"E-KETHA" : ENRICHING RICE FARMER'S QUALITY OF LIFE THROUGH A MOBILE APPLICATION.

2022-81

Final Report

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B.Sc. (Hons) Degree in Information Technology

Department of Computer Science and

Software Engineering

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The supervisor/s should certify the proposal report with the following declaration.

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

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ABSTRACT

In our country of Sri Lanka, rice is the most common type of food that is consumed on a daily basis. Due to that rice farmers face a huge amount of stress to supply according to the massive demand. One of the main problems rice farmers are currently facing is the improper use of fertilizers and the negative consequences due to it. These can range from harming the environment and the paddy itself then even harming humans. These topics were chosen due to there being recent reports of people getting sick. The aim is to develop a mobile application that will help farmers solve this particular problem. The application will use images to conduct image processing to analyze the area of the paddy field then again use image processing to identify the fertilizer belonging to the farmer. Finally, machine learning and deep learning will provide adequate dosage and instructions.

Keywords :- rice crops, machine learning, image processing, deep learning, fertilizer

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1. INTRODUCTION

1.1 Background

As the most popular food in Sri Lanka [1] that is concerned on a daily basis, rice has quite a high demand. One of the prime reasoning for not being able to fulfill this requirement is the improper use of fertilizers affecting the crops negatively.

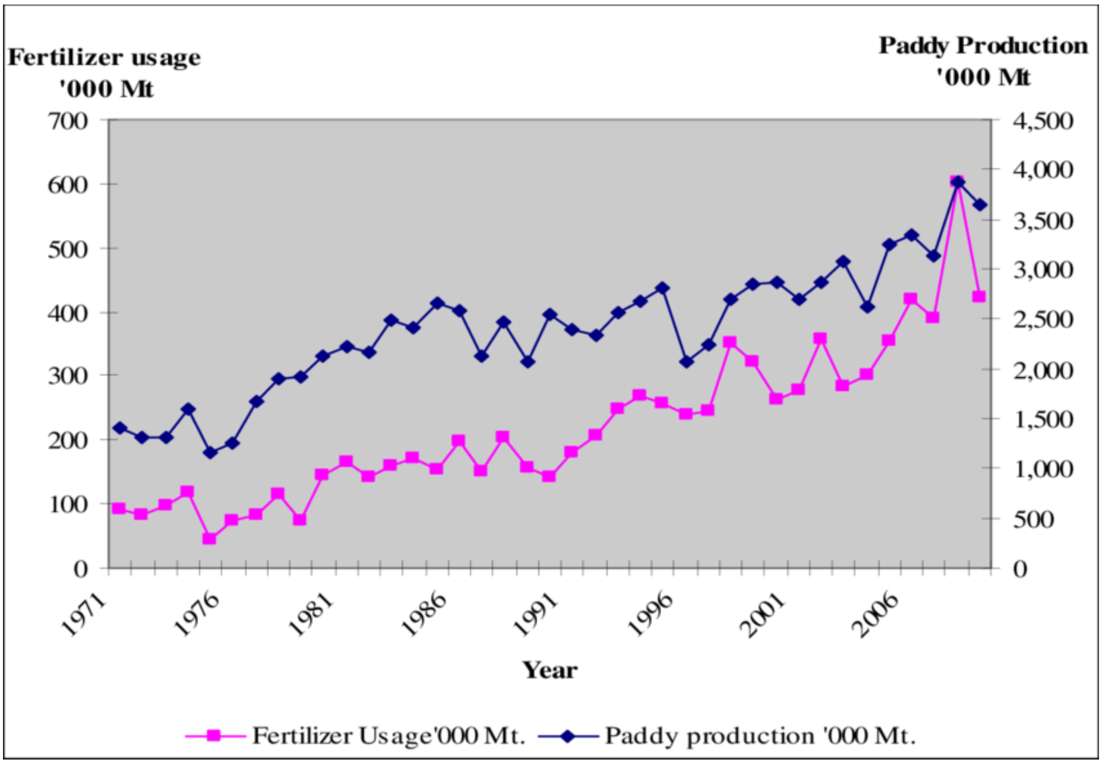

Figure 1: Paddy production according to the fertilizer usage

As it is shown in the above figure 1 [2] during the period of 1971 – 2010 the use of fertilizers has steadily increased in the country of Sri Lanka with it directly impacting the production of paddy. In the time duration of 1988 – 1991, there is a fluctuation in the usage of fertilization and if we see the same time period of paddy production the same exact fluctuation can be seen as well.

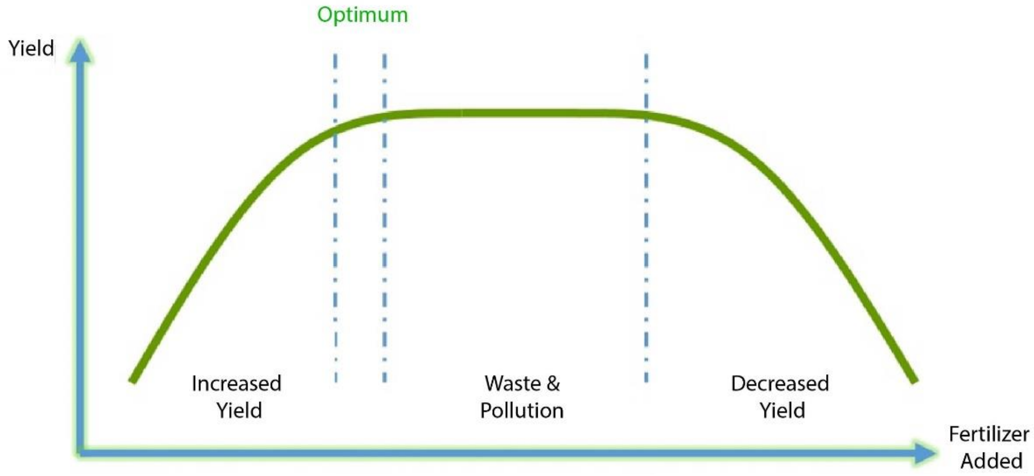

Figure 2:Increase of problems due to high improper fertilizer usage

When it comes to the negative effects of improper fertilizer usage above figure 2 [3] can be used as evidence. While reaching the optimum point, the yield will steadily increase and after the optimum point, the surroundings will be polluted due to the buildup of toxicity. And it further continued even the crops will be harmed.

As a solution for all these issues, a mobile application will be proposed.

1.2 Literature Survey

In the literature survey, I have looked for the same research areas and functionalities that are related to my research.

1.2.1 A nutrient recommendation system for soil fertilization based on evolutionary computation

This study [4] is about predicting the fertilizers for different crops and giving nutrient recommendations by analyzing crop fertility and yield production. However, this application is limited to selected fertilizers (Nitrogen (N), Phosphorus (P), and Potassium (K)). This recommendation is done by using an improved genetic algorithm (IGA) which will use time-series sensor data and recommends various crop settings. By analyzing the way that fertilizer works, the application will be able to give instruct farmers to get the maximum yield output.

1.2.2 On-line fertilizer recommendation system

This application [12] will require several inputs from the user(Select state, select district, select soil type, select crop, select crop variety, select season). After providing the required information, the dominant cropping systems in his district, the average soil fertility status of the district, and also the agroclimatic zone in which the district occurs will be shown to the farmer. Finally when the submitting farmer will be given the required quantities of nitrogen, phosphate, potash, and straight fertilizers shown in order to get the desired yield target. This application is available in up to 18 states.

Access: http://www.nic.in/

1.2.3 Prediction of Crop Fertilizer Consumption

This research [13] is focused on the identification of nitrogen deficiency and the prediction of fertilizers consumption in chilly. The first images of chilly are taken in two stages. The leaf part will be used to identification of nitrogen deficiency. This application will give proper guidance for the optimal usage of these fertilizers and also get the required yield outcome that the farmers are expecting by minimizing wastage.

1.2.4 Integrated Fertilizer Management System (urvarak.nic.in)

The integrated Fertilizer Management System (iFMS) [14] is functional since 2016 June. This system continues all the functionalities regarding the fertilizer supplier chin.

Uses of the application will be able to monitor all the fertilizer sales all over the country. To keep up the system to date, the application will gather fertilizer information from Aadhaar-enabled PoS devices and update the software according to the information gathered, while making the payment to the participating companies on a weekly basis.

Access: https://dbtfert.nic.in/iFMS/

1.3 Research Gap

The proposed application is to provide farmers with proper guidance on how to apply fertilizers. Although there are several existing applications found, the majority of them do not achieve the main goal which is to give proper guidance to the farmers on how to fertilize their paddy fields with their preferred fertilizer. The proposed application will have the ability to achieve the above-mentioned goal.

Feature	A nutrient recommendation system	On-line fertilizer recommendation	Prediction of Crop Fertilizer	iFMS	E - Ketha
Calculate paddy area	✗	✗	✗	✗	✓
Identify fertilizer	✗	✗	✗	✗	✓
Recommend fertilizer	✓	✗	✗	✗	✓
limited fertilizer range	✓	✗	✗	✗	✓
Able to use for rice plant	✓	✓	✗	✗	✓
Provide guidance	✓	✓	✓	✗	✓
Monitor fertilizer sales	✗	✗	✗	✓	✓

Table 1: Comparing existing applications and our application features

2. RESEARCH PROBLEM

Recognition of suitable fertilizers that are needed for the crops to grow healthy and abundant. Farmers due to a lack of proper guidance tend to use incorrect fertilizers, not only does it affects the yields, but fertilizers also have considerable side effects or even the correct fertilizers in the wrong amounts thus making them harmful. This has become a major problem in Sri Lanka today due to there being reports of various health concerns for the consumer such as increased risk of Alzheimer's disease and Diabetes [5]. At worst, these fertilizers can cause the risks of being exposed to cancer in both adults and children adversely affecting fetal brain development [6] [7] [8].

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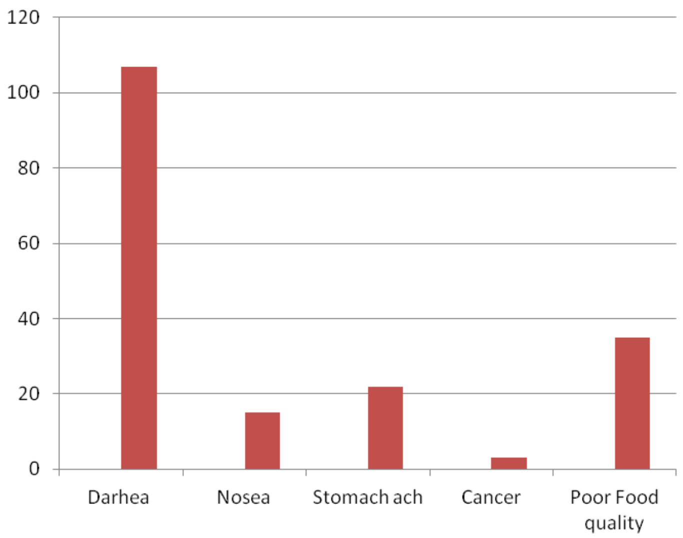

Figure 3: Heath concerns in Buea

Figure 3 [9] represents the average health issues that occurred in Buea, Cameroon caused due to improper use of fertilizers.

