Architecture of proposed model

Fields are encircled by a wire and end point of wire is connected with a plug. When an animal tries to enter in field then wire is removed with jack then sensor measure a small current because when jack free with plug then circuit path is completed and current flow will start. After sensing the current the sensor send data to the database through raspberry and app will also get data from database then it will inform the farmer by generating alert message. Now farmer find information about that on his app in anywhere so he will take decision regarding that.

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### Weather forecasting in Android application

In this work, we did next seven-day weather forecasting for current using OpenWeatherMapAPI. We used this API not only for next seven days' weather forecasting but also for get all information about Weather such as temperature, humidity, air wind. We have used Flutter framework and Dart programming language to implement weather forecasting. To get farmer current location we used Google map API and after this we find the current location weather. There are many libraries available in flutter to get data from API so we used Https to parsing API. We have shown weather forecasting in Fig.7.


Fig 7: Weather forecasting UI View

### Alert message Implementation

Field is encircled by a wire and end point of wire is connected with a plug. When an animal tries to enter in field then wire is removed with jack then sensor measure a small current because when jack free with plug then circuit path is completed, and current flow will start. After sensing the current the sensor sends data to the database through raspberry and app will also get data from database then it will inform the farmer by generating alert message. Fig.8 show the alert massage display UI.


Fig 8: Alert Display UI

### RESULT DISCUSSION

Because we will build a nylon rope cover around the field, the efficiency of our entire system is dependent on the length/width of farmland. Within a certain length/width of farmland, system efficiency will be good; but, as the length of farmland increases, system efficiency will decrease. Implementation of the proposed model is shown in Fig 9.

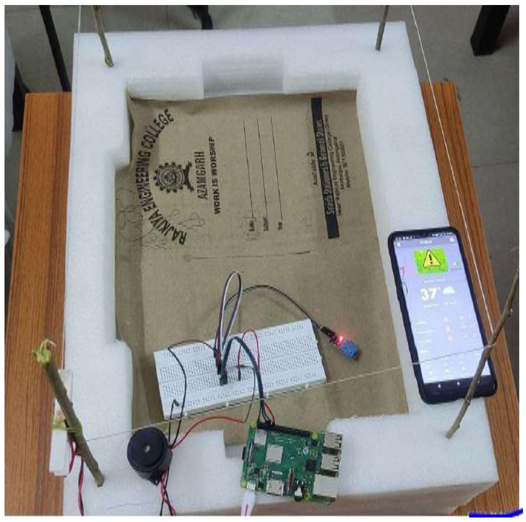

Fig 9: Implementation of model

Our method outperforms other proposed systems such as PIR sensors, drones, and satellite-based crop



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monitoring. Because it is less expensive and takes less time to notify the farmer, this technique is preferred. In fig.10 our system's efficiency is good within the first 100 meters of field length, but as the length increases, the efficiency decreases.

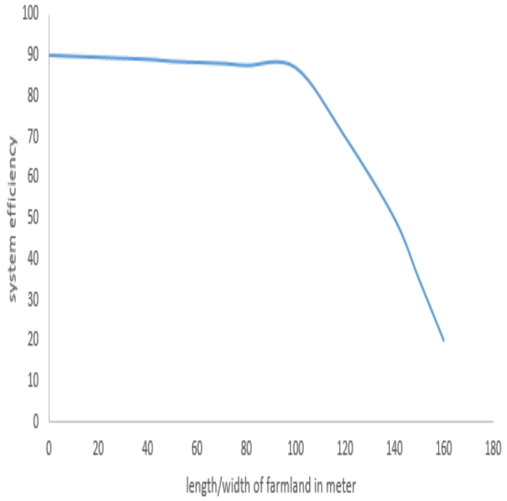


Fig 10: System efficiency vs. width/length of field

We will need poles to build a nylon rope cover around farmland, therefore the system's efficiency will be determined by the distance between poles. We generate a graph for system effectiveness vs. distance between poles in feet, as shown in Fig11. When the distance between poles exceeds 13 feet, the efficiency of the system drops. As a result, the distance between poles should not be greater than 13 feet in order to achieve good efficiency.

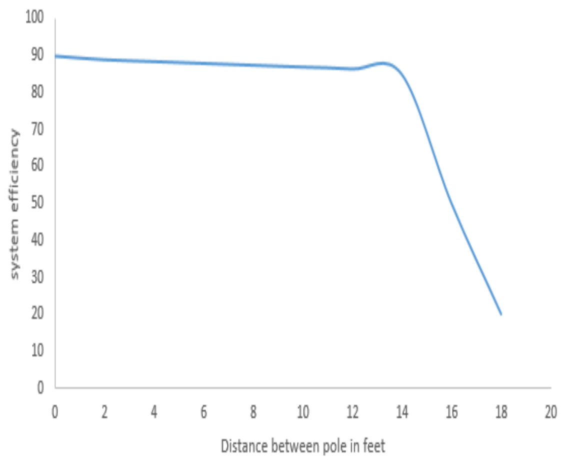


Fig 11: System Efficiency vs. Distance between poles

Following the above results, the length/width of farmland should not be greater than 100 meters, and we will require some poles to encircle the farmland with nylon rope so the distance between two poles should not be greater than 13 feet to achieve good efficiency. At one corner, the nylon rope was plugged into the system. and when an animal enters the farmland, the nylon rope is unplugged from the system, causing a little current to be produced, which is detected by the Raspberry Pi. After the current is identified, an alert message is sent to the farmer's phone, and the speaker in the farmland is turned on. This speaker will also be controlled by the farmer phone, and it will be capable of delivering a variety of sounds.

## CONCLUSION

The problem of wild animals destroying crops has become a major concern for farmers. To resolve this critical situation, an efficient solution and rapid attention are required. We created a smart application using IoT to tackle this farmer's problem. The key goals of this application are to reduce crop loss and protect the crop field from wild animals that do serious damage. As a result, our proposed approach will assist farmers in protecting their fields from wild animals. This application also allows farmers to monitor the humidity, temperature, and weather forecast for the next seven days, as well as protect their crops from animals 24 hours a day, seven days a week. This approach increases crop yield while reducing crop waste. The developed application is more economical, effective, and efficient that produces more feasible results.

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