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Leaching Estimation for Paddy Crop using IoT and Machine Learning

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Abstract*— Soil salinity is a major issue in farming faced by many farmers across the globe. So it is very much important to identify the salinity level of the soil. Internet of Things (IoT) assisted solution is proposed to determine Electric Conductivity, temperature, and Moisture level at the root zone of the crop field. Internet of Things (IoT) and Machine Learning (ML), based leaching water requirements estimation for saline soils is made using the onsite monitoring of the salinity level and crop field temperature and crop growth stage. Food and Agricultural Organization (FAO) proposed method of leaching requirement is implemented for efficient leaching water estimation. These parameters are used to train and test the Machine learning model to predict the leaching requirement. The performance of machine learning is measured in terms of accuracy.
***Keywords*— Soil Salinity, Leaching, IoT, ML, Electric Conductivity**

I. INTRODUCTION

Soil salinity is the gradual gathering of salt in the soil due to poor water quality and irrigation practices. Soil salinity is measured in terms of electric conductivity. This indirectly affects the yield of the crop, to reduce this salinity we use a method called leaching. Leaching is a process of providing a sufficient amount of water to the crops so that the salt in the soil will be dissolved in this water and the salinity level will be reduced. Estimating the amount of leaching is a very important factor. Along with soil salinity temperature and soil moisture and the growth stage of the crop plays a very important role in finding the leaching for that particular soil. So we use the Internet of Things to find out these parameters using various sensors.
Most of the irrigation water is being wasted due to improper knowledge on soil salinity as the salinity value is unknown the farmer couldn't able to find the accurate leaching for the crop.

II. LITERATURE SURVEY

There are many methods to find soil salinity few of them are soil laboratory testing, Remote sensing, ground survey. Soil library testing is the common method used by the farmers to find out the salinity level. The laboratory collects soil samples and finds the salinity level in the laboratory. This method is time-consuming end costlier. There are different ways to detect, monitor, and map soil salinity. The most important are laboratory analysis, ground surveys, proximal sensing, remote sensing, Unmanned Aerial Vehicle (UAV) assisted Ariel photography. All of these approaches have their pros and cons. Laboratory tests are a valid and proven method for mapping soil salinity. Many irrigation automation systems were proposed, but not a single solution targets the saline soil. Not a single IoT assisted precision irrigation study was conducted using in-situ monitoring of field parameters related to salinity and applied the machine learning approach to predict such recommendation in the futures based on microenvironment data

III.PROPOSED SYSTEM

A. Internet of ThingsModule

In the IoT module, we have three important sensors electric conductivity sensor soil moisture sensor, and temperature sensor. An electric conductivity sensor is used to find the salinity level in the soil more the value of EC the salt in the soil and vice versa. A soil moisture sensor is used to find the moisture in the soil which helps in finding the leaching. The temperature sensor is used to find the temperature near the cross-field all these three sensors are incorporated near the crop and all the sensors are connected to the database so the sensor values will be updated after every particular interval to the database.

B. User Interface Module

It is very much important to do to have an interface for the farmer to view the live values of the sensors and to find the leaching, a mobile application will be developed for both admin and farmer. Admin can create a farmer account and he can view the existing accounts and also view the sensors which are currently active and so on. Farmer can view the live sensor values in the mobile application these values are retrieved from the database the former will be provided with a reaching calculus button where he can find the leaching required by providing the growing stage of the crop.

C. Machine Learning Module

A classification model will be trained with the existing data set which contains four input attributes EC value soil moisture temperature and growth stage of the crop show the model will process these inputs and predict the leaching. So whenever farmer clicks calculate leaching in the mobile application will communicate with the machine learning model using an API and the fetched results will be displayed to the former in the mobile application as shown fig 1.

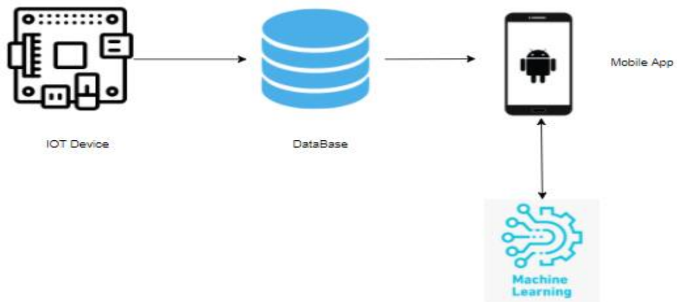

Figure 1: Block Diagram

IV. IMPLEMENTATION

A. Internet of Things module

In the IoT module, we have three important sensors electric conductivity sensor, Soil moisture sensor, and temperature sensor, and all these sensors are connected to Raspberry Pi. Let us look at the functionality of each sensor

1) *Electric Conductivity Senor:* This sensor helps to find the salinity level in the soil. More the value of EC more the soil salinity in the soil and vice versa. It is inserted in the soil and it is connected to Raspberry Pi so that the sensor values will be sent to the database after every particular interval. If the EC value is more the soil requires more water to dissolve the salts.