Country	Fertilizer consumption (kg/hectare of arable land)
Sri Lanka	284.3
Bangladesh	164.5
Pakistan	163.3
India	153.5
Bhutan	9.0
Nepal	7.7

Figure 4:2013 Sri Lanka's Fertilizer consumption

According to the local newspaper [16] which was published in 2013, The World Health Organization warned Sri Lanka because of high fertilizer consumption. At that time Sri Lanka was ranked as the number 1 country when it comes to fertilizer consumption among Asian countries. Figure 4 [17] shows the fertilizer consumption amounts in 2013.

The environment is also damaged as a repercussion, examples being contaminated waterways, soil pollution, and the destruction of algae [10] [11]. Therefore there is a need for a proper guidance system that helps the farmers to continue their farming while preventing these issues.

3. OBJECTIVES

3.1 Main Objectives

Introduce a mobile application to Identify the fertilization information. Then give guidance to the farmer on how to use it properly according to fertilizer type.

The main objective of the application is to give proper guidance to the farmer on how to use fertilizers. In order to do that user will have the ability to take a picture of rice fields and fertilizers. This will help to identify the best utilization methods with detailed instructions including the amount and dosage of fertilization that could be used to aid their growth using machine learning. Then the farmer can easily conduct the fertilization according to the instructions given by the application.

3.2 Specific Objectives

1. Calculate the area of the paddy field.

   By using this paddy image taken by the farmer, first, the application will analyze the image and calculate how much of an area that particular paddy field contains. This information will be further used for the task of providing instructions.

2. Identify the fertilizer type.

   By analyzing the fertilizer image, the application will identify which type of fertilizer the farmer is trying to apply.

3. Providing information on how to use the fertilizer properly.

   After the completion of the first 2 phases, the application will analyze and get the optimum solutions to the farmer on how to fertilize their paddy field properly.

4. METHODOLOGY

4.1 Methodology

This section consists of a description of the techniques, and mechanisms that will be used and what are the data sources, and how they will be collected to build up this “Fertilizer recombination system”.

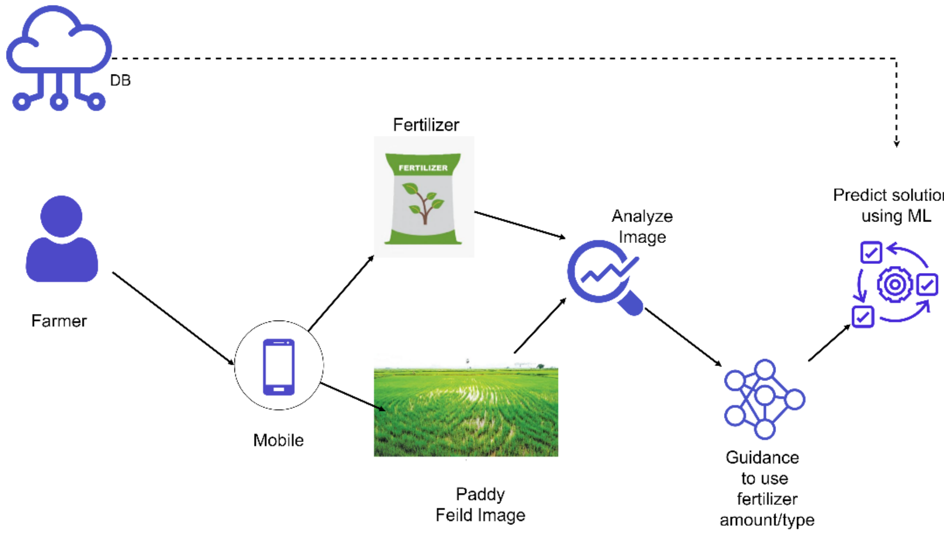

Figure 5: fertilizer recommendation overview

S shown in figure 4 this component has 3 major functionalities.

1. Calculate the area of the paddy field.

    To give proper guidance to the farmer, first, we need to identify how much paddy field the farmer needs to fertilize. By using this information the application will be able to give exact fertilizer amounts that have to apply for a specific paddy field. In order to predict this image processing technology will be used to identify and calculate the area of the specific paddy field. The farmer just has to take an image of the paddy field by using their mobile camera and the application will analyze the image and then record the information.

2. Identify the fertilizer type.

    To identify which type of fertilizer the farmer is trying to use, image processing will be used. In this phase also farmer has to take a picture of the fertilizer. Then the application will analyze the fertilizer image to identify the type of the fertilizer. In order to do this application will keep up a labeled image dataset of fertilizers. Results gained from the recognition process will be recorded. Later this information will be used to predict optimum solutions.

3. Providing information on how to use the fertilizer properly.

After the first 2 phases are completed to predict the optimum outcome machine learning algorithms will be used. By using the fertilizer type application will look for the best ways of utilizing that particular fertilizer. Then by using the paddy field area the application will give proper guidance to the farmer on how to utilize the fertilizer. What amount should be applied, How the fertilization to conduct, What is fertilization during different time phases, etc. Refer the figure 5 [15].

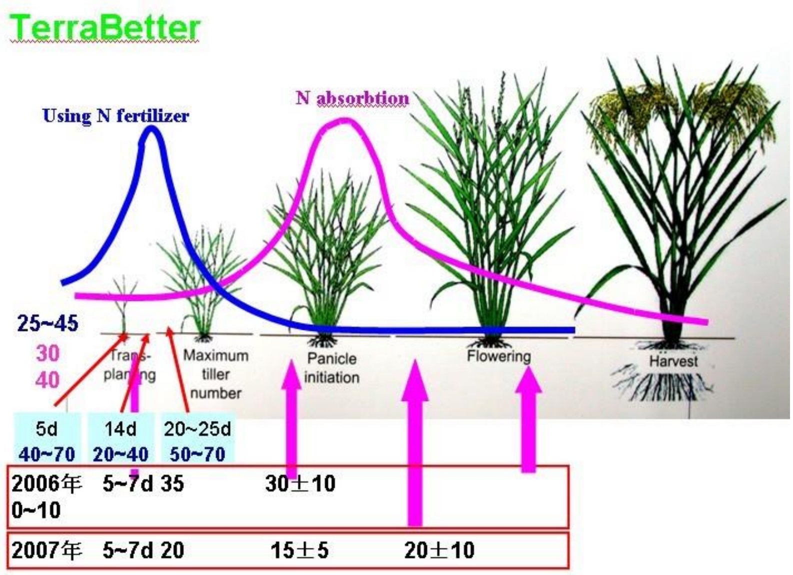

Figure 6:fertilization stages

4.1.1 Research Area

When it comes to the research area, four features were identified. Such as Image processing activities, Classification activities, Detection activities, and finally solution prediction. In order to conduct the research, deep learning technology has been taken as the core foundation.

4.1.2 Requirement Gathering and Analyzing

Due to the importance of requirement gathering and analysis, major emphasis was put on this section. Since there is a need for this process to be strictly on the "fertilizer management" part below mentioned approaches were used.

- Reading research papers relevant to the research problem.
- Studying existing systems related to our research area.
- Contacted experts at Rice Research and Development Institute(RRDI), Bathalagoda.
- Met with Sri Lankan paddy farmers.

To get an idea about the research problem, studying related research papers is a must. The next step was to understand what types of systems already exist, so as to see what is lacking and needs improvements. Finally, to see if the proposed solution is viable in the current environment, specialists on the field and traditional farmers were contacted.

4.1.2.1 Functional requirements

- Ability to upload paddy field imagery.
- Calculate the paddy field area.
- Ability to upload fertilizer imagery.
- Identify fertilizer type.
- Propose solutions.
- Show proposed solutions.

4.1.2.2 Non-functional requirements

- Reliability
- Accuracy
- Availability
- Performance
- User friendly

4.1.3 Design

The design phase encompasses what is needed for the estimation of hardware and system requirements by the creation of a system architecture, due to the needs and specifications being included. The architecture will entail the components separated into manageable levels according to the respective research project member. In this case, it will be the "fertilizer management" component.

4.1.4 Tools and Technologies

4.1.4.1 Tools

- Android Studio
  - This is chosen due to it being the primary IDE recommended for Java mobile application development. The user-friendliness coupled with the performance, security, and feature richness also makes this the most suitable option.
- Google collab
  - Since some of the deep learning models require high amounts of computational resources a virtual environment like google collab is most appropriate.
- Google Drive
  - Since google collab is used for the model training, the dataset cannot be stored on personal computers thus google drive is needed for storing the dataset.

4.1.4.2 Technologies

- Deep learning
  - Deep learning is the only solution for image classification and identification tasks such as this. Due to there being no similar prior work, a model has to be created and trained from scratch.
- Models
  - CNN
    - A custom CNN model was identified to be the best for the identification of fertilizer.

    The evidence for this is provided below within the methodology.
- Android Java
  - Since the application is initially targeted toward android devices, in order to provide the smoothest experience possible native android java is used.

- Firebase
  - Due to the application requiring a real-time online connection to the database firebase is chosen as the primary database. Since the data set mostly consists of images the need for a document-based database is further insinuated.
- Python
  - For the machine learning and deep learning parts of the application, python is used due to the wide range of libraries and frameworks available for such tasks compared to other languages. The simplicity and consistency with the large community are also a benefit.
  -

4.1.5 Data acquisition

A custom-made dataset has been created for this component which contains 785 images split into 4 different fertilizer types has been used for the model training and they are " Muriate of Potash (MOP)", " Triple Super Phosphate (TSP) ", "Urea" and "Zinc Sulphate" used for providing fertilization solutions according

4.2 Commercialization aspects of the product

4.2.1 Target audience

The primary target audience for this application will be rice farmers with rice suppliers, researchers, buyers, sellers, and any person who is connected to the rice farming process being the secondary audience.

4.2.2 Design of the app

A comprehensive and easily understandable UI and UX are created so that even non-tech-savvy users will not be confused while using the application. This will make sure that the application will reach a wide audience.

4.2.3 Gap in the market

Currently, in the play store, there is no other similar application to be found. This already makes the application unique and stand out.

4.2.4 Marketing Plan

The initial incentive will be to introduce this application to the farmers themselves. This will enable us to get feedback directly from the primary target audience which will then make it easier to enhance and optimize the application further, thus making a better product.

