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Machine Learning-Based Smart Farming with Matlab

Nayana N. Ghuikar

Assistant Professor, Information Technology, SSGMCE Shegaon

Abstract

A key part of the Indian economy is agriculture. However, India's agriculture is currently going through a structural shift that is creating a catastrophe. The sole solution to The crunch is to do everything within our power to turn agriculture into a lucrative business and entice farmers to keep growing crops. This project would use machine learning to assist farmers in making informed decisions about their crops in an attempt to move in this direction. The goal of this study is to employ supervised machine learning algorithms to predict the crop that will be grown based on historical data and environmental conditions. Based on meteorological conditions, this study will provide a crop selection strategy for maximizing crop production. Using seasonal weather forecasting, it also recommends the ideal time to plant certain crops. The Random Forest classification technique is used for selecting appropriate crops, while machine learning algorithms are used to predict the weather.

Keywords: Machine Learning, Random Forest.

1. Introduction

Agriculture plays a crucial role in advancing a nation, and India, often referred to as an agricultural country, is renowned for its fertile lands and abundant resources. However, recent challenges, such as fluctuating temperatures and soil moisture levels, have adversely impacted agricultural growth, including productivity, crop health, and yield. These issues have become significant obstacles to the nation's development, emphasizing the need to modernize traditional agricultural practices. The adoption of new agricultural trends, such as cultivating crops in controlled environments like greenhouses, is essential to address these challenges. In India, agriculture is the primary occupation, with 28% of the population engaged in the sector, which contributed 19.9% to the nation’s GDP in 2020-21.

The agricultural crisis in India has far-reaching consequences, potentially disrupting other sectors and affecting the national economy. To mitigate this crisis, it is crucial to make agriculture a profitable enterprise and encourage farmers to continue crop production activities. Traditionally, farmers relied on their previous year's experiences to predict yields. However, with advancements in data analytics and the availability of various algorithms, crop yield prediction has become more precise. Modern farmers, however, often lack awareness of optimal crop cultivation practices, such as the right time and place for sowing. Factors like weather and temperature pose additional challenges, and the absence of adequate solutions and technologies has exacerbated the situation. Accurate historical data on crop yields is essential for making informed decisions regarding agricultural risk management.

This paper proposes a solution to predict crop types and yields based on climatic conditions and historical crop data. This approach enables farmers to estimate production per acre before planting, helping them make informed decisions.[2]

Objectives:

a. Utilize machine learning techniques to predict crop types and yields.
b. Effectively analyze and process data to achieve more accurate predictions.
c. Enhance the performance of machine learning models.
d. Develop a user-friendly web application.

The proposed **Smart Farming Application** leverages machine learning, specifically the Random Forest algorithm, to assist farmers in selecting weather-appropriate crops that maximize yield.

2. Literature Review

The Project work on Smart Farming System based on Machine learning been carried out based on following literatures reviewed. We will be now being discussing in brief the literatures pertaining to effect of temperature rise, yield variation and predictive analysis based on Machine Learning algorithm.

2.1 Effect of Temperature Rise

Farming is influenced by various factors such as climate, soil, season, rainfall, and humidity. An analysis was conducted to examine the unexpected rise in temperature in India, which has caused disruptions in crop yields. The study focused on the multitemporal characteristics of radar signatures across consecutive years using ERS SAR images of agricultural crops.

2.2 Climatic Changes on Food Security and Yield

A paper was published discussing the impacts of drastic climate change in India, a country heavily reliant on agriculture. It highlighted the lack of specialized and financial support for adapting to and mitigating the effects of climate change. The study emphasized that favourable conditions require a balance of factors; for instance, adequate rainfall alone or optimal temperatures alone are insufficient both must work together. It pointed out that inconsistent climatic conditions, such as rainfall paired with unfavourable temperatures, can significantly undermine agricultural productivity.

The paper also drew attention to the increased frequency of natural calamities caused by climate change, confirming that such events can lead to severe declines in agricultural yield, exacerbating issues of food insecurity and rural poverty. It analysed changes in key climate factors, such as temperature and precipitation, and examined how variations in these factors affect the yields of different food crops. Additionally, it provided recommendations for addressing climate variability to ensure food security.

