AN INTELLIGENT SYSTEM FOR FORECASTING FARMER'S REQUIREMENTS IN MAHAWELI PROJECT: A CASE STUDY

Project ID - 20_21-J11

Final (Draft) Report

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BSc (Hons) in Information Technology Specializing in Software Engineering

Department of Computer Science and Software Engineering

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(The dissertation was submitted in partial fulfilment of the requirements for the B.Sc. Special Honors degree in Information Technology)

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DECLARATION

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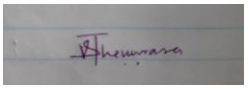
V.S Thenuwara	IT16073760	

The above candidates have carried out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor: Date:

(Prof.Pradeep Abegunawardhana)

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Abstract

Mahaweli development project is the largest irrigation development program in agricultural sector of Sri Lanka. However due to lack of performance of the project has increasingly come under criticism for past decade [1]. Hence the solution is introduced for the farmers and buyers as 'Mahaweli Market' where the application is designed to analyze and predict the harvesting, marketplace, yield quality and disorders and enhanced with the trade platform for sales. This proposal is about the Harvest analysis and prediction component one of the major components of the application. Currently the farmers facing a huge challenge with harvest requirements to fulfill the market needs. Hence the component gathers farmers historical harvest details of farmers and analyze them while forecasting necessary and possible harvest for next season. And this component can provide clear understanding about the yield obtained in a period related with the climatic changes. All the graphs and highly advanced comparison methodologies are used to give clear understanding about their harvesting for a period. Not only the farmers harvest analysis details are used to compare it with market analysis to fulfill the requirement gaps. Here both farmers and buyers are beneficial with results.

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LIST OF ABBREVIATION

Abbreviation	Description
GANs	Generative Adversarial Networks
3D	Three- dimensional
2D	Two-dimensional.

1. INTRODUCTION

1.1. Background

Currently in Sri Lanka, Farmers face lot of challenges when dealing with their harvest, market, weather etc. ... Same problem is seen in areas belonging to Mahaweli development project. Authorities has not done relevant studies about the current situation of the farming, so no solutions were introduced to overcome those challenges. As Mahaweli project is the largest irrigation project in Sri Lanka It's a necessity to develop platforms to find solutions for farmers and buyers. Hence, Mahaweli Market is a need of the hour in sake of solving major issues faced by the community. Mainly farmers belong to Mahaweli development project requires proper guidance mainly with the climatic conditions around the area. Whether they have proper rain and sunlight for cultivations. And how successful the harvesting is for last few years. Hence forecasting the future harvest under possible environmental conditions is a requirement of the farmers to be fulfilled. Next, quality of such produce yield needs to be measured properly to find a relevant marketplace. Farmers and buyers require a proper platform to buy and sell such produced crops matching the supplier and consumer requirements. Other than those key requirements farmers need to get proper knowledge about the Mahaweli development project, farming and irrigation system. So necessary important information needed to upload so that it reaches all the stakeholders in smaller period. It's clear that quickly accessible user interactive platform is the basic need for the development of Mahaweli project. Simply the main objective of all the key components and final product is to gather all the information necessary for all the farmers and buyers as it a key development process for Mahaweli project-based farming.

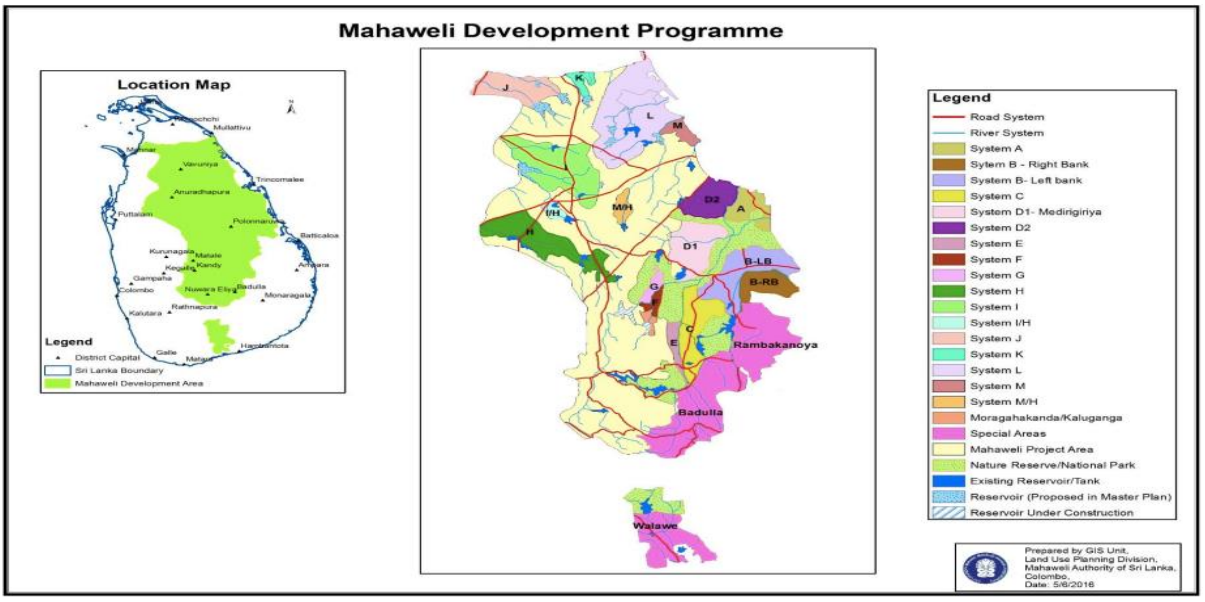


Figure 1: MASL Commanded Area

1.1.1. Weather forecast

Farmers in Mahaweli development area has an important requirement to know climatic changes for next coming days. It is necessary to forecast seven days climatic changes which helps farmers to take decisions in cultivations.

1.1.2. Real time harvesting data gathering and presenting.

In this system harvest selling details of farmers are gathered in real time database and displayed in bar graph real time. It is classified under filtering according to crop.

1.1.3. Harvest requirement forecast.

We are hoping to size and grade the pattern blocks generated to actual standard body sizing method. British standard sizing and grading method will be used in fitting and grading of the pattern blocks.

1.2. Literature Review

The most important of the most relevant articles is the Cultivation and Cost Management Systematic 'IFarm' proposed and developed to assist efficient farmer management. The system includes smartphone applications, web browsers, and a cloud server. Farmers on farms can easily access work projects, enter domain data into the cloud system, and share real-time head office using smartphones. Used to evaluate crop yield data samples and include horticultural products (banana), cash crops (sugarcane), food crops (rice), Caribbean, Rabi season (Tamil Nadu and US Regional Database). Optimization and classification methods can be used Create a system that seeks to create a statistical model and provide well-developed machine learning methods that provide accurate and systematic learning considering soil conditions and past weather conditions. Helps to make the right decisions about the crops that can be grown cheaply in the future. Further research aims to provide information and knowledge about low-income small-scale farms and agro-micro enterprises in Bangladesh, India, Sri Lanka, and Thailand. The micro-enterprises in this study include only small retailers selling agricultural products, collectors, and agricultural products. This report explores the use of information and communication technologies (ICT) and mobile phone applications among these micro enterprises. Predicting annual changes in the yields of major global crops is expected to be useful in strengthening communities' ability to better respond to rising food prices triggered by food production shocks and climate change. However, significant improvements are needed in the methods used for global crop forecasting to achieve reliable operational service.