This application will be promoted by famous influencers and through social media platforms.

4.2.5 Pricing

Most of the functionality will be provided for free with them including,

- Pest identification
- Disease identification
- Weed identification
- Fertilizer type identification
- Weed mapping
- Growth deficiency identification

This will be with a free application.

In order for the solution providing functionality associated with the above-mentioned features to be enabled, a small price will have to be paid on a monthly basis.

4.2.6 Budget

A price will have to be allocated for the influencer and social media promotions. In order to publish the application another, sum also has to be assigned. Finally, the database will also be required of a monthly payment.

4.2.7 WBS

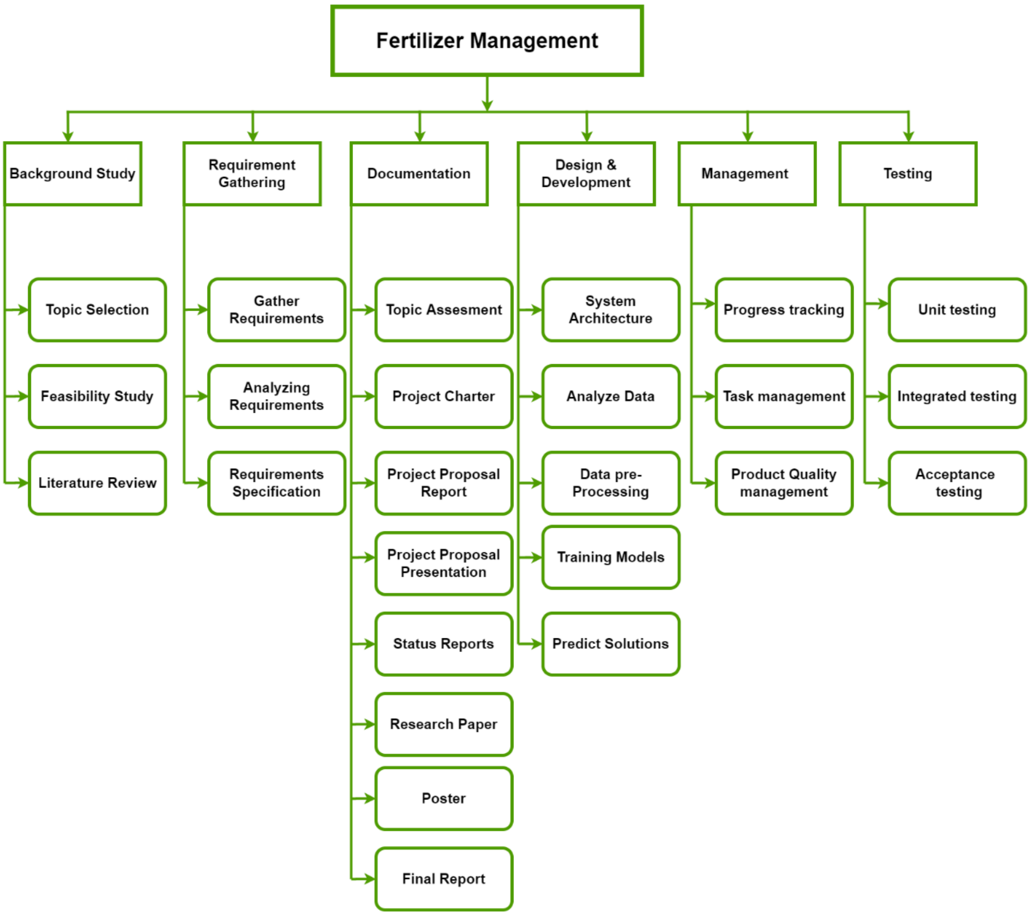

Figure 7:WBS

4.2.8 Gantt Chart

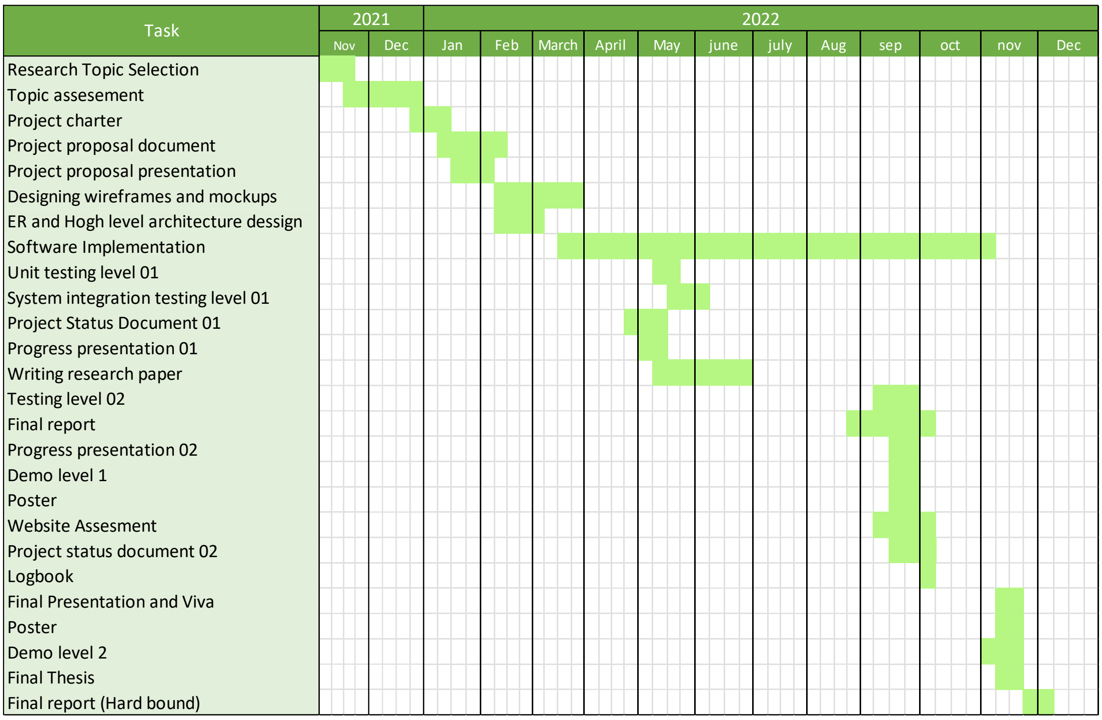

Figure 8:Gantt Chart

5. Testing & Implementation

5.1 Implementation

In this stage of the project, the implantation of the system will be started. This will be in accordance with the system architecture proposed in the previous design phase. The "Identification weeds and proposing solutions" component will be further split into three subcomponents, with them being

- Calculate paddy area using paddy imagery
- Identification of fertilizer using imagery
- Proposing solutions.

5.1.1 Pre-processing

When it comes to pre-processing all the models that are described below went through the same process. Which includes shuffling, resizing, rescaling, and flipping horizontally and vertically. Finally, normalization was performed according to the mean and standard deviation calculated for the datasets.

5.1.2 Model

5.1.2.1 IDENTIFY FERTILIZER TYPE:

A TensorFlow Keras model is used for creating this model. Customized CNN was used as the main model for fertilizer identification. CNN was chosen due to it being one of the most basic deep learning models which can take input images and have them differentiated.

The. 80% and 20% split was made for the training and testing set.

As for the train, test, and validation datasets, a batch size of 32, and a target size of 256*256 due to the resolutions of the preprocessed images and categorical class mode since there are multiple classes.

The layers of the model have been modified accordingly in order to get maximum accuracy.

- 4 - Convolution2D layers with ‘relu’ activation function
- 4 - pooling layers
- 4 - MaxPooling2D layers
- 4 – Dropout layers
- 1 - Flatten layer (to get output in the set of numbers)
- 1 – Dense layer with ‘SoftMax’ activation function (to change the output into a probability)

As for the Optimizer ‘Adam’ was used due to the problem being large and containing lots of data and parameters.

‘categorical_crossentropy’ is used as a loss function because the dataset contains more than 2 classes.

Hyperparameter tuning [6] was performed for the parameters of batch size, learning rate, and epochs. Due to there being research showing that higher values for learning rate and batch size do not always provide Higher results, a lower number was chosen initially with it gradually going higher. As for the epochs, a brute force method was used to see which would be best.

Fertilizer classification model summary

```
Model: "model_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_3 (InputLayer)        [(None, 256, 256, 3)]     0

 conv2d_8 (Conv2D)           (None, 254, 254, 32)      896

 max_pooling2d_8 (MaxPooling  (None, 127, 127, 32)     0
 2D)

 dropout_8 (Dropout)         (None, 127, 127, 32)      0

 conv2d_9 (Conv2D)           (None, 125, 125, 64)      18496

 max_pooling2d_9 (MaxPooling  (None, 62, 62, 64)       0
 2D)

 dropout_9 (Dropout)         (None, 62, 62, 64)        0

 conv2d_10 (Conv2D)          (None, 60, 60, 128)       73856

 max_pooling2d_10 (MaxPoolin  (None, 30, 30, 128)      0
 g2D)

 dropout_10 (Dropout)        (None, 30, 30, 128)       0

 conv2d_11 (Conv2D)          (None, 28, 28, 128)       147584

 max_pooling2d_11 (MaxPoolin  (None, 14, 14, 128)      0
 g2D)

 dropout_11 (Dropout)        (None, 14, 14, 128)       0

 flatten_2 (Flatten)         (None, 25088)             0

 dense_2 (Dense)             (None, 4)                 100356

=================================================================
Total params: 341,188
Trainable params: 341,188
Non-trainable params: 0
_________________________________________________________________
```

5.1.2.2 CALCULATE THE SIZE OF THE PADDY FIELD:

In order to calculate the area of the paddy field, a Mobile device's GPS has been used. The application was developed so that a user can easily calculate any paddy field part that they want to fertilize. The user has to ping the 4 corner locations of the area that is required for fertilization. Then the application will get the latitude and longitude of each location and calculate the area of the paddy field.

5.2 Testing and Maintenance

As the final phase of the SDLC is the testing and maintenance phase which will be done under the discipline of functional and non-functional testing. The functional testing will mainly consider the functional requirements of the system and unit testing will be taken as the basis. Then in order to check the nonfunctional requirements such as performance and availability various nonfunctional testing will be conducted. As for the maintenance of the application after the publication, various support features will be added.