2.3 Effect on Seasonal Crops with Climate Change

A study was conducted on four key seasonal Indian crops—cotton, wheat, rice, and sugarcane—spanning the period from 2004 to 2013. The primary challenge faced not only by India but globally is climate change. Rapid changes in climate have left many farmers uncertain about which crops to cultivate on their land. This research analyzed the impact of climate variation on agriculture and food security using specific state-level data. Understanding climate variations helps identify the most suitable farming practices. The study was carried out across seven agriculturally intensive states with diverse climatic conditions.

3. Problem Definition

Farmers often resort to suicide as an extreme step to end their lives due to a multitude of reasons. Factors such as floods, famines, indebtedness, geographical isolation, loss in productivity, distress sales, and the inability to repay loans push them into despair, often leading to such tragic outcomes. Additional issues like illness, climate change, and flawed national agricultural policies further compel farmers to take such drastic measures. The inability to repay debts borrowed from banks or commission agents frequently acts as a catalyst for these suicides.

The imbalance between input costs and net profits frustrates farmers to the point of no return, ultimately driving them to take their own lives. As their income diminishes, they find themselves with no viable alternatives. Recent media reports have highlighted a concerning rise in farmer suicides across India. This alarming trend has been linked to issues such as agricultural system restructuring, crop failures (particularly cotton in recent years), increasing debt, and unemployment.

The media reports underscore the need for a thorough review of agriculture-related policies and a deeper investigation into the underlying causes of this crisis. An analysis of the agricultural suicide profile revealed that small and marginal farmers, particularly those with landholdings of up to 5 acres, are more vulnerable to suicide.

Crop selection and yield prediction are critical challenges in agriculture. The objective of this project is to use machine learning algorithms to recommend suitable crops based on climatic parameters and location while also predicting crop yield based on the season and the size of the cultivated area.[3]

3.1 Proposed System:

In the past, it was assumed that farmers would actively engage in their fields and harvest their crops. However, as conditions change rapidly over time, farmers are increasingly compelled to cultivate a growing variety of crops. In this evolving scenario, a significant number of individuals lack awareness about new crops and remain uninformed about the benefits of advancements in agricultural practices.

Crop yield efficiency can be improved by understanding and predicting crop performance under varying environmental conditions. The proposed system incorporates user input, including location data, to generate insights. This consolidated information integrates crop-related data sourced from various platforms. The system utilizes prediction algorithms and machine learning techniques to identify patterns in the data and apply them based on the inputs provided.

Key objectives include determining the accuracy of the training and testing datasets, specificity, false positive rates, precision, and recall. These metrics are evaluated by comparing different algorithms, with a particular focus on the Random Forest algorithm.

The following Involvement steps are,

- Outline a problem
- Formulating data
- Assessing algorithms
- Refining outcomes
- Predicting results

A dataset is typically organized as a table, where rows represent individual observations and columns denote the characteristics and values of those observations. At the beginning of a machine learning project, the dataset is usually divided into two or three subsets: a training dataset and a test dataset as a minimum, and sometimes an additional validation dataset. Once these subsets are created from the primary dataset, a predictive model or classifier is trained using the training data. The model’s predictive accuracy is then evaluated using the test data.

Machine learning systems leverage algorithms to model data and simultaneously uncover patterns, often with the objective of making predictions. These algorithms are grounded in statistics and mathematical optimization techniques. Essentially, the goal of utilizing machine learning algorithms and optimization techniques is to automatically learn highly accurate predictive or classification models or to discover hidden patterns in the data.[5]

The process involves importing library packages, loading the provided dataset, and analyzing variables by identifying data shape, data types, and addressing issues such as missing or duplicate values. The **Smart Farming Application** developed in this project uses machine learning concepts, specifically the Random Forest algorithm, to assist farmers in selecting weather-appropriate crops that yield higher productivity.

4. Analysis

To implement the application, decided to focus on Maharashtra State only in India. Historical data about the crop and the climate at the district level was needed to implement the system. This data has been gathered from the government website www.data.gov.in and https://www.mahabeej.com which includes State, District, Season, Crop, Area and Production.