1.3. Research Gap

Current trends in machine learning apply to the most advanced software solutions in every nook and corner of the world. But there is a significant drawback with the application of machine learning algorithms in agriculture-based software solutions. Out of the few such intelligent systems, we came across one linear regression model application, one model that doesn't specifically identify forecasting for different seasons. In addition, water use efficiency has been adjusted for the total biomass and grain yield of each important crop. In addition, biomass production and water consumption data were collected and redesigned to assess the potential for generating a comprehensive regression equation related to production. Under all seasonal conditions, water use and total production use is a linear regression model. Hence, we proposed more accurate methodology which is not currently used in any other web or mobile solutions. We propose to introduce multiple models for each season and android application manages the relevant model and run accordingly according to user input. According to this method 2*n number of models are necessary for accurate prediction. (n – number of crops)

1.4. Research Problem

Most of the agricultural activities in Sri Lanka are related to the Mahaweli Development Project. Sri Lanka has a long history of irrigated agriculture and now 31.8% of the population is engaged in agriculture. Agriculture and allied sectors such as afforestation and fisheries accounted for 18% of GDP in 2014 and about 26.4% of labor or employment [4]. Hence significant output of agriculture is dependent on Mahaweli development project. Most of the research done for the development of the Mahaweli project and mainly satisfy farmer's needs. But it's clear that farmers satisfaction is significantly low according to the conclusions of research [3].Specifically, farmers concern more about climatic conditions and rainfall which is a key factor that affects their cultivation. Research done for analyzing climatic changes is rare, so no platforms developed to share information related to predicted data. Secondly farmers have a challenge to identify crops those can give highest marketplace in specific season under the prevailing weather conditions and region. This prediction is necessity of the farmers to take confident decision on what they are going to cultivate next season. As the projects conducted past few years with the development of the technology it's not precisely shown proper results web platform to overcome the challenges is need of the hour. The research basically focusing on finding digital solution for the above-mentioned challenges.

1.5. Research Objectives

- Identify the required environment for the specific crops to cultivate in each season in given area.Forecast harvest yield for future seasons using environmental(waters supply), climatic and historical data. Presenting analyzed data using user interactive models.

1.5.1. Specific Objectives

- Analyze the historical harvest data in different aspects considering climatic and regional changes.
- Analyze climatic changes considering historical climatic databases specific to the region.
- Analyze cultivation according to the specific region with previous regional harvest data collected.
- Combining climatic, harvest, regional data to a specific statistical model for forecasting.
- Introducing new methodology to manage 2n number of linear regression models from android backend.
- Supports three main languages Sinhala, English, and Tamil.

2. METHODOLOGY

2.1 Methodology

Developing an intelligent decission making application agriculture based requirement is always challenging due to data collection issues , communicaton issues , technology literacy of people. But with all the challenges harvesting module completely developed giving solutions for all the requirements raised in requirement analysis. Most important asects in the methology were data gathering in order to achive necessary analysis, developing an architecture to fulfill software requirements, creating a database for data collection usimg firebase, developing machine learning models, user experince upgrade with adobe XD and commercialization aspect of the product.

2.1.1 Data Gathering

Data gathering mainly based totally from direct contact of the Mahaweli Development Authority.The provided offical documentation contained all the data that the authority doncucted surveys on and also which are necessary for their own statistical analysis. This report contains information on the progress of socio-economic and environmental activities with the Sri Lankan Mahaweli Authority annually. It also provides an insight into the current state of the authority, which is vital in formulating sustainable development policies.. Important tables from the documentation is as follows.

Table 2.3: Town and Area Centers in Mahaweli Areas

	System	Town Centers	Area Centers
1.	B	1. Welikanda 2. Aralaganvil;a 3. Manampitiya	1. Dimbulagala 2. Sewanapitiya 3. Ellewewa 4. Damminna 5. Senapura 6. Aselapura 7. Singhapura
2.	C	1. Dehiaththakandiya 2. Giradurukotte	1. Nuwaragala 2. Siripura 3. Sadunpura 4. Medagama 5. weheragala 6. Mahawenawela
3.	D	1. Bisopura	1. Bisopura
4.	G	1. Laggala 2. Bakamoona	1. Diyabeduma 2. Aththanakadawala 3. Heerati Oya 4. Wellewela 5. Thorapitiya
5.	H	1. Nochchiyagama 2. Thambuththegama 3. Thalawa 4. Galnewa 5. Meegalawa	1. Bulnewa 2. Mahailluppallama 3. Eppawala
6.	L	1. Sampathnuwara	1. Ethawatunuwewa 2. Kiriibbanwewa
7.	Huruluwewa	1. Madatugama 2. Galkiriyagama 3. Palugaswewa	
8.	Udawalawa	1. Embilipitiya 2. Sooriyawewa 3. Angunukolapelessa	1. Sevanagala 2. Kiriibbanwewa 3. Kuttigala 4. Thunkama 5. Mayurapura 6. Udawalawa 7. Barawakubuka 8. Mamadala
9.	Victoria	1. Digana	1. Theldeniya 2. Kundasale 3. Kothmale
10.	Rambakan Oya	1. Maha Oya 2. Padiyathalawa	

Source: Land Use Division, Mahaweli Authority of Sri Lanka

According to the Mahaweli development master plan, development work has already started on six proposed development zones and four systems. The modern Mahaweli development area covers 15 administrative districts of Sri Lanka and consists of 22 departments with 47 departments and 10 Mahaweli systems. Mahaweli consists of Badulla, Trincomalee, Matale , Anuradhapura, Kurunegala,

Mullaitivu, Vavuniya, Ratnapura, Polonnaruwa, Batticaloa, Ampara,Moneragala, Hambantota, Kandy and Nuwara Eliya.

Table 3.4: Irrigation Water Issues, Water Duty and Water Productivity in Maha season

	Unit	Maha									
		2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
System B												
Water Issues	MCM	209.10	288.50	221.90	217.70	266.60	115.30	218.70	221.60	255.20	134.70	189.54
Water Duty	M	1.27	1.54	1.19	1.10	1.42	0.61	1.17	1.19	1.33	0.72	0.96
Water Productivity	Kg/M^{-3}	0.36	0.33	0.41	0.16	0.37	0.71	0.49	0.43	0.40	0.69	0.57
System C												
Water Issues	MCM	270.50	340.60	260.70	241.60	288.60	171.80	286.50	267.10	290.70	178.60	304.47
Water Duty	M	1.27	1.48	1.14	1.06	1.26	0.75	1.26	1.18	1.27	0.81	1.36
Water Productivity	Kg/M^{-3}	0.39	0.38	0.48	0.27	0.43	0.55	0.46	0.42	0.44	0.66	0.42
System G												
Water Issues	MCM	99.80	96.40	98.80	87.60	104.70	68.70	87.30	95.10	105.00	56.90	60.39
Water Duty	M	1.90	1.80	1.80	1.74	1.57	1.16	1.24	1.57	1.57	1.22	1.16
Water Productivity	Kg/M^{-3}	0.25	0.27	0.30	0.19	0.27	0.37	0.40	0.36	0.29	0.45	0.40
System H												
Water Issues	MCM	360.70	364.40	369.40	251.80	334.90	235.20	333.80	273.70	328.40	118.30	225.27
Water Duty	M	1.15	1.14	1.16	0.79	4.93	3.28	1.04	0.99	1.17	1.07	1.31
Water Productivity	Kg/M^{-3}	0.47	0.49	0.52	0.58	0.39	0.52	0.53	0.59	0.47	0.48	0.41
System HU												
Water Issues	MCM								85.60	64.00	32.00	167.82
Water Duty	M								1.03	0.60	0.64	1.95
Water Productivity	Kg/M^{-3}								0.70	0.95	0.96	0.27
System Uw												
Water Issues	MCM	278.10	391.50	381.00	409.80	327.70	328.80	324.50	316.80	421.00	82.40	304.71
Water Duty	M	1.66	2.18	2.03	2.10	2.94	2.77	1.35	1.43	1.82	0.95	1.56
Water Productivity	Kg/M^{-3}	0.48	0.38	0.40	0.37	0.26	0.23	0.81	0.29	0.21	0.19	0.28

Source: Seasonal Summary Report for the Maha Season: Water Management Secretariat

Table 3.5: Irrigation Water Issues, Water Duty and Water Productivity in Yala season