6. RESULTS AND DISCUSSION

6.1 Results

6.1.1 IDENTIFY FERTILIZER TYPE:

Epoch	loss	accuracy	Val_loss	Val_accuracy
86/90	0.2031	0.8649	0.2297	0.8438
87/90	0.1995	0.8906	0.3161	0.8125
88/90	0.2211	0.8750	0.2790	0.8438
89/90	0.2056	0.9062	0.2989	0.8438
90/90	0.2444	0.8919	0.3199	0.8750

Table 2:Model accuracy

- Loss: 0.2241
- Accuracy: 94.20%

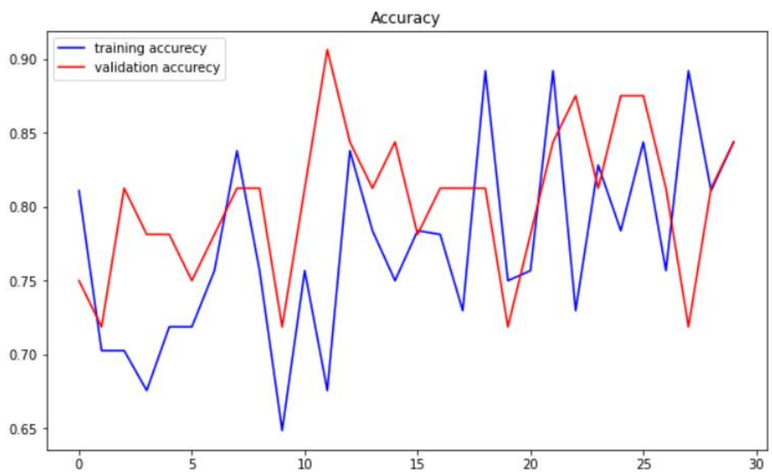

Figure 9:Training accuracy chart

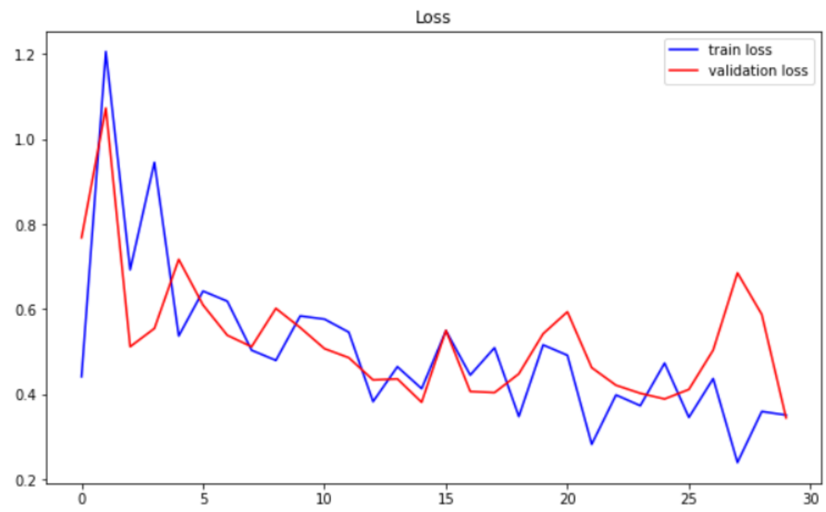

Figure 10:Training Loss chart

The above figure represents training and validation accuracy. The y-axis depicts the accuracy, and the x-axis depicts the number of epochs. In this graph, both the training and validation oscillate very frequently but near the end, they both merge and provide a steady result.

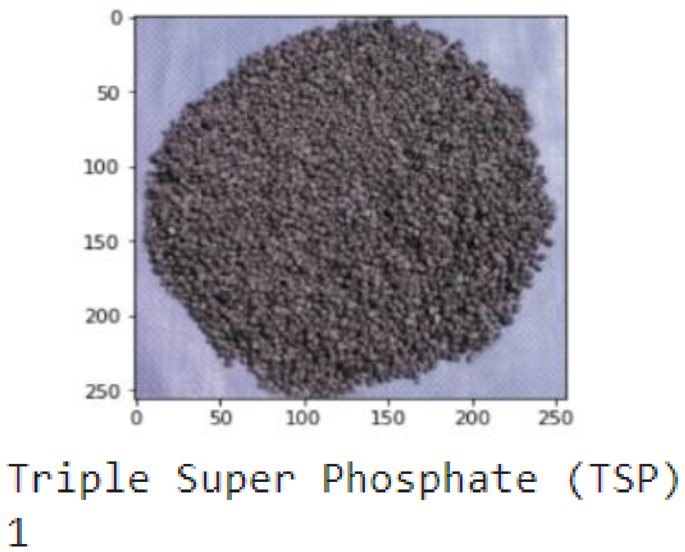

Figure 11:Fertilizer type prediction output

6.1.2 CALCULATE THE SIZE OF THE PADDY FIELD

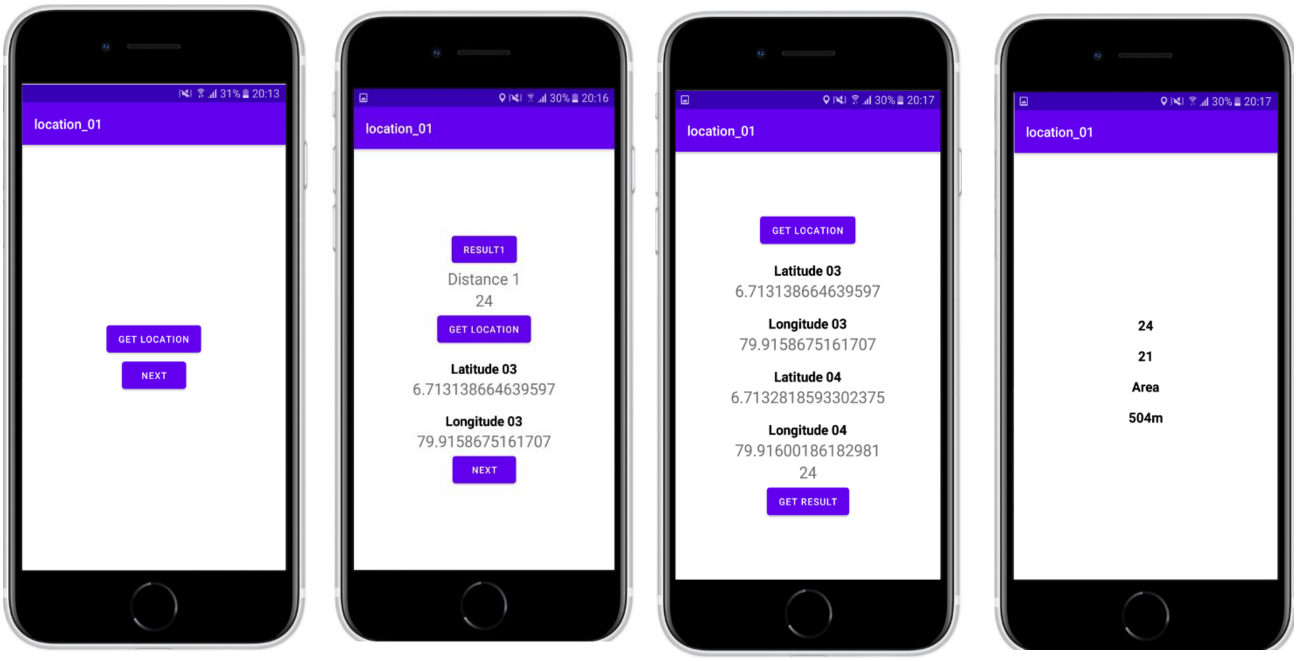

Figure 12:Area calculation

6.2 Research Findings

95.23% training accuracy and 94.20% test accuracy were able to be reached using this model as shown in the examples above with the predictions for the test data shown below. Finally, in order to get the maximum test and training accuracy hyperparameters were tuned accordingly,

- Batch size – 32
- Epoch - 90

Maximum accuracy was achieved, according to the previously mentioned configurations

Adam optimizer was also used here when it comes to model compilation due to the previously mentioned reasons with categorical cross entropy as this has multiple classes.

6.3 Discussion

After comparing with the other models such as customized AlexNet and custom CNN models, this ResNet model with the above-mentioned configurations was found to give the best accuracies for the weed identification task.

6.4 Summary of Each Student's contribution

- Discovering the best model for fertilizer type identification from a pool of different CNN models
- Discovering the best configurations for that said model to acquire the best results
- Create a feature for calculating the area of the paddy field
- Creating a mobile application for the created components
- Making the application as user-friendly as possible
- Find an appropriate dataset to train the models

Conclusions

This research paper was performed in order to provide rice farmers with solutions to the four major issues that they are currently facing which include pests, disease, weeds, fertilizers, and growth defects. In this research four CNN models are compared and contrasted in order to identify which one of them is best suited when it comes to rice and paddy farm datasets. Considering the outputs provided by four models which are used for image classification, the resnet50(modal 02) model performed best with it providing 99.43% for training accuracy and 97.04% for validation accuracy. Some additional research has also been done for the purpose of creating approaches for area calculation of the paddy fields.