4.1Analysis of Crops:

In the crop analysis to find out all details regarding crop like time of sowing, spacing varies with variety used, sowing Depth, Method of sowing, seed rate and multiple crop varieties with their life span.

4.1.1 SOYABEAN:

Time of sowing

Optimum time for kharif cultivation is in first fortnight of June month. Sow seeds only when, sufficient moisture is present in soil (at least 50-60mm rainfall received for 2-3days).

Spacing

Spacing varies with variety used. Like for spreading variety keep row to row distance of 45cm. whereas for non-spreading variety use row to row spacing of 40cm. Keep plant to plant spacing of 15cm.

Sowing Depth

Under optimum moisture condition, sow seeds at depth of 2.5 to 3cm. Avoid deep sowing as it will affect germination.

Method of sowing

Sow seeds with help seed drill.

Seed Rate

For sowing one acre land, use seed rate of 28-32kg/acre.

Variety of Soyabean with Duration

Following Table shows the multiple variety of soyabean with different lifespan of each variety.[4]

Table 4.1.1: Different variety of Soyabean

Variety	Water Required	Region	Duration(days)
NRC-37 (Ahilya 4)	More	Vidarbha, Maharashtra	102
JS-9752	Less	Maharashtra	90
JS93-05	Moderate	Maharashtra	95
RAUS-5	More	Maharashtra	104
MAUS-32(Prasad)	More	Maharashtra	105
MAUS-2(Pooja)	More	Maharashtra	110
MAUS-612	Moderate	Maharashtra	98

MAUS-1(Arti)	Moderate	Maharashtra	95
MAUS-158	Moderate	Marathwada	98
MAUS-162	More	Marathwada	103
MAUS-81(Shakti)	Moderate	Maharashtra	97
MAUS-71(Samruddhi)	Moderate	Maharashtra	100
MAUS-61-2(Pratishtha)	More	Maharashtra	105

4.1.2 COTTON

Time of sowing

Under irrigated conditions, complete sowing in May month. And for rainfed areas, complete sowing with onset of monsoon.

Spacing

For varieties, use spacing of 90cmx60cm. For Hybrid and BT varieties, use spacing of 90x90cm for medium soils and 90x120cm for heavy soils.

Few gaps arise due to failure of seed germination and mortality of seedling. To overcome this gap filling it is necessary, it must be filled by sowing 2-3water soaked seeds/hill out of these keep only one healthy seedling after germination. Two weeks after sowing the weak/diseased/damaged seedlings should be removed by keeping a healthy seedling/hill.[4]

Sowing Depth

Sowing should be done at depth of 4-5 cm.

Method of sowing

For sowing use seed drill for Desi cotton while dibbling of seed is done in case of hybrids and Bt cotton.

Seed Rate

Seed rate varies with variety, growing zones, irrigation etc.

For hybrids, use seed rate of 1.4-1.6kg and for local varieties use seed rate of 4-4.8kg/acre for per acre land.

Variety of Cotton with Duration

Following Table shows the multiple variety of Cotton with different lifespan of each variety.[4]

Table 4.1.2: Different Variety of Cotton

Choose Variety for Cotton	Water Required	Region	Duration(days)
Buri 1007	More	Vidarbha	220
A.K.H. 081	Less	Vidarbha	160
Rajat (H.K.H.84635)	Moderate	Vidarbha	190
A.H.H.-468	Moderate	Vidarbha	190
S.R.T.1	Moderate	Vidarbha	180
L.R.A. 5166	Moderate	Maharashtra	180
L.R.K. 516	Moderate	Maharashtra	160
M.C.U.5	More	Central M	165

Laxmi	Moderate	Central M	180
Ankur 651	Moderate	Maharashtra	180
Eknath	Less	Marathwada	160
Rohini	Moderate	Marathwada	180
Jyoti	Moderate	Nashik,Jalgaon, Dhule	190

4.1.3 WHEAT:

Time of sowing

For rainfed areas, Middle of October is optimum time for wheat sowing. For timely sown Irrigated areas, complete sowing in first forthnight of November month. In case of late sown irrigated areas, complete sowing from 15th of November to 15th of December.