	Unit	Yala										
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
System B												
Water Issues	MCM	398.00	193.80	369.10	399.40	323.40	375.50	249.10	385.20	376.90	195.64	308.90
Water Duty	M	2.30	1.68	1.89	2.04	2.17	2.02	2.67	2.05	1.94	1.88	1.56
Water Productivity	Kg/M^{-3}	0.21	0.27	0.26	0.29	0.22	0.21	0.26	0.26	0.26	0.27	0.31
System C												
Water Issues	MCM	433.60	177.10	426.00	513.60	358.60	415.30	328.90	456.30	461.10	217.45	383.44
Water Duty	M	2.02	1.85	1.94	2.31	1.97	1.81	1.44	1.99	2.02	1.73	1.74
Water Productivity	Kg/M^{-3}	0.26	0.28	0.27	0.25	0.23	0.23	0.29	0.28	0.27	0.29	0.31
System G												
Water Issues	MCM	113.80	82.40	122.60	120.90	106.80	137.70	49.10	139.40	100.40	35.71	103.32
Water Duty	M	2.21	2.91	2.33	2.36	1.99	1.96	1.41	1.99	1.88	1.02	1.90
Water Productivity	Kg/M^{-3}	0.23	0.17	0.23	0.22	0.23	0.13	0.33	0.22	0.19	0.50	0.31
System H												
Water Issues	MCM	385.50	227.10	333.40	408.80	302.60	362.70	161.70	265.50	226.50	192.34	281.89
Water Duty	M	1.23	1.72	1.04	1.28	5.53	5.32	0.94	1.01	1.56	1.29	1.42
Water Productivity	Kg/M^{-3}	0.45	0.31	0.52	0.45	0.03	0.17	0.57	0.58	0.36	0.47	0.44
System HU												
Water Issues	MCM								114.70	67.10	287.61	325.55
Water Duty	M								1.30	1.14	4.91	3.75
Water Productivity	Kg/M^{-3}								0.66	0.76	0.18	0.17
System Uw												
Water Issues	MCM	458.90	397.70	495.70	506.30	278.80	420.70	389.30	402.80	537.90	266.90	424.79
Water Duty	M	2.51	2.41	2.51	2.52	3.56	3.77	1.66	1.43	2.48	1.69	2.15
Water Productivity	Kg/M^{-3}	0.33	0.34	0.36	0.33	0.21	0.17	0.58	0.43	0.32	0.50	0.41

Source: Seasonal Summary Report for the Yala Season: Water Management Secretariat

Irrigation water is released to Yala and Maha seasons in the areas of the Mahaweli development authority of Sri Lanka. The capacity of irrigation reservoirs used for agricultural activities as on 31.12.2018 is given in the tables above.

Table 7.4: Paddy and Rice Availability in Mahaweli Areas

Component	2010	2011	2012	2013	2014	2015	2016	2017	2018
Paddy Production Maha (Mt)	507,635	329,808	515,246	471,613	512,522	545,578	541,414	290,816	469,176
Paddy Production Yala (Mt)	421,574	459,423	312,312	378,200	241,280	460,116	343,454	217,011	436,875
Total Paddy Production (Mt)	929,209	789,231	827,558	849,813	753,802	1,005,694	884,868	507,827	906,051
Wastage = 6% (2012 & 2013)	46,460.45	39,462	49,653	50,989	45,228	60,342	53,092	30,470	54,363
Total Extent of Paddy (Ha) Yala+ Maha	172,492	175,113	158,766	161,230	130,626	180,870	158,628	98,931	165,420
Total Seed Paddy Requirement (Mt) (102.35/1000*Total Extent of Paddy)	17,655	17,923	16,250	16,502	13,370	18,512	16,236	10,126	16,931
Availability of Paddy for human Consumption (Mt)	865,094	731,847	761,655	782,322	695,204	926,840	815,540	467,233	834,758
Rice availability for human Consumption (Milling ratio =0.68) (Mt)	588,264	497,656	517,925	531,979	472,739	630,251	554,567	317,718	567,635
Mahaweli Population	864,657	878,152	884,942	905,228	1,001,096	1,007,904	1,128,404	1,140,887	1,116,646
Per Capita Rice Availability in Mahaweli Areas (Kg/Year)	**680**	**567**	**585**	**588**	**472**	**625**	**491**	**278**	**508**

Source: Crop Forecast, Socio Economics & Planning Centre, Department of Agriculture

According to the table 7.4 above data related to annual and seasonal paddy production can directly obtained. This value first divided by the area under cultivation and obtain its harvest per unit hectare. Then it is used as a data for modelling

2.2 High Level Architecture Diagram

Weather forecast

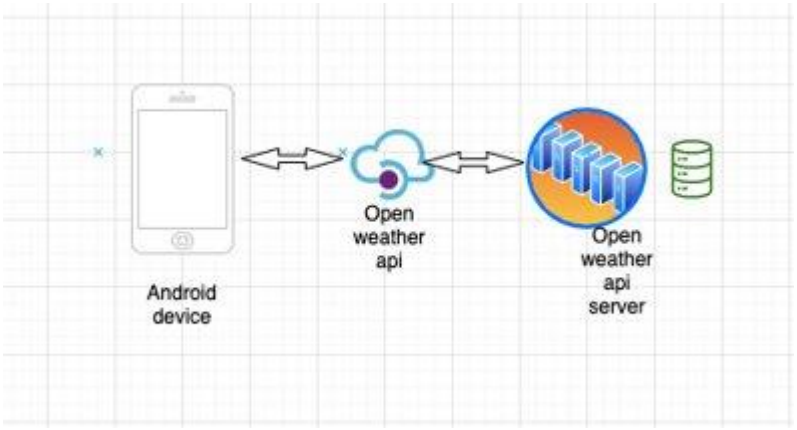


Figure 2.2.1 high level architecture diagram weather prediction

Weather prediction module is a basic weather application that displays basic weather information for the user's location. I created a basic user interface that looks like a card and displays the current location and weather information of each card. Create an API key for your weather API. After registration, go to the API section of the website and select the automatically generated Weather API key. Save this API key as it should be called from your application.

Harvest Prediction

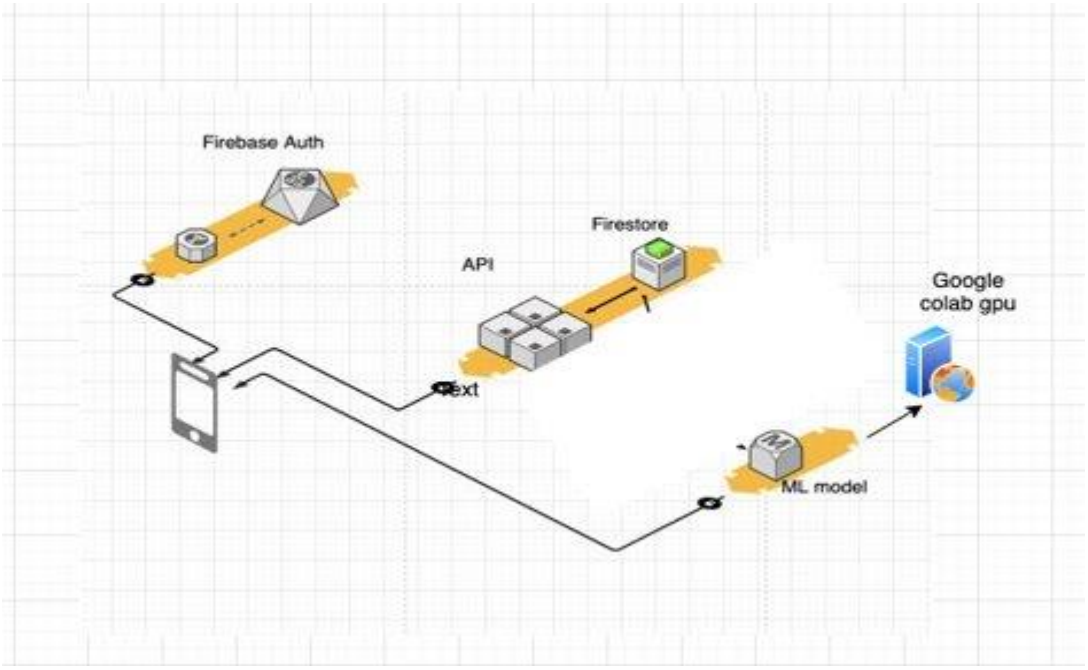


Figure 2.2.2 high level architecture diagram harvest prediction

Most applications require user identification. Knowing the user's identity allows the application to store user data securely in the cloud and provide the same personalized experience on all user devices.
Firebase Authentication provides authentication services from your application, easy-to-use SDK, and ready-made user interface libraries. Support the use of passwords, phone numbers, popular federal identity providers (such as Google, Facebook, Twitter, etc.) for identity verification. Firebase Realtime Database is a cloud database. The data is stored as JSON and synchronized to all connected customers in real-time. In the Firebase database, data is stored in one place. The pointer to that location is called the Firebase report. If multiple statements start from the same path, it will result in the same level.