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Glossary

CNN – Convolutional Neural Network

FCN — Fully Convolutional Network

SDLC - Software development life cycle

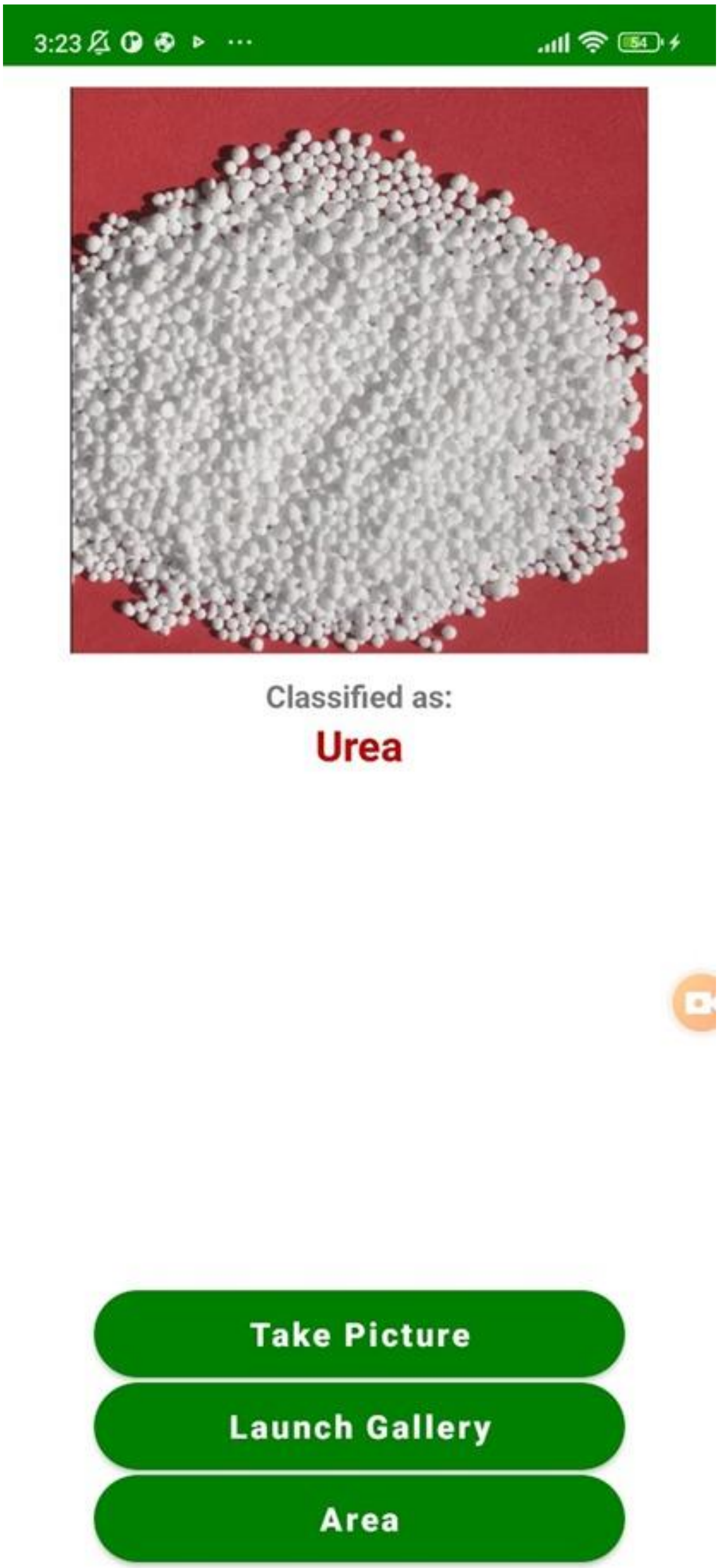
GPS - Global Positioning System

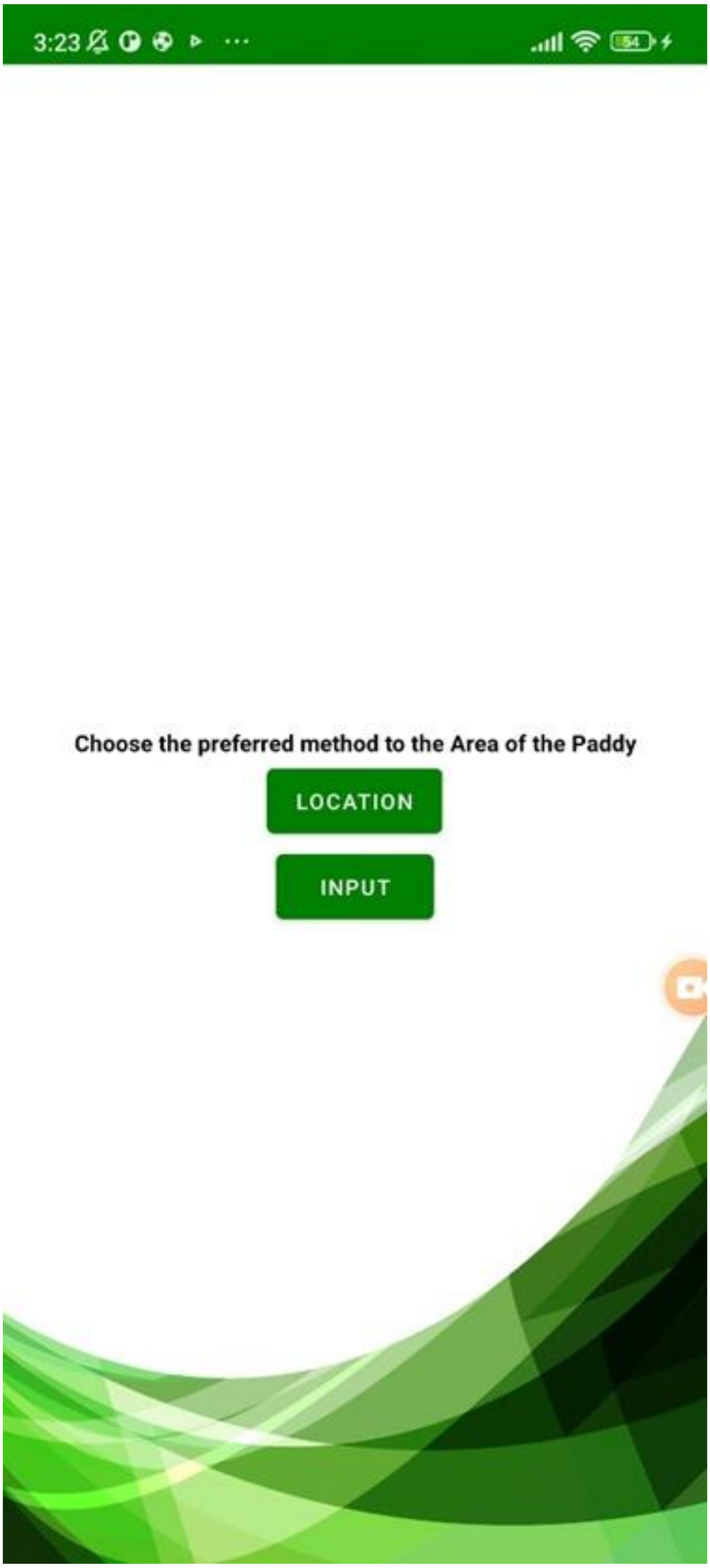
UI – User interface

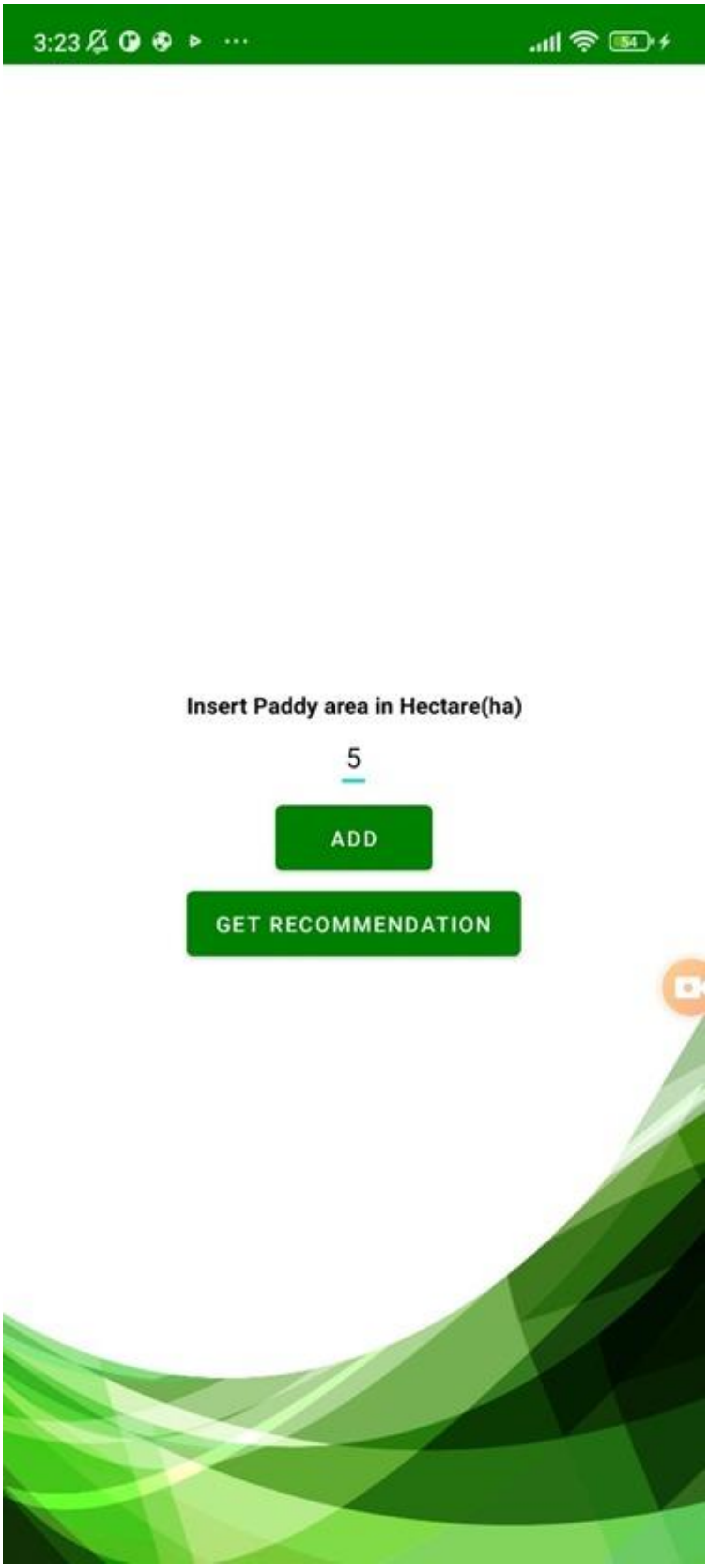
UX – User experience

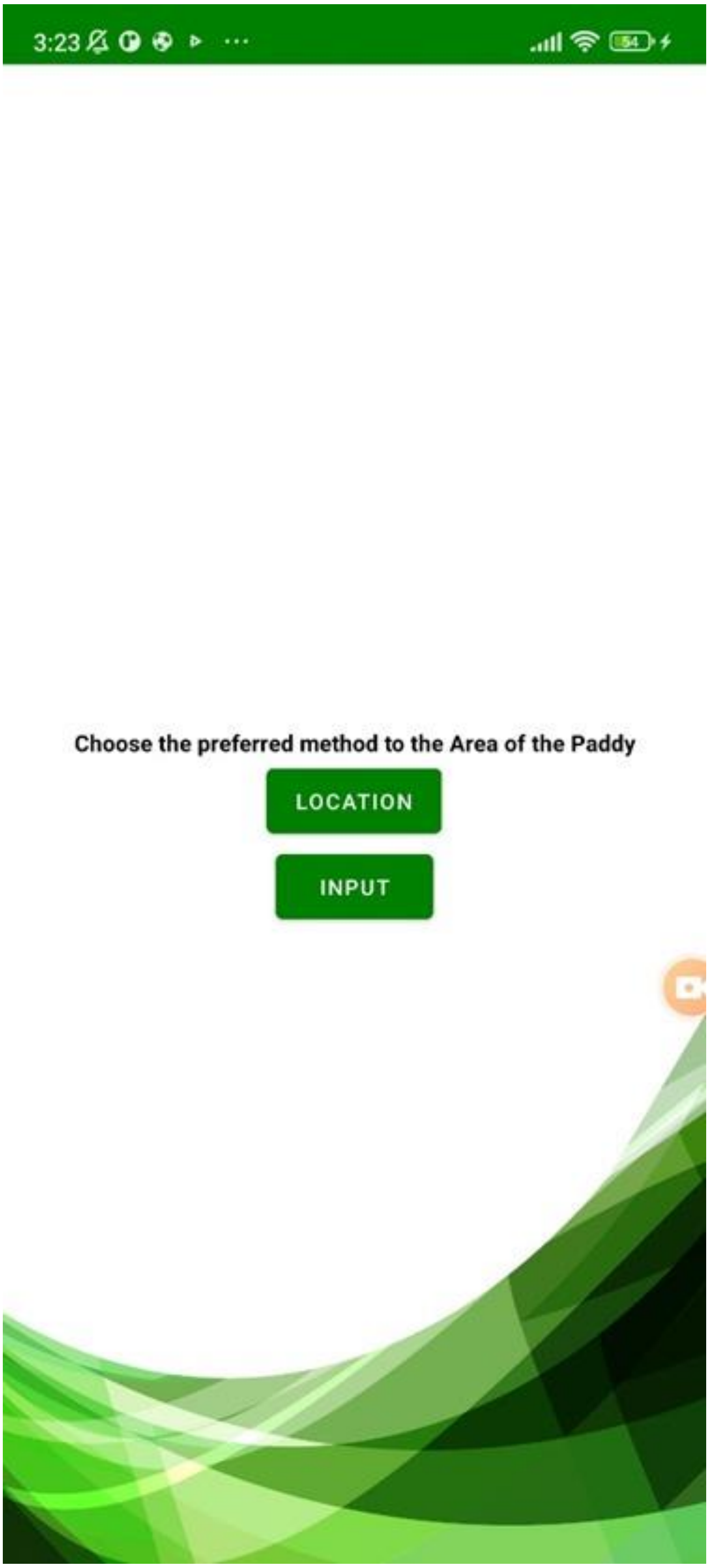
Appendices

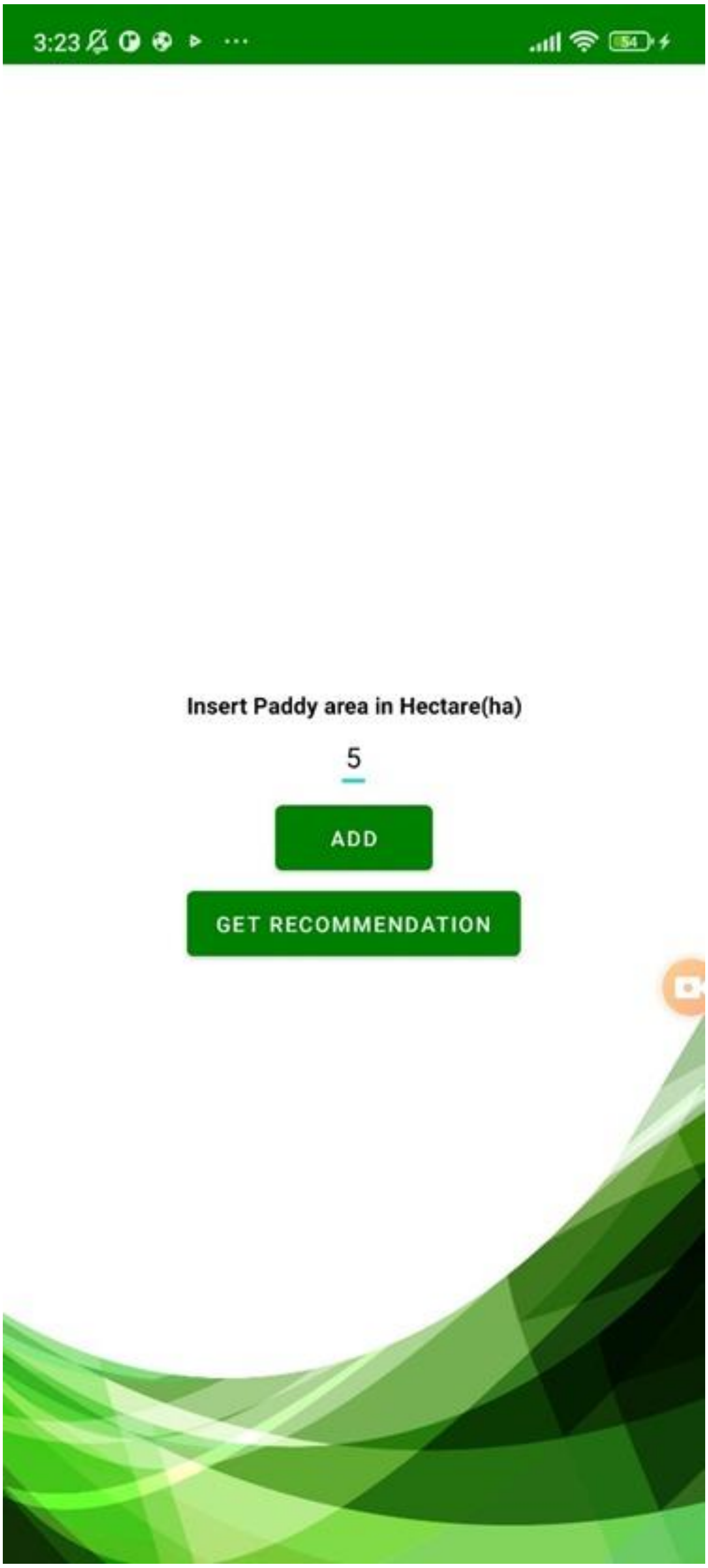
Screenshots of the Application

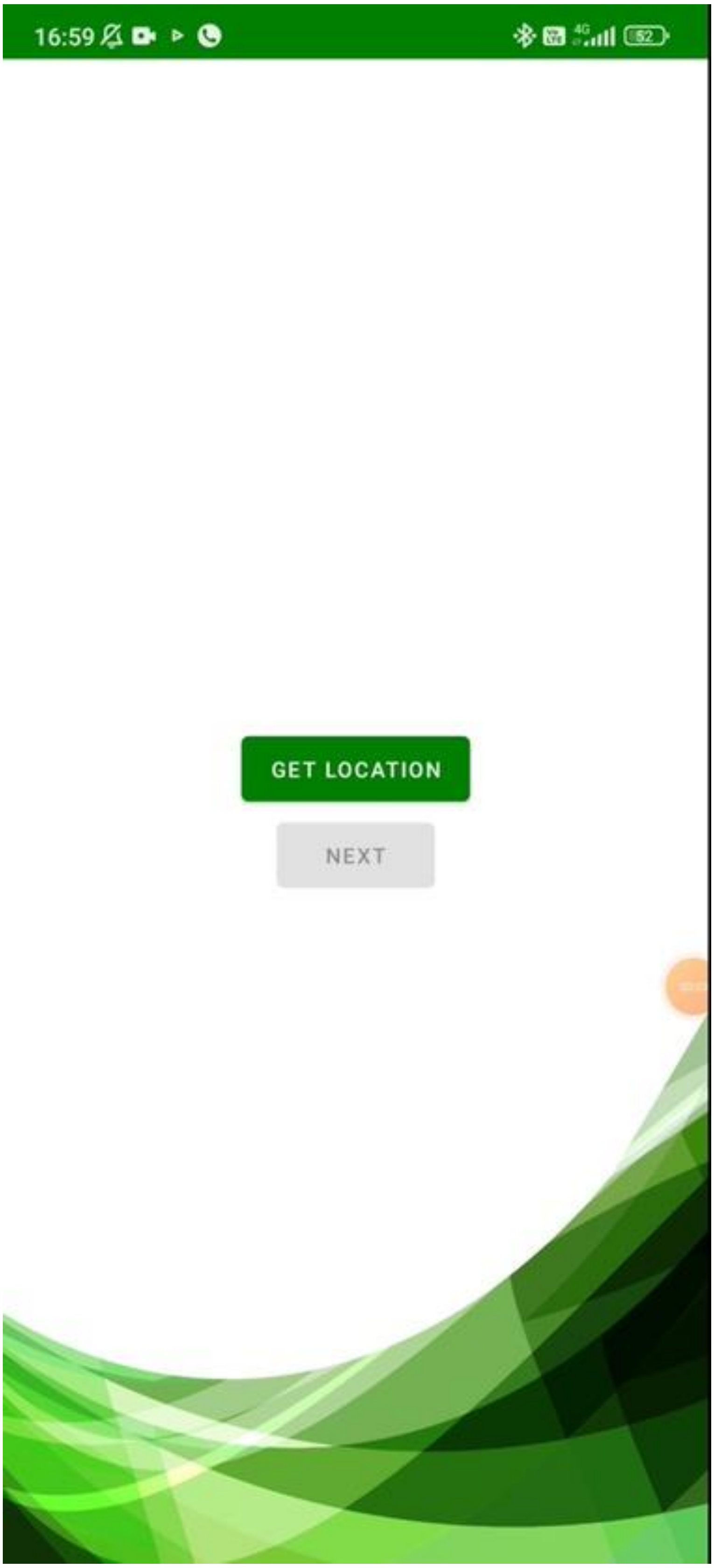

3:23
Classified as:
Urea
Take Picture
Launch Gallery
Area

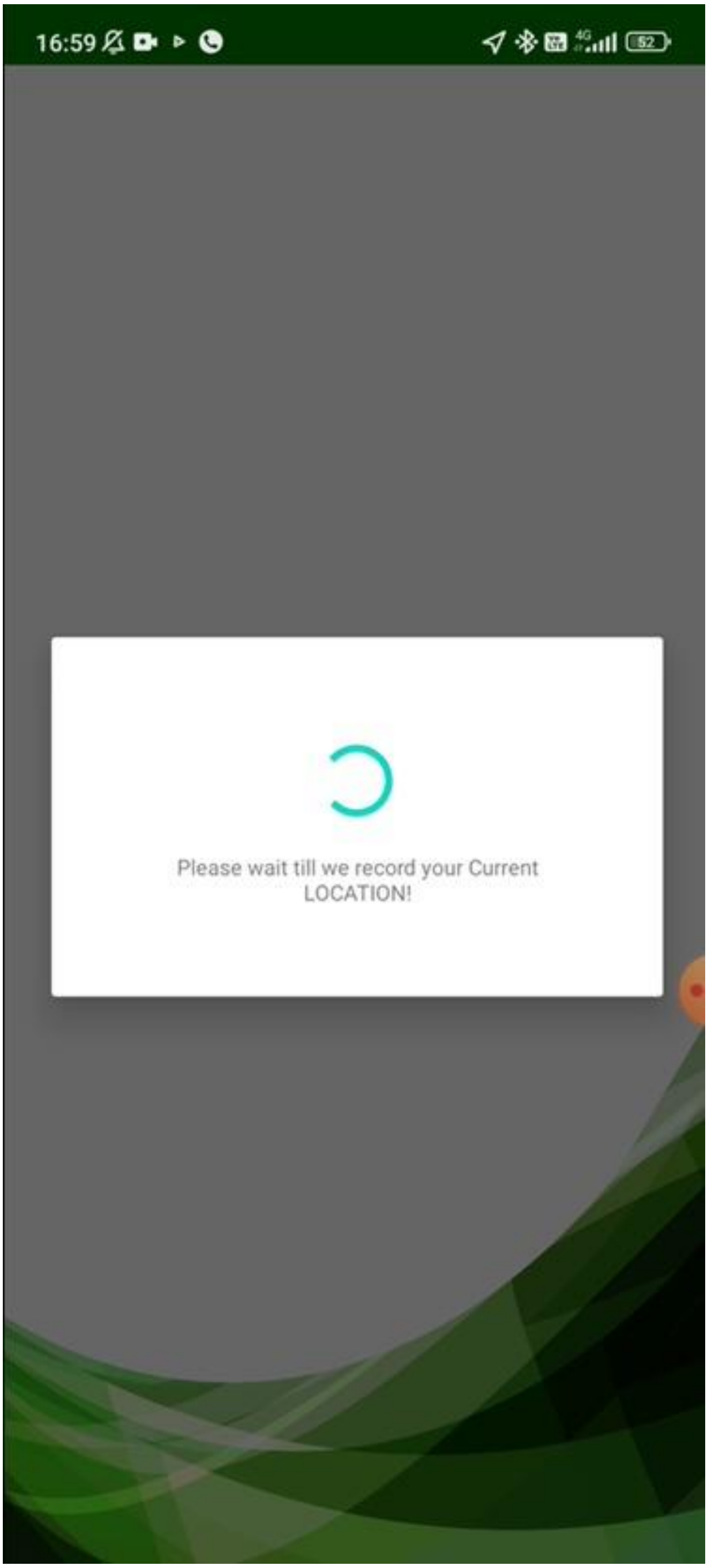

3:23
Choose the preferred method to the Area of the Paddy
LOCATION
INPUT

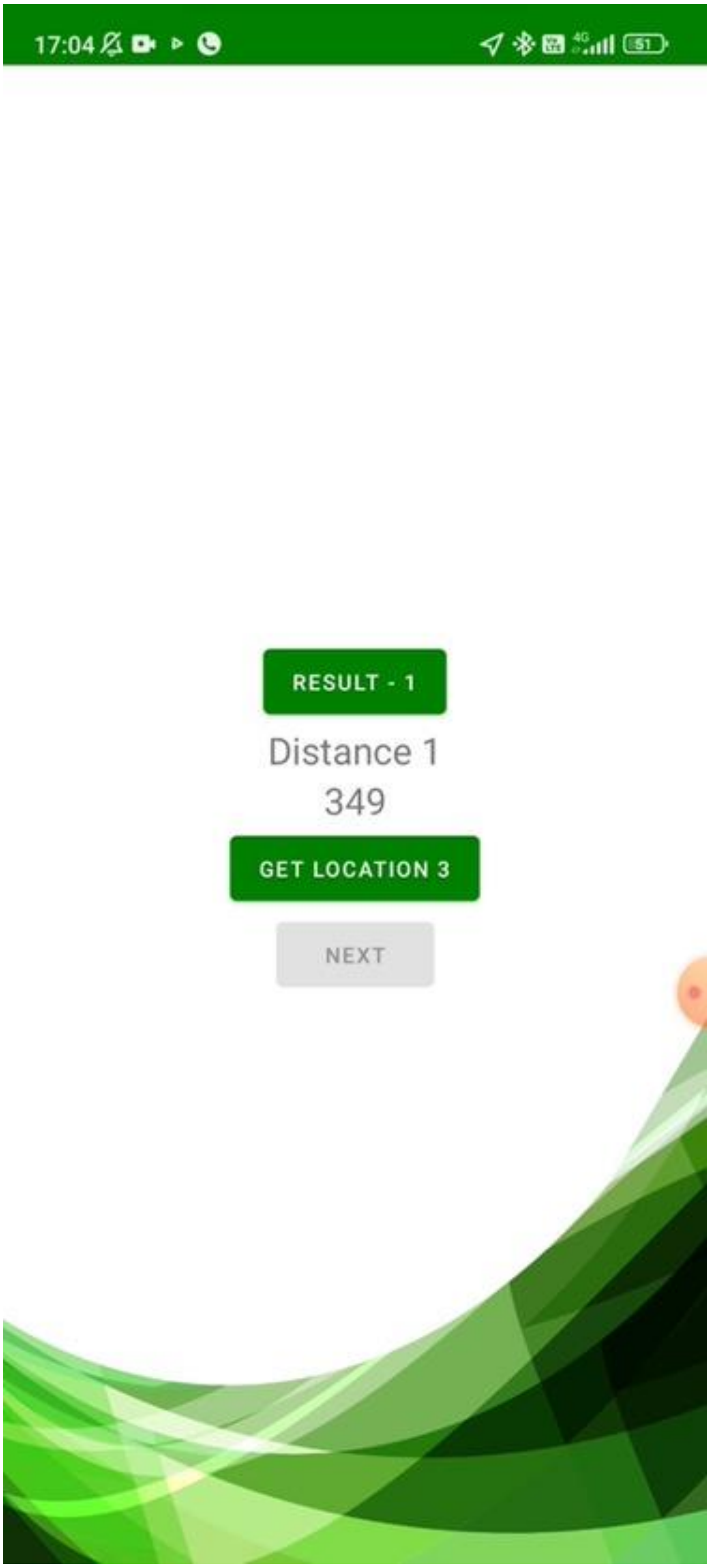

3:23
Insert Paddy area in Hectare(ha)
5
ADD
GET RECOMMENDATION

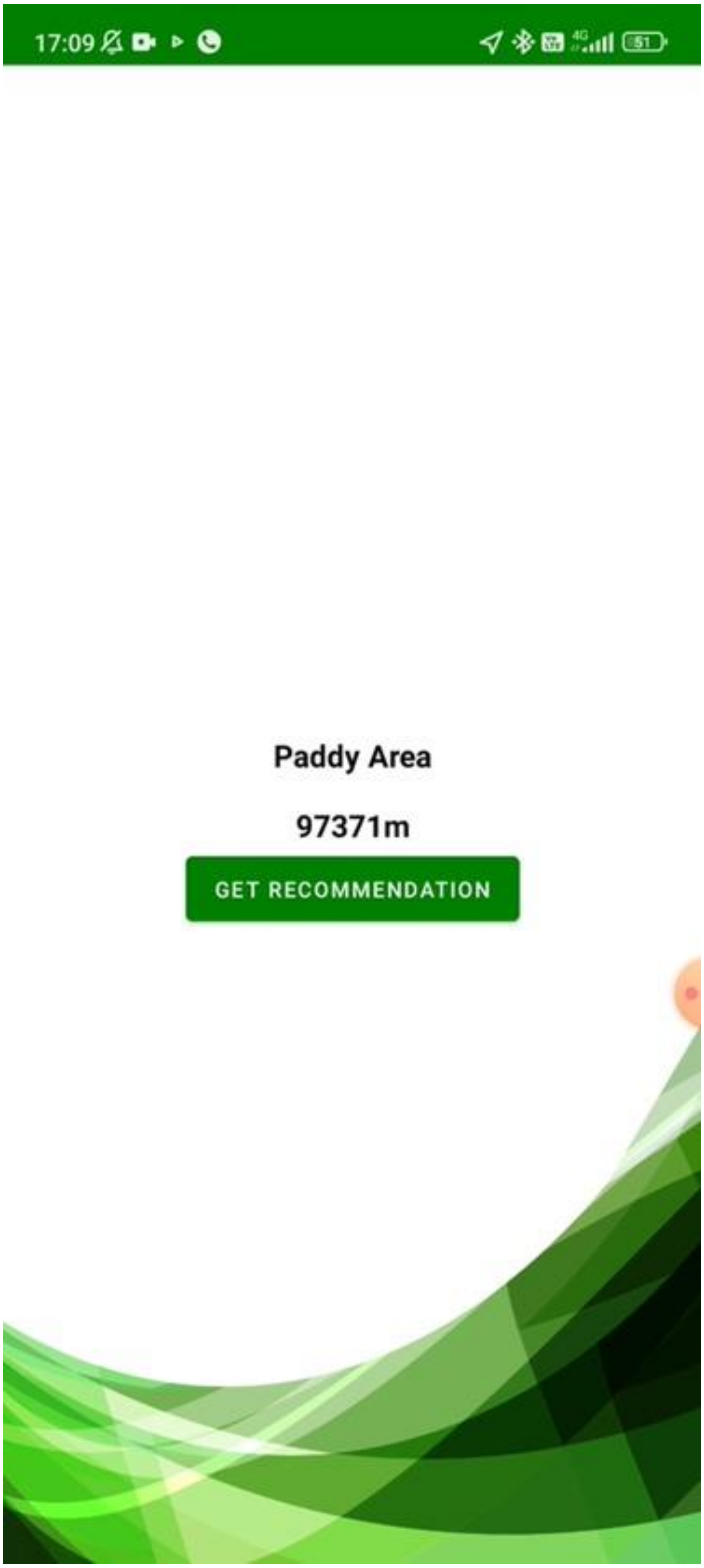

3:23
Choose the preferred method to the Area of the Paddy
LOCATION
INPUT

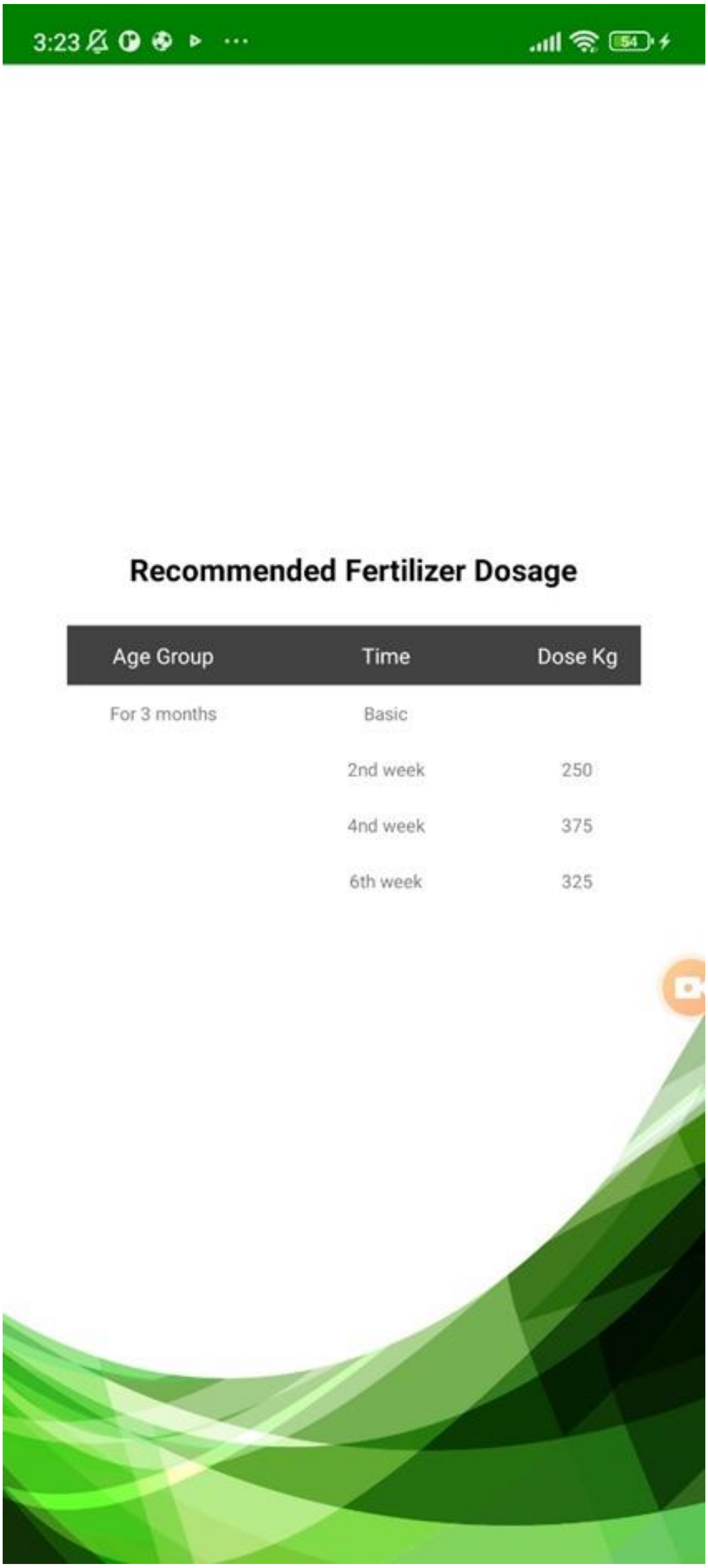

3:23
Insert Paddy area in Hectare(ha)
5
ADD
GET RECOMMENDATION


16:59
GET LOCATION
NEXT


16:59
Please wait till we record your Current LOCATION!


17:04
RESULT - 1
Distance 1
349
GET LOCATION 3
NEXT


17:09
Paddy Area
97371m
GET RECOMMENDATION



Age Group	Time	Dose Kg
For 3 months	Basic	
	2nd week	250
	4nd week	375
	6th week	325

Training fertilizer classification model

```
Epoch 75/90
2/2 [==============================] - 4s 1s/step - loss: 0.2148 - accuracy: 0.8919 - val_loss: 0.2958 - val_accuracy: 0.8750
Epoch 76/90
2/2 [==============================] - 4s 4s/step - loss: 0.1888 - accuracy: 0.9189 - val_loss: 0.1914 - val_accuracy: 0.9375
Epoch 77/90
2/2 [==============================] - 4s 1s/step - loss: 0.1154 - accuracy: 1.0000 - val_loss: 0.2521 - val_accuracy: 0.8750
Epoch 78/90
2/2 [==============================] - 4s 1s/step - loss: 0.2780 - accuracy: 0.8649 - val_loss: 0.2205 - val_accuracy: 0.8438
Epoch 79/90
2/2 [==============================] - 6s 3s/step - loss: 0.3761 - accuracy: 0.7812 - val_loss: 0.2141 - val_accuracy: 0.9062