Spacing

For timely sown irrigated areas and rainfed areas, use row to row spacing of 22.5cm. For late sown irrigated areas, use spacing of 18cm.

Sowing Depth

Sow seeds in North-South direction. For tall varieties use sowing depth of 6-7cm where as for other varieties use sowing depth of 5-6cm.

Method of sowing:

sowing can be done manually by

1. Seed drill
2. Broadcasting method

Seed Rate

For rainfed areas, use seed rate of 30-40kg/acre. For timely sown irrigated areas, seed rate of 40-50kg/acre. For late sown irrigated areas, 50-60kg per acre.[4]

Table 4.1.3: Different Variety of Wheat

Variety	Water Required	Region	Duration(days)
(JL-24) Phule pragati	Less	Maharashtra	97
Karad 4-11	More	Maharashtra	145
Improved spanish	Less	Maharashtra	105
Improved small japan	Less	Maharashtra	95
AK-10	Moderate	Maharashtra	120
AK-8-11	Moderate	Maharashtra	120
Faizpur 1-5	Less	Maharashtra	105
S.B.11	Moderate	Maharashtra	110
JL-220	Moderate	Maharashtra	110
TPG-41	More	Western Maharashtra	130
Phule RHRG-6021	Moderate	Western Maharashtra	125
B95(koyana)	More	Western Maharashtra	140
Phule warana(KDG)	Moderate	Maharashtra	120

4.1.4 GOUNDNUT:

Time of sowing

For kharif season, complete sowing in month of June - July. For summer season, carry out sowing from 15th January to 15th of February.

Spacing

For sowing use spacing of 30cmx10cm i.e. row to row spacing of 30cm and plant to plant spacing of 10cm.

Sowing Depth

Pods are sown with help of seed drill at depth of 3 to 5cm.

Method of sowing

Seeds are sown with help of seed drill. Planters are also available for sowing groundnut. Sow seeds on ridge bed to obtained higher result.

Seed Rate

Seed rate vary with variety used. For JL 501, TJ 26, SB 11 use seed rate of 40kg per acre.
Whereas for variety like Phule Pragati, TPG 41 used seed rate of 45-50kg/acre.[4]

Table 4.1.4: Different Variety of Groundnuts

Variety	Water Required	Region	Duration(days)
(JL-24) Phule pragati	Less	Maharashtra	97
Karad 4-11	More	Maharashtra	145
Improved spanish	Less	Maharashtra	105
Improved small japan	Less	Maharashtra	95
AK-10	Moderate	Maharashtra	120
AK-8-11	Moderate	Maharashtra	120
Faizpur 1-5	Less	Maharashtra	105
S.B.11	Moderate	Maharashtra	110
JL-220	Moderate	Maharashtra	110
TPG-41	More	Western Maharashtra	130
Phule RHRG-6021	Moderate	Western Maharashtra	125
B95(koyana)	More	Western Maharashtra	140
Phule warana(KDG)	Moderate	Maharashtra	120

4.2 SYSTEM DESIGN PROCESS:

4.2.1 ALGORITHM

4.2.1.1 RANDOM FOREST

Random Forest Classifier (RFC) is an ensemble algorithm. In this we will combine two or more algorithms to classify data accordingly. Running prediction with “Naive Bayes”, “Support Vector Machine” and “Decision Tree”, at that point taking a vote in favor of conclusive comprehension of class for the test object. RFC makes group from randomly chosen subsets of training sets of the different decision trees. Then it makes a group of the votes from several different outputs of decision trees to choose the concluding class of the given test entity. Suppose the training data set is given as : [X1, X2, X3, X4] with labels mapped to the following as [B1, B2, B3, B4], random forest classifier may make three or four decision trees taking input of subset for example as given, 1. [X1, X2, X3] 2. [X1, X2, X4] 3. [X2, X3, X4] The code used for Random Forest Classifier is similar to previous classifiers. 1. Import library 2. Create model 3. Train 4. Predict