2.3 Dataset

Data set is derived from merging important tables of documentation of Mahaweli Authority.

Year	Season	Crop	Area	Water Supply	Rainfall	Yield

Hence the dependency of Yield against water supply plotted for ‘Yala’ and ‘Maha’ Seasons based on the crop type and the area those cultivations are done. This is because the water supply for different sections in Mahaweli development may vary with their location.

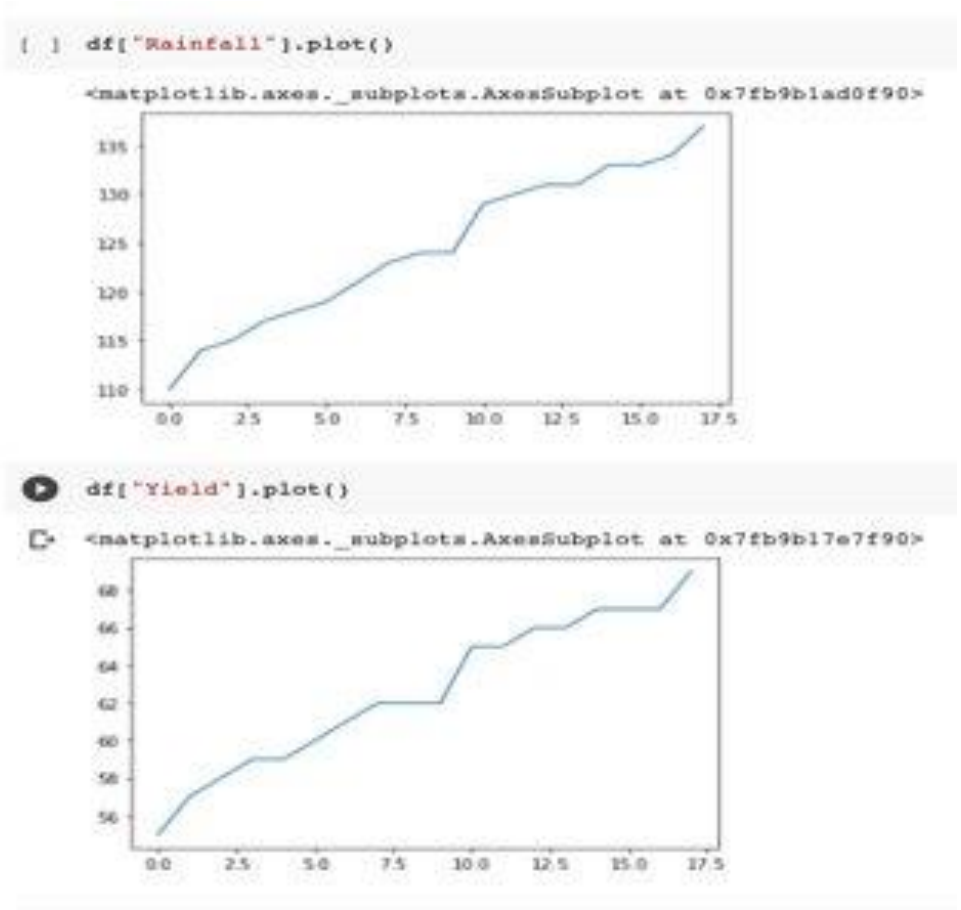


Figure 2.3.1 graphs to identify Yield and rainfall relationship

As the above line graphs explains the rainfall and the yield of crops (here paddy) has a linear increase.This is the first approch of selecting a related machine learning model.Accordingly for the modelling linear regression , ridge regression and gradient boosting trees are suggested. So proceeding with them one model needs to finalize with least error for long run.

2.4 Modelling

Linear regression is the most advanced and easy-to-understand method for learning statistics and machines. This is a gentle introduction to high technology, and it provides as much background as possible to use your own questions as effectively as possible. Machine learning is the most accurate prediction, mainly to minimize model errors or make more accurate predictions of descriptive damage. In learning utility machines, we borrow, reuse, and steal from various fields (including statistical information) and use it for these purposes. Therefore, linear regression has been developed in the field of statistics and used as a model to understand the relationship between statistical input and output. Change, but borrowed from machine learning. It is a statistical algorithm and a machine learning algorithm. Linear regression is a linear model, such as a model that uses a linear relationship between an input variable (x) and a single output variable (y). More specifically, y can be calculated from a linear combination of input variables (x). Although there are many input variables, the statistical literature often refers to this method as multi-line regression. Different techniques can be used to create or construct linear regression equations based on data, the most common being small squares. Therefore, it is common practice to develop the model as least square linear regression or least square inverse. Representation is a linear equation that combines the input value (x) and the predicted output (y) of these input values. Therefore, both the input value (x) and the output value are numbers. The linear equation assigns a scale factor to each input value or column, called the large-scale beta factor (B). An additional coefficient is added, which gives the line more degrees of freedom (for example, moving a two-dimensional shape more and more downwards), and is often referred to as the absorption coefficient or tilt coefficient.

$$y = B0 + B1 * x1$$

A regression coefficient in other words **slope of the line of the regression equation**. Equation of the regression coefficient

$$B_1 = b_1 = \Sigma [(x_i - x)(y_i - y)] / \Sigma [(x_i - x)^2]$$

formula to compute the test value (**n** is the sample size):

$$T = R \sqrt{\frac{N-2}{1-R^2}}$$

Ridge regression is a sample tuning method used to analyze any data affected by multi-colinearities. This method regulates L2. When there is a problem with multi-colinearities, at least the squares are neutral and the variables are large, resulting in the predicted values being further away than the actual values.

$$\hat{\beta}^{ridge} = \underset{\beta \in \mathbb{R}}{argmin} \|y - XB\|_2^2 + \lambda \|B\|_2^2$$

Lamda also penalty period. The alpha parameter of the ridge function is here. Therefore, we also control the penalty time by changing the values of the alpha. The higher the value of the alpha, the larger the fine and the smaller the coefficient. It summarizes the parameters. Therefore, it is used to prevent multiple linearities. This reduces the sample problem by multiplying the coefficient stands for the dependent variable, X represents independent variables, B stands for regression coefficient to be rated and E stands for error residue.Once the lambda function is included in this equation, the variance not estimated by the normal model is considered. Once the data has been prepared and identified as part of the L2 regulation, there are steps that one can take. Pro and variance trading is generally complex

when creating ridge lag models in a virtual database. However, one common trend to keep in mind is that as the trend increases, the variance decreases as it increases. The assumptions of ridge regression are similar to linear regression: linear, constant variation, and independence. However, error distribution for general needs should not be considered as the ridge lag does not provide reliable limits.