Epoch 80/90
2/2 [==============================] - 5s 2s/step - loss: 0.3031 - accuracy: 0.8378 - val_loss: 0.4106 - val_accuracy: 0.7500
Epoch 81/90
2/2 [==============================] - 5s 5s/step - loss: 0.3072 - accuracy: 0.8108 - val_loss: 0.3842 - val_accuracy: 0.7500
Epoch 82/90
2/2 [==============================] - 4s 4s/step - loss: 0.2454 - accuracy: 0.8649 - val_loss: 0.2122 - val_accuracy: 0.8750
Epoch 83/90
2/2 [==============================] - 5s 2s/step - loss: 0.1635 - accuracy: 0.9189 - val_loss: 0.2611 - val_accuracy: 0.8438
Epoch 84/90
2/2 [==============================] - 5s 2s/step - loss: 0.3550 - accuracy: 0.7568 - val_loss: 0.3077 - val_accuracy: 0.8438
Epoch 85/90
2/2 [==============================] - 4s 4s/step - loss: 0.4292 - accuracy: 0.8108 - val_loss: 0.2468 - val_accuracy: 0.8438
Epoch 86/90
2/2 [==============================] - 4s 4s/step - loss: 0.2031 - accuracy: 0.8649 - val_loss: 0.2297 - val_accuracy: 0.8438
Epoch 87/90
2/2 [==============================] - 6s 3s/step - loss: 0.1995 - accuracy: 0.8906 - val_loss: 0.3161 - val_accuracy: 0.8125
Epoch 88/90
2/2 [==============================] - 7s 3s/step - loss: 0.2211 - accuracy: 0.8750 - val_loss: 0.2790 - val_accuracy: 0.8438
Epoch 89/90
2/2 [==============================] - 7s 4s/step - loss: 0.2056 - accuracy: 0.9062 - val_loss: 0.2989 - val_accuracy: 0.8438
Epoch 90/90
2/2 [==============================] - 5s 4s/step - loss: 0.2444 - accuracy: 0.8919 - val_loss: 0.3199 - val_accuracy: 0.8750
<keras.callbacks.History object at 0x0000026403E49AF0>
```

Fertilizer TensorFlow lite model

Kotlin Java

```java
try {
    BmodelTO model = BmodelTO.newInstance(context);

    // Creates inputs for reference.
    TensorBuffer inputFeature0 = TensorBuffer.createFixedSize(new int[]{1, 256, 256, 3}, DataType.FLOAT32);
    inputFeature0.loadBuffer(byteBuffer);

    // Runs model inference and gets result.
    BmodelTO.Outputs outputs = model.process(inputFeature0);