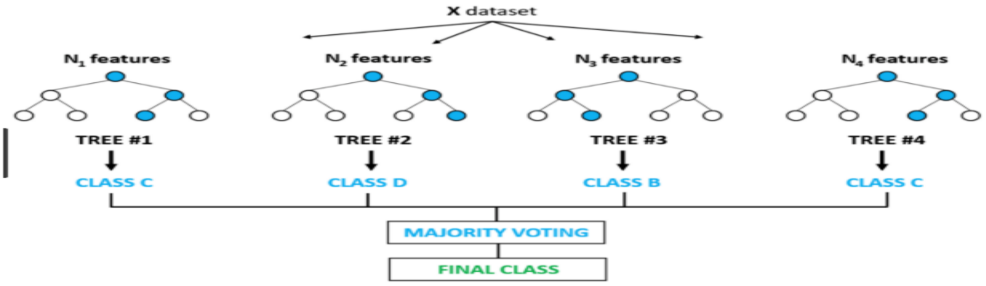

Figure 4.2: Describing Random Forest

4.3 SYSTEM ARCHITECTURE

The design outlines a representation and provides details about the software's data structure, architecture, interfaces, and components essential for the system's functionality. Crop information is stored in a dataset with various attributes used to compare and establish relationships between them. Once the behavior of the attributes is analyzed, data transformation is performed.

Given the size of the dataset, a subset is created for training purposes, typically using, for example, the first thousand entries of the dataset. This subset serves as the Model Training dataset. Using a specific algorithm, predictions are made with the highest possible accuracy.

This system primarily assists farmers in determining which crop to cultivate and provides an estimate of the cost, enabling them to approximate their potential profit.[8]

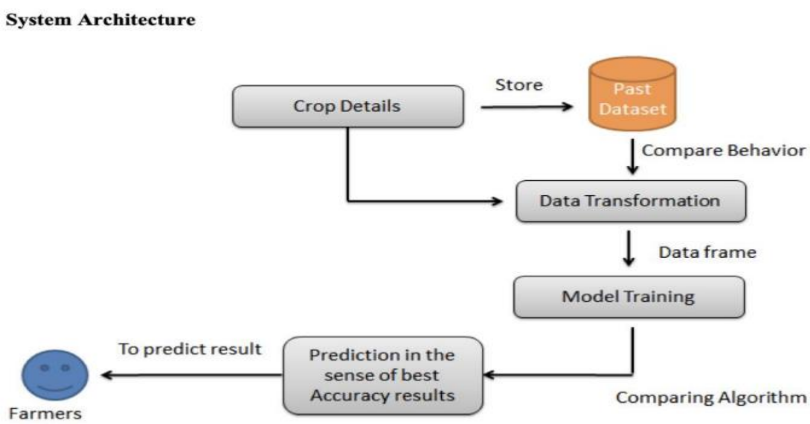

Figure 4.3: System Architecture

5. RESULT

In the result Farmer give the input state, crop, Farm type (Irrigated, Non- Irrigated), Village Name, Soil Type, Farmer Name. After Clicking on Random Forest Button, they give the prescription and other details of Weather Warning (date& Time, Humidity, Monthly rainfall, Temperature, live forecast Status) and Weekly