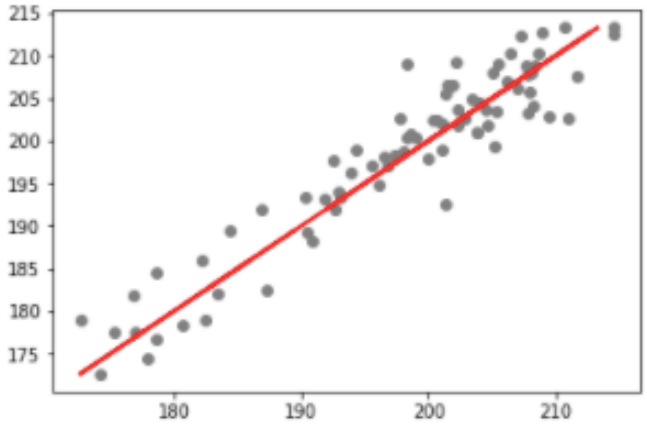


Figure 2.4.1 linear regression

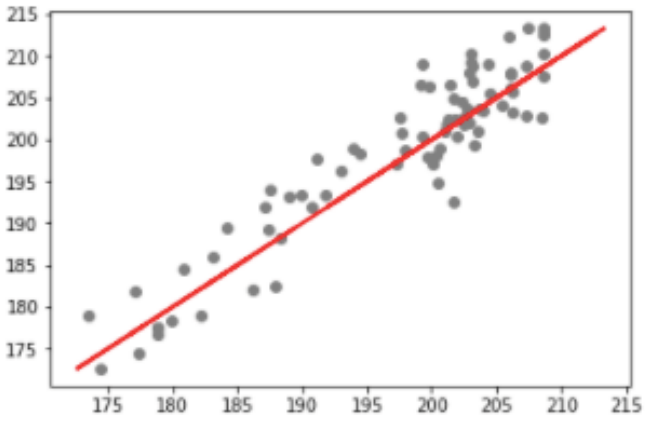


Figure 2.4.2 Ridge regression

Based on the above outcome linear regression model is identified as the model with least error. Hence proceeding with linear regression model for two seasons ‘Yala’ and ‘Maha’ and three crops ‘Paddy’ , ‘Potato’ and ‘Onion’ Six different models trained and converted to tensor flow lite models in a way that it can applied in android applications.

C) Model Integration with Android App

All the linear regression models relevant to crops separately trained using TensorFlow. But TensorFlow models can’t be used in android sdk environment. Hence the models are further converted to TensorFlow lite models and added to assets folder in Android project as .tflite.

Figure 2.4.3 using tensor flow lite models in sdk

D) Manipulating set of models in java backend android environment.

Models are varying according to the crop and season that user input. Simultaneously relevant model executes and on plot command and plot the forecast result along with the historical records retrieved from firebase real time database.

```
if(selected_crop.equals("Paddy")){
    if(selected_season.equals("Yala")){
        float predictionPaddyYala = inference(predict, crop: "Paddy", season: "Yala");
        finalPredictPaddyYala =  predictionPaddyYala*3;
        dataVals2.add(new Entry( x: 18,finalPredictPaddyYala));
        Toast.makeText(getApplicationContext(), text: "Yield : " + predictionPaddyYala, Toast.LENGTH_LONG).show();
    }else{
        float predictionPaddyMaha = inference(predict, crop: "Paddy", season: "Maha");
        finalPredictPaddyMaha =  predictionPaddyMaha+70;
        dataVals2.add(new Entry( x: 18,finalPredictPaddyMaha));
        Toast.makeText(getApplicationContext(), text: "Yield :" + predictionPaddyMaha, Toast.LENGTH_LONG).show();

    }
}else if (selected_crop.equals("Potato")){
```

Figure 2.4.3 handling models in andorid sdk

This code repeatedly used for all the crops that included in the list. Hence if the number of crops taken as ‘n’ related number of models would be 2*n.

E) Real time selling data plot.

Real time data update and plotting scenario implemented using firebase real-time database. It keeps track of data changes that occur in real time db. Whenever changes occur it retrieve new set of data and plot the graph.

```
root2.addValueEventListener(new ValueEventListener() {
    @Override
    public void onDataChange(@NonNull DataSnapshot snapshot) {
        ArrayList<BarEntry> yield = new ArrayList<>();
        try {
            DailyHarvestArrayList.clear();
            for (DataSnapshot dataSnapshot : snapshot.getChildren()){
                Model model = dataSnapshot.getValue(Model.class);
                list.add(model);

                int x= Integer.parseInt(model.getPrice());
                Float y= Float.parseFloat(model.getWeight());
                String crop = model.getCrop();
                String date = model.getDate();
                if(crop.equals(selectedCrop)){
                    DailyHarvestArrayList.add(new DailyDarvest(y,date));
                }

            }

        }catch(Exception e){
            Toast.makeText(getApplicationContext(), text: "Error : " + e, Toast.LENGTH_LONG).show();
        }



        for (int i =0; i < DailyHarvestArrayList.size();i++){...}

        BarDataSet barDataSet=new BarDataSet(barEntriesArrayList, label: "Weight(Kg)");
        barDataSet.setColors(ColorTemplate.MATERIAL_COLORS);
        barDataSet.setValueTextColor(Color.BLACK);
        barDataSet.setValueTextSize(16f);

        BarData barData =new BarData(barDataSet);
```

Figure 2.4.3 plotting real time data

F) Weather prediction

Weather prediction for next week is simply done using a request call from open weather Api. Users need to provide the location and it converts to latitude and longitude.

```
requestQueue = Volley.newRequestQueue( context: this);
String URL = "https://api.openweathermap.org/data/2.5/onecall?lat="+lat+"&lon="+lng+"&exclude=current,minutely,hourly,alerts&appid=462f445100
```

Figure 2.4.3 using tensor flow lite models in sdk

2.3 Commercialization Aspects of the Product

'Mahaweli market' mobile app basically designed for Mahaweli development project. It's based on the requirements of buyers and sellers of harvest in different seasons. And some other requirements raised from the authorities related to Mahaweli development project. Hence the usage of application is directed towards a community directly dealing with the Mahaweli development project. But the whole solution has its own features to fulfill the basic requirements of sellers and buyers of crops around the country. Basically, models are trained based on 'Yala' and 'Maha' seasons. Hence the solution is applicable for Sri Lanka compared to currently available features. When considering the farmers and other wholesale business dealers we can firmly tell that this kind of software solution will end their plenty of headaches. Main reasons for this are,

- Application gives cultivation related accurate weather forecast for next coming seven days.
- It gives the recent selling prices of crops in different areas.
- It gives a user-friendly representation of current harvest selling details.
- It gives a forecast of harvest requirement for next season based on their cultivating area.
- The module designed with highly advanced UI/UX experience.
- The app and module support three different languages namely Sinhala, English and Tamil.

As per the information provided by the government Sri Lanka has about two million community who directly involves in farming and cultivations.

1.2. Testing & Implementation

1.2.1. Implementation

Mahaweli Market app is totally and Android app most of the UI design is done using adobe XD. The application backend is fully java based. To make the app user-friendly it consists of three language translations. The backend models are running as TensorFlow lite assets.

Phone Specification: .apk can install in any android device with min sdk level 28 and display size above 5'.

User Interfaces Listed below are the main interfaces and their functionalities of the proposed product to be implemented.

1.2.2. Testing

Unit testing

The unit testing is carried out by dividing the harvest prediction module and weather forecasting module into smaller parts known as units. Each individual unit should be tested under unit testing. When the system design documents are received, the work is divided into modules/ units, and actual coding is started. The system is first developed in small programs called units, which are integrated into the later phase. Each unit is designed and tested for its functionality. Unit testing mainly verifies if the modules/ units meet their specifications.

Test cases for the next season harvest prediction

Next season harvest is expected to have in a range of data plotted in past 18 years.