Figure 2: Electric Conductivity Sensor

2) *Soil Moisture Sensor:* It is very much important to monitor the moisture level in the soil. So we are using a soil moisture sensor to find out the moisture in the soil. It is one of the important parameters in estimating leaching.

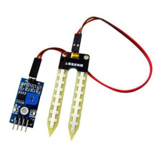

Figure 3: Soil Moisture Sensor

3) *Temperature Sensor:* DHT22 temperature sensor is used to find out the temperature near the crop field. If the temperature is too high we need to give more water to the crops.

Figure 4: Soil Moisture Sensor

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So once all the sensors are installed near the crop field these sensors are connected to the Raspberry Pi as shown in fig 2 to store the sensor values in the database. Once the values are stored in the database they can be viewed by the farmer using the mobile application.

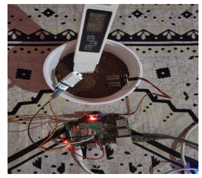

Figure 5: IOT Module

B. Machine Learning Module

The data set is prepared manually by contacting some of the farmers who are working with the paddy field. The data set contains four input labels Electric Conductivity, Temperature, Soil Moisture, and Crop Growth Stage. The data set contains one output label Leaching required based on the four input labels. All the input labels are divided into different classes based on the values.

Soil Salinity (EC)	
EC (dSm-1)	Class
<2	Non Saline
2-4	Slightly Saline
4-8	Moderately Saline
8-16	Strongly Saline
>16	Very Strongly Saline

Growth Stage of Crop	
Days from Sowing	Class
30	Initial
30-80	Mid
Above 80	Late

Maximum and Minimum daily Temperature (°C)	
Temperature(°C)	Class
>37	hot
27-37	medium
<27	cold

Soil Moisture
Class
Low
High

Figure 6: Classification of Input attributes

EC is divided into five classes depending on the value. The classes are Nonsaline, Slightly saline, Moderately saline, Strongly saline, Very strongly saline.

The second input label temperature is divided into three classes Cool, Normal, Hot. The growth stage is divided into three classes. Paddy usually takes 3 to 6 months for development. So depends on this we categorized classes into Initial, Mid, Late.

Output label Leaching required is divided into 5 classes

- Not Required
- Lightly Required
- Medium Required
- Heavily Required
- Extensively Required