    TensorBuffer outputFeature0 = outputs.getOutputFeature0AsTensorBuffer();

    // Releases model resources if no longer used.
    model.close();
} catch (IOException e) {
    // TODO Handle the exception
}
```

```java
@Override
protected void onActivityResult(int requestCode, int resultCode, @Nullable Intent data) {
    if(resultCode == RESULT_OK){
        if(requestCode == 3){
            Bitmap image = (Bitmap) data.getExtras().get("data");
            int dimension = Math.min(image.getWidth(), image.getHeight());
            image = ThumbnailUtils.extractThumbnail(image, dimension, dimension);
            imageView.setImageBitmap(image);

            image = Bitmap.createScaledBitmap(image, imageSize, imageSize, filter: false);
            classifyImage(image);
        }else{
            Uri dat = data.getData();
            Bitmap image = null;
            try {
                image = MediaStore.Images.Media.getBitmap(this.getContentResolver(), dat);
            } catch (IOException e) {
                e.printStackTrace();
            }
            imageView.setImageBitmap(image);

            image = Bitmap.createScaledBitmap(image, imageSize, imageSize, filter: false);
            classifyImage(image);
        }
    }
    super.onActivityResult(requestCode, resultCode, data);
}
}
```

```java
public void classifyImage(Bitmap image){

    try {
        BmodelTO model = BmodelTO.newInstance(getApplicationContext());

        // Creates inputs for reference.
        TensorBuffer inputFeature0 = TensorBuffer.createFixedSize(new int[]{1, 256, 256, 3}, DataType.FLOAT32);
        ByteBuffer byteBuffer = ByteBuffer.allocateDirect(4 * imageSize * imageSize * 3);
        byteBuffer.order(ByteOrder.nativeOrder());

        int[] intValues = new int[imageSize * imageSize];
        image.getPixels(intValues, offset: 0, image.getWidth(), x: 0, y: 0, image.getWidth(), image.getHeight());
        int pixel = 0;