Table 3.1 Test case : Generating next season forecast

Test case ID	002
Description	Next season harvest requirement prediction.
Steps	Register/Log in to the application. Select seller. Select Harvest component in home page. Click on harvesting division in Harvest Dashboard. Select a Crop, Season, Area from drop down list. Click on Plot.
Input Data	Crop, Season, Area
Expected Output	Line chart plotting last 18 year's harvest data in relevant season with next coming season forecast.
Actual Output	Line chart plotting last 18 year's harvest data in relevant season with next coming season forecast.

Integration test

In the integration test, the individual modules are combined and tested. The purpose of this test is to ensure that the interactions between two or more components yield results that meet the functional requirement. A section with integrated harvest details in the Market Analysis section. The team conducted completion tests for each category of clothing involved.

System tests

Checking the entire system according to specifications is called system control. Once the tested units are integrated into the final system, the system must be tested to ensure proper integration and consistency between the various units. The Systems test falls within the scope of the black box test, so no knowledge of internal code design or logic is required. As a group, integrated system errors were tested and replaced.

User acceptance test

After team members implement and test the design, users are presented with a proven version of the final program. They then use the computer and check if their needs are met by the computer. If the user agrees that the software is satisfactory, the process is complete. However, if the user is not satisfied with some aspects of the software, the design team will resolve the issue.

2.4.3 Interfaces

Figure 2.4.3.1 Registration or login interface

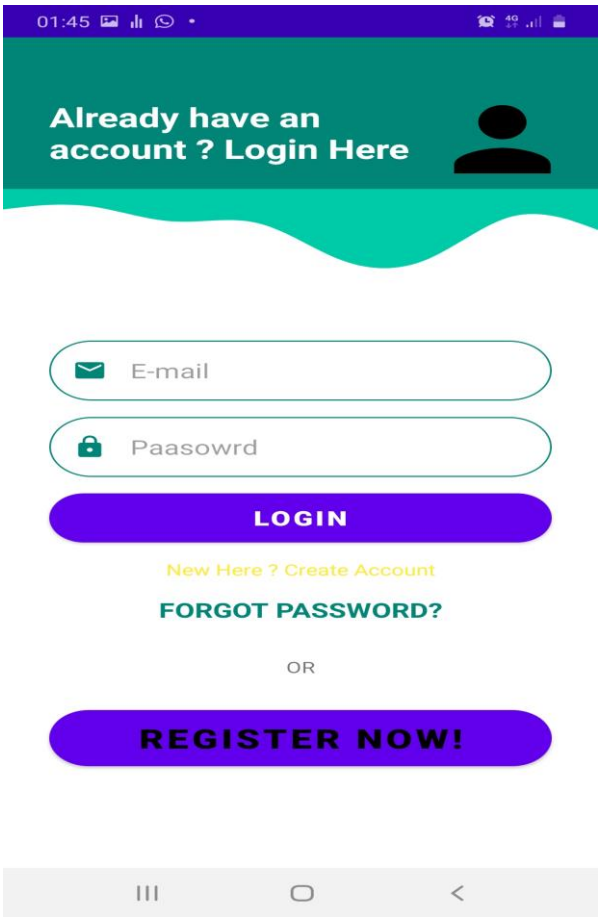
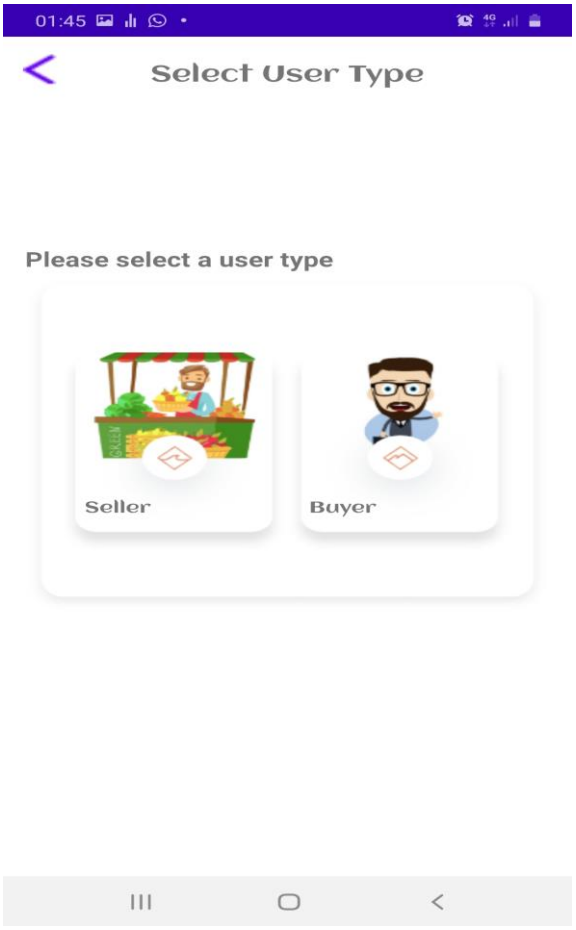


Figure 2.4.3.3

Figure 2.4.3.4 Harvest Home interface

Figure 2.4.3.2 Language selection interface


01:45
Select User Type
Please select a user type
Seller
Buyer

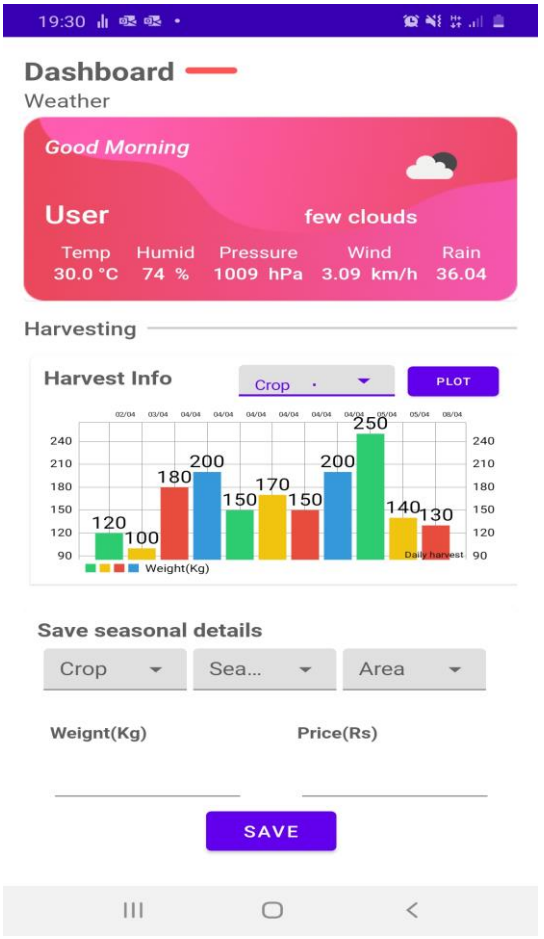

19:30
Dashboard
Weather
Good Morning
User
few clouds
Temp Humid Pressure Wind Rain
30.0 °C 74 % 1009 hPa 3.09 km/h 36.04
Harvesting
Harvest Info
Crop
PLOT
240 210 180 150 120 90
120 100 180 200 150 170 150 200 250 140 130
Weight(Kg)
Daily harvest
Save seasonal details
Crop
Sea...
Area
Weignt(Kg)
Price(Rs)
SAVE