The entire data set is split into two parts training data set and testing data set. The decision tree classifier is trained with the training data set. After successful training, we tested the model with the testing dataset.

```
Accuracy : 0.9157894736842105
Precision : [1.         0.76923077 0.86363636 1.         0.95348837]
Sensitivity/Recall : [0.875      1.         0.9047619  0.71428571 0.97619048]
Confusion Matrix :

<matplotlib.axes._subplots.AxesSubplot at 0x20435672438>
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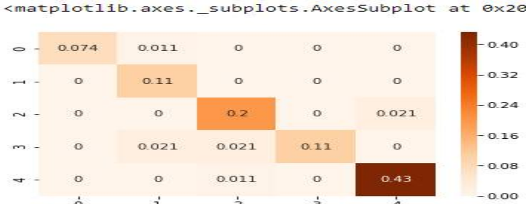

Figure 7: ML Model Test Result

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C. User Interface Module

The Mobile application is developed using the flutter framework. The application is for the end-user to view real-time values of sensors and to calculate leaching and also for the admin to manage users and sensors.

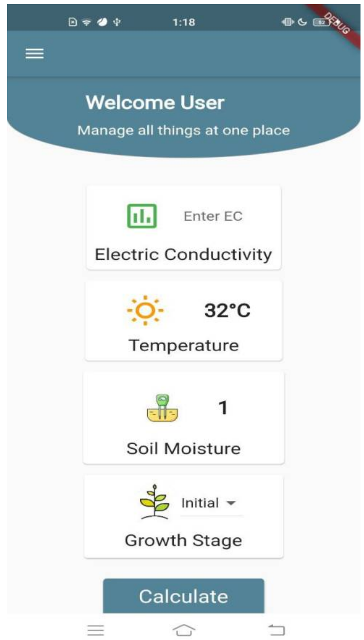

Figure 8: Mobile Application Farmer Home page

Farmer can log in to the application by providing valid email and password which were created by admin. After Successful login farmer will be redirected to the farmer home page. Farmer can view live data generated by sensors. Farmer can calculate leaching by entering Ec value by checking Ec meter and also farmer need to enter the crop growth stage.

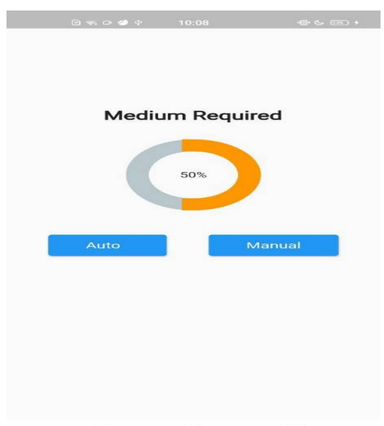

Figure 9: Leaching output

So whenever a farmer clicks on calculate button, the Mobile application will communicate with the ML model with the help of API and gives the Leaching Required for the crops. Leaching required is also shown in terms of percentage to make farmers understand. By looking at the output farmer can provide leaching as suggested by the application to get more yield. Auto mode is to automate the irrigation process which will be added in the future.

V. CONCLUSION

The IoT-based device is used to calculate the leaching required for the paddy crop based on the salinity, moisture, and growth stage of the crop. The machine learning model is trained using these values. The Decision Tree Classifier shows 90% accuracy and high precision, f-measure, and recall. IoT-assisted crop field context is used to determine the leaching irrigation requirements in saline soils to leach down salts from the root zone of the crop. These requirements are used to train and test the Naive Bayes classifier for the machine learning model, to make leaching requirements prediction in the future using temperature and salinity level only. The proposed model shows 85% of accuracy and high f-measure, precision, and recall for making a prediction. These estimates and predictions proved to very effective in the recommendation of water requirements for leaching of the salts from the root zones of the plants for better production in saline soils .in future these methods can be applied for other types of crops at present these are meant for paddyIt can extend it for multiple crops and implement the automatic leaching controlling feature which controls the water motor without the involvement of farmer. The mobile application can be made available in various Indian local languages which helps the farmer to easily interact with the application.

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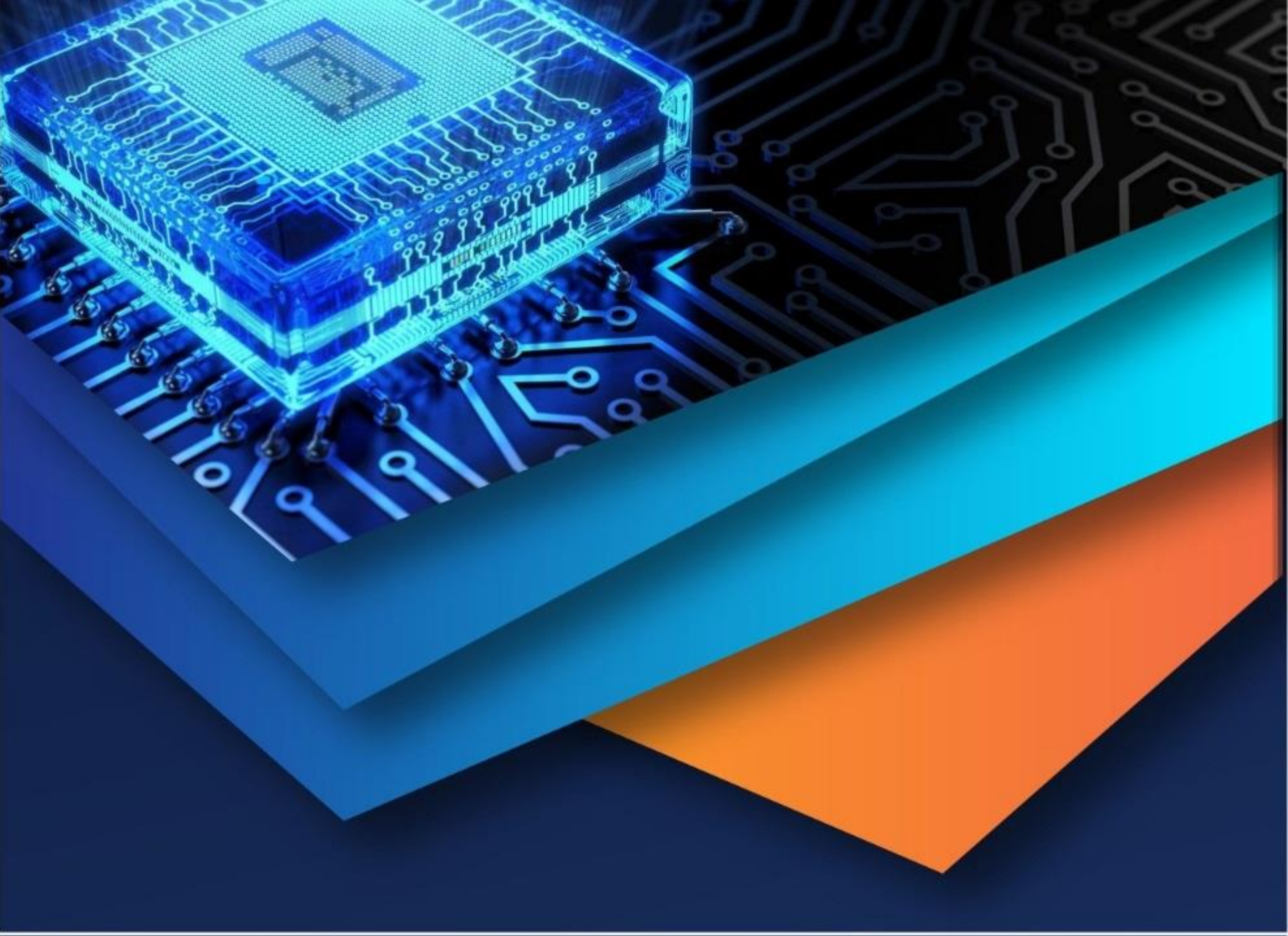

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