        //iterate over each pixel and extract R, G, and B values. Add those values individually to the byte buffer.
        for(int i = 0; i < imageSize; i ++){
            for(int j = 0; j < imageSize; j++){
                int val = intValues[pixel++]; // RGB
                byteBuffer.putFloat(((val >> 16) & 0xFF) * (1.f / 1));
                byteBuffer.putFloat(((val >> 8) & 0xFF) * (1.f / 1));
                byteBuffer.putFloat((val & 0xFF) * (1.f / 1));
            }
        }

        inputFeature0.loadBuffer(byteBuffer);

        // Runs model inference and gets result.
        BmodelTO.Outputs outputs = model.process(inputFeature0);
        TensorBuffer outputFeature0 = outputs.getOutputFeature0AsTensorBuffer();
```

```java
inputFeature0.loadBuffer(byteBuffer);

// Runs model inference and gets result.
BmodelT0.Outputs outputs = model.process(inputFeature0);
TensorBuffer outputFeature0 = outputs.getOutputFeature0AsTensorBuffer();

float[] confidences = outputFeature0.getFloatArray();
// find the index of the class with the biggest confidence.
int maxPos = 0;
float maxConfidence = 0;
for (int i = 0; i < confidences.length; i++) {
    if (confidences[i] > maxConfidence) {
        maxConfidence = confidences[i];
        maxPos = i;
    }
}
String[] classes = {"Muriate of Potash (MOP)", "Triple Super Phosphate (TSP)", "Urea","Zinc Sulphate"};
result.setText(classes[maxPos]);

if(classes[maxPos] == "Muriate of Potash (MOP)"){
    Toast.makeText(getApplicationContext(), "1", Toast.LENGTH_SHORT).show();
    fertilizerType = "1";
}
else if(classes[maxPos] == "Triple Super Phosphate (TSP)"){
    Toast.makeText(getApplicationContext(), "2", Toast.LENGTH_SHORT).show();
    fertilizerType = "2";
}
else if(classes[maxPos] == "Urea"){
    Toast.makeText(getApplicationContext(), "3", Toast.LENGTH_SHORT).show();
    fertilizerType = "3";
}
else{
    Toast.makeText(getApplicationContext(), "3", Toast.LENGTH_SHORT).show();
    fertilizerType = "4";
}

area.setEnabled(true);

// Releases model resources if no longer used.
model.close();
```