Figure 2.4.3.5

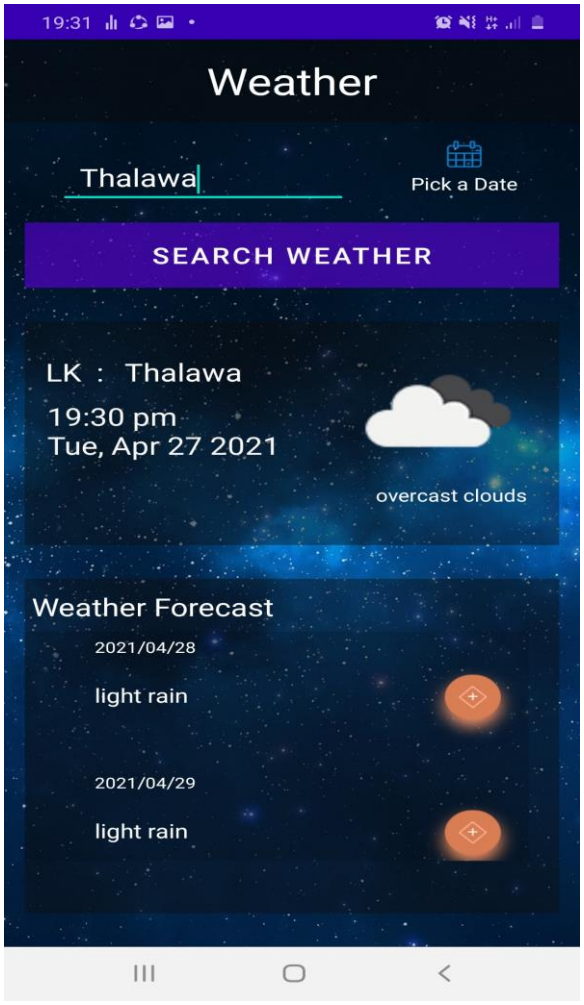
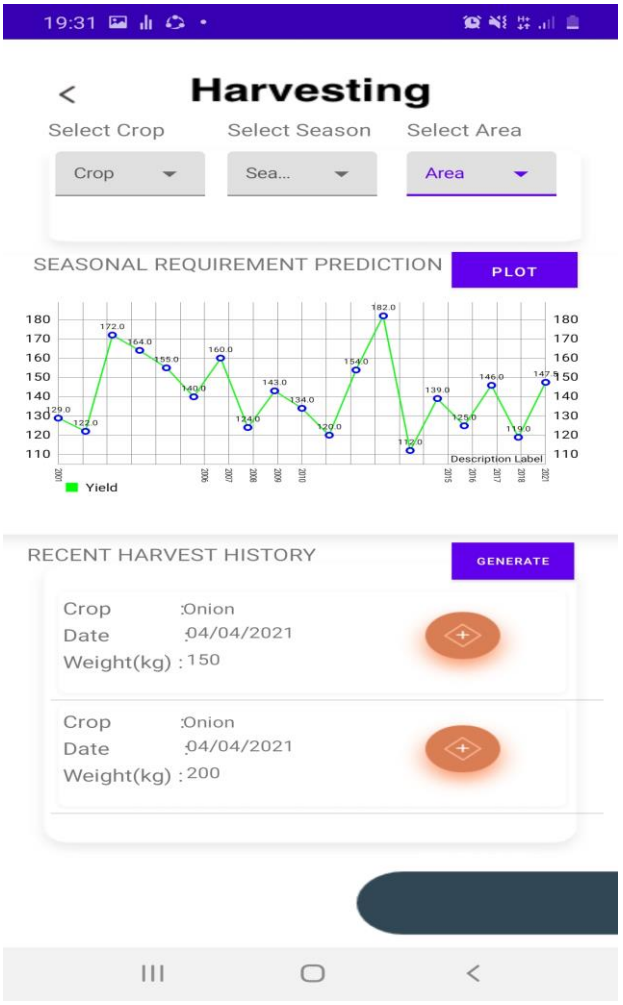


Figure 2.4.3.6 Harvest Prediction interface



Language selection

Mahaweli market app supports three different languages namely Sinhhala, English and Tamil. When a user clicks on specific language the app changes all componants and labels change to that secific language.

Registration

For the user interface related, refer ‘Figure 2: Registration Page’ . Following would be captured as the inputs,

- Name
- Email Address
- Contact Number
- Password – Password should contain one numerical number, one special character with a minimum of 8-character length.
- Confirm Password - used to validate the password

All the input data will be validated for the accuracy and the format, before saving them in the database if they are validated, successfully registering the user with the system. If the data is not valid, user is informed about it and the registration would be discontinued.

Login

For the user interface related, Login Page. For the completion of the login functionality, email and the password are required as the inputs. Either the email address or the contact number can be use as the username. These would be validated for the accuracy with what was stored in the database during the registration. If invalid data is inputted, login would be haltered after informing the user. After first successful login it saves the login credentials using firebase authentication and automatically stay logged in.

Buyer or Seller selection page

Mahaweli market app contains four main modules. These modules can be accessed as buyer or seller. This window allows to choose ether the specific user is logged as a seller or buyer. Accordingly access for those models are enabled.

Home Page

Home page contains all four main modules in such away user can select from slider. Additionally, user details are displayed on top.

Harvesting module dashboard

Dashboard is the main interface of harvest prediction module. Where it contains a card with today's weather details. Clicking on the card will redirects the user to weather prediction interface. Next dropdown can be used to select a crop from the crops list and clicking on the plot button will plot the real time harvest selling graph. Clicking on the graph will redirect to harvest prediction interface. Next part is relevant to insert farmers selling details in database. It gets the crop, season, area, unit price and weight of the yield farmer sold which simultaneously updates the graphs real time.

Weather Prediction interface

First part of the interface is providing the todays weather details on selected area. And the list generated down is the weather prediction for next coming seven days. It is possible to get forecasted weather condition when the location is provided in the search box.

Harvest Prediction interface

At the top user can select the crop, season, and relevant area. And then clicking on the 'plot' button will draw a line graph containing last annual harvest and will forecast the harvest requirement for next coming season. Clicking of the 'generate' button will create a list of recent harvest sales by farmers with these prices filtered out according to crop, season, and area.

Software interfaces

- Python – Interpreted, high- level, general- purpose programming language.
- TenserFlow – TensorFlow and end-to-end platform that makes it easy for you to build and deployed the Machine learning modules. Can build and train the models buy using the high level Keras models.
- Tensorflow Lite – To Convert tensorflow models compatible with android

3. RESULT AND DISCUSSION

3.1. Results and Research Findings

The initial steps for the research were taken from visiting the Mahaweli authority of Sri Lanka. According to the requirements the authority provided us most important data and information necessary for the research via the official statistical book '2018 Socio-Economic Statistics' of Mahaweli Authority of Sri Lanka.

The results obtained from the report had to reorganize which were gathered referring important tables and which contained official data of harvest in 'Yala' and 'Maha' seasons in different crops. So, the average seasonal harvest is given in Mt/Ha and water supply in MCM.

Figure 3.1.1 model comparison graph

According to above graph most accurate model for long run is linear regression model which is represented in orange bars. Even though most of the occurrences of ridge regression tally with linear regression it's easy to use linear regression due to lesser complexity.

3.2. Discussion

Including machine learning applications in Software Solutions is one of the demanding trends. Hence in Mahaweli market app there is a requirement to forecast harvest for next season. This requirement is fulfilled using linear regression model as the seasonal average yield is linearly dependent upon water supply from reservoirs in different areas.

This approach was not straight forward, even though the plotted graph of yield against water supply had a linear distribution linear regression model Ridge regression model and gradient tree model also compared to obtain most suitable model with minimum standard error. One key factor related to modeling was when the yield is plotted against water supply it was clear that lower values and upper values of water supply had two separate linear relationships. With this it was quite clear that significant difference is due to seasonal change. When the dataset is separated as Yala and Maha two different models are introduced to each crop. Further three main crops namely Paddy, Potato and Onion named for the analysis hence six different models are trained to increase the accuracy of each forecast.

As observed in results section comparison of accuracy using bar graph clearly explains that most significant for linear regression. And it’s quite possible to proceed with ridge regression as well. But there is a considerable error with gradient boosting tree. For the long run most prominent model to continue is linear regression.

3.3. Summary of Each Student's Contribution

Table 6 Summery of each student's contribution

Personal	Functionality	Description
V.S Thenuwara	Harvest Prediction Module	• Weather forecasting for next seven days using open weather API. • Real time selling price and harvest weight data collection and display component. • Harvest prediction for different crops in different areas according to rainfall using Linear regression model.