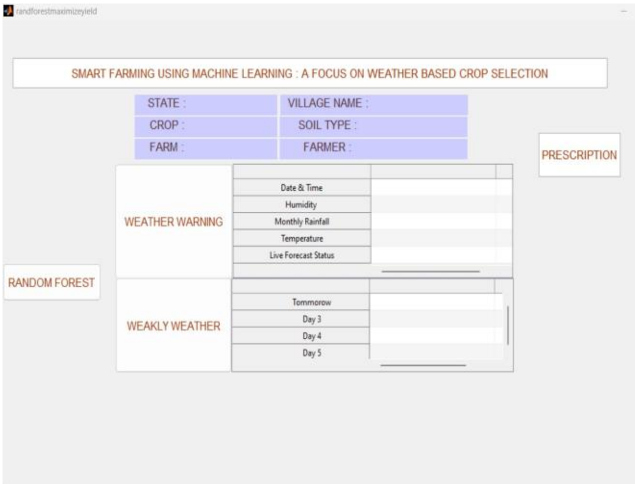

Figure 6.1: Screenshot GUI of Project

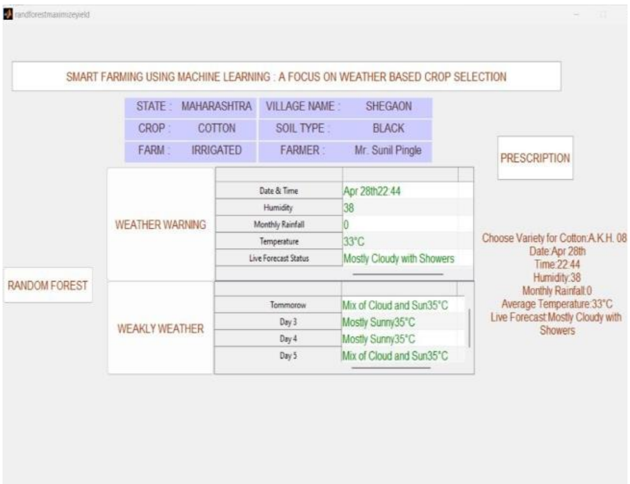

Figure 6.2: Screenshot of Farmer 1(Cotton crop Variety)

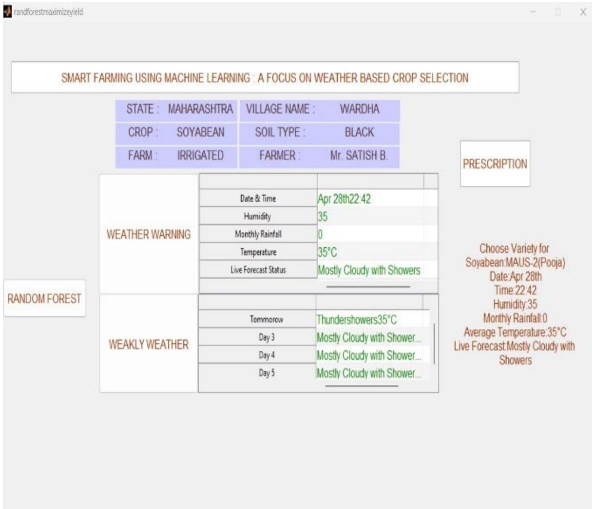

Figure 6.3: Screenshot of Farmer 2(Soyabean Crop Variety)

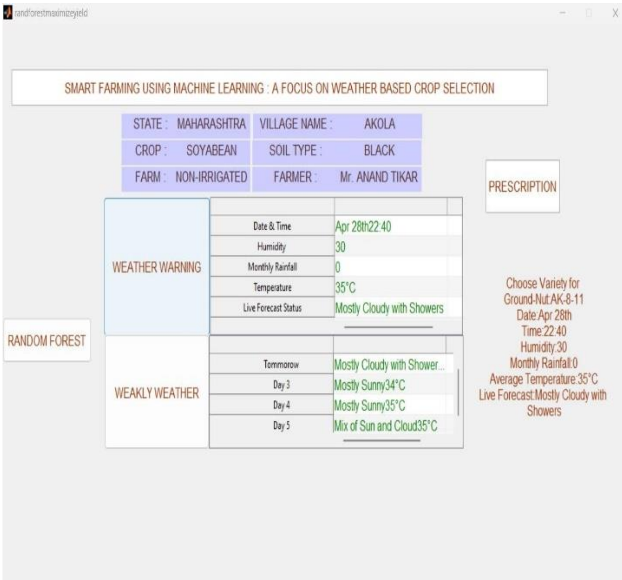

Figure 6.4: Screenshot of Farmer 3(Ground –Nut Crop Variety)

Conclusion

Makes a list of all the crops, it helps in decision making for the farmer and helps the farmer to decide which crop to sow. Likewise, the given framework makes sure that the past generation of information that can enable the farmer to comprehend the understanding of the different expense of harvests and their interest in the market. This system helps the farmer in prediction the yield of any crop in a particular district based on various environmental and ecological conditions like Temperature, Humidity, and amount of rainfall, etc.

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