4. CONCLUSION

Mahaweli market is next generation mobile application to solve basic but important requirements of Mahaweli farmers in Sri Lanka. The proposed solution as separate harvest predicting module which consists of sub functionalities for climate prediction real time selling price demonstration component and harvest forecasting feel requirements of farmers. Technically the weather forecast is done for next coming seven days, and it is done using open weather API. Real time data collection is done using firebase Realtime database. Harvest forecasting for next season is a critical requirement. Hence linear regression machine learning model is specifically used for harvest prediction which is related with the rainfall of different areas related to Mahaweli project. To increase the accuracy of the model a set of linear regression models are used separately for Yala and Maha seasons. Hence the collection of data claims that the linear relationship of seasonal harvest related to water supply of different sections in Mahaweli development area which depends directly on rainfall. Future of the application is more about finding out further environmental features to increase the accuracy of models. Currently the harvesting module specifically solves all the requirements of Mahaweli farmers is fulfilled and the objective of creating such module is successfully achieved with expectations of further development.

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6. GLOSSARY

Term	Definition
Machine Learning	Machine learning is a type of artificial intelligence (AI) that provides computers with the ability to learn without being explicitly programmed. Machine learning focuses on the development of computer programs that can change when exposed to new data.
Linear Regression algorithm	This a Machine Learning algorithm categorized supervised learning. Predict the numeric values based on independent variables.

7. APPENDICES

7.1. Survey Results – Data Gathering

Dataset

Year	Season	Crop	Area	Rainfall	water supply	Yield	Index
2001	1	1	1	115	30	16.8	1
2002	1	1	1	129	25	15	2
2003	1	1	1	119	25	12.9	3
2004	1	1	1	110	31	16.3	4
2005	1	1	1	131	30	13.7	5
2006	1	1	1	114	26	11.3	6
2007	1	1	1	124	29	16.5	7
2008	1	1	1	117	28	16.6	8
2009	1	1	1	133	28	18.2	9
2010	1	1	1	131	29	12.5	10
2011	1	1	1	123	25	11.5	11
2012	1	1	1	124	31	16.8	12
2013	1	1	1	137	31	13.5	13
2014	1	1	1	121	25	13.4	14
2015	1	1	1	133	24	12.3	15
2016	1	1	1	134	28	15.7	16
2017	1	1	1	130	31	15.8	17
2018	1	1	1	118	27	16.9	18

Table 7 Final dataset

2. Research Banner

AN INTELLIGENT SYSTEM FOR FORCASTING FARMER'S REQUIREMENTS IN MAHAWELI PROJECT

Thenuwara V.S De Silva D.K.G Wijethunga W.P.T.T Kavindi H.G.A

ABSTRACT

Mahaweli development project is the largest irrigation development program in the agricultural sector of Sri Lanka. However, the lack of performance of the project has increasingly posed under criticism for the past decade. Hence this solution is introduced for the farmers and buyers as 'Mahaweli Market' where the application is designed to analyze and predict the harvesting, marketplace, yield quality, and deviation and enhanced with the trading platform for easier. This article explains predicting future harvesting, future needs to the marketplace of cultivated crops, buying and selling platform, and crop healthiness predicting modules integrated with an android mobile app. Understanding the reasons for the reduction of the above mentioned hindrance is crucial. Specifically, the harvest prediction is done using a linear regression model and prediction relationship, seasonality, market analysis and prediction are done for the initial stage gather model data and create linear regression model. Thirdly, an online trade platform 'Mahaweli market' to support buyers and sellers is introduced as another module developed using Collaborative Filtering. A Mobile Application will fully. Finally, the component that helps out, checking healthiness of a specific crop. Healthiness of crops are predicted for the first phase of the implementations, the crop identification part has been done using image classification by Keras Sequential model using python.

RESEARCH PROBLEM

The purpose of the research is to analyze and predict harvest requirements, healthiness of a crop and the marketplace of the specific crop for Mahaweli project farmers in Sri Lanka. And to develop a trade platform for buyers and sellers.

BACKGROUND AND DISCUSSION

During the ancient kingdoms Sri Lankan was leading agrarian societies in Asia[1]. Sri Lanka has a great standing history for first agriculture and industrial public civilization destination at that time. In that time agricultural production were harnessed and mainly farming for the domestic consumptions. Sri Lanka faced significant changes during the colony era in various industry. Therefore, agriculture industry also changed in the basis and consolidating market over consumption based agriculture. Considering agriculture there are mainly 4 categories we can categorized, Planning, Farming, Analytical and Statistic and further we can divide into 16 subcategories for accomplishing better professional. In this research we considered crop prediction agriculture.

In a tropical country like Sri Lanka, agriculture takes an important point of living and economy. There were many researches have done by global requirements for design the solutions for this forecasting farmer's requirements based on the problem details and user experience. Most of them are done by Indians for their agriculture industry. Therefore here found several research papers and crops related to forecasting farmer's requirements while surveying with this proposed system.

OBJECTIVES

RESULTS

According to the first phase of the implementation, authors have been able to achieve successful results. As the component of measuring healthiness of a specific crop, author has achieved the identification of a specific crop. Created a Machine learning model and train the model. Crop price prediction, predict the crop price for next year. Display province public income as seasonal wise. In the component of the online trade platform the author has achieved to complete the android application with the main functions for gaining the farmer and buyer relationship in the initial stage of the project. Android can predict the future trends in harvesting based on the climate conditions of future seasons' rain and wind.

SYSTEM OVERVIEW DIAGRAM

METHODOLOGY

1) HEALTHINESS DEADLINE FOR SPECIFIC CROP

The component in which the Mahaweli farmer or seller need to measure the healthiness of a specific crop is included four sub components. They are the mobile device to capture the image which will be used to classify the image to find out the correct healthiness level and the database component to store the collected data at a given time.

2) ONLINE TRADING PLATFORM FOR FARMERS AND BUYERS

Farmers can add their products to sell in selling page with specific details such as Product name, quantity, unit price, total price, location, authors' name and contact number etc. Buyers can have categories as mail such as wholesale buyers or retail buyers. Buyers can rate and add comments or reviews for product as their wishes and buyers can add rating and reviews to the sellers also. Sellers can add their product selling advertisements based on the location. There is option for matching sellers' parties and buyers according to the location, product and quantity details.

3) PREDICT STOCK PRICES FOR CROPS

To update the model, need to get current data from the farmers. Farmers can select the crop, year, season and the price amount related their fields and system will predict the prices for desired crop for next season. Using machine learning kernel regression model predict the prices of the crops. Using android studio and Tensor flow create model and display the predicted prices in the mobile app. Using waterfall software life cycle outline all possible requirements before the development phase starts.

4) PREDICTING FUTURE WEATHER

Weather Forecasting is a key component to predict weather conditions of Mahaweli development project areas. For this process a separate module is designed to obtain the specific area that user requires to forecast weather. Automatically, it will provide forecast weather details of one week ahead. Secondly, this one module is the working method where the user needs to select specific crop, season and area to forecast the harvest necessary for next season.

CONCLUTION

With the prevailing challenges in the country like pandemics, economy, degradation Mahaweli Market has engaged extraordinary position in the government. It has become the most prominent platform to connect buyers, sellers and government officials together under one roof. All the most important features integrated to the application which were stated in objectives.

Many discussions and meetings, Specifically in harvest prediction analysis, discuss the relationship between weather and harvest in Kelani Basin, Mahaweli project increased drastic. These conclusions help the solution to predict values with least error. Also considering the means of capturing weather in a mobile platform using its Android Smartphone. Finally, the unique features are processed to identify the healthiness of the crop. Nature of such dataset reveals the use of Keras Sequential Model for predictions. Basically, the app provides different aspects of cultivation process starts with decision making. Hence larger portion of the future of cultivation in Sri Lanka will be handled.

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3. Gannt Chart