FARMING MADE EASY USING MACHINE LEARNING

M.Venkatarao M.Tech
Computer Science & Engineering
Narasaraopeta Engineering College
Narasaraopet, India
venkatmarella670@gmail.com

Potturi Lahari
Computer Science & Engineering
Narasaraopeta Engineering College
Narasaraopet, India
lahari168@gmail.com

Krishna Sai Sreeja Chennakesavula
Computer Science & Engineering
Narasaraopeta Engineering College
Narasaraopet, India
ks.sreedevis08@gmail.com

Gogineni Saikalpana
Computer Science & Engineering
Narasaraopeta Engineering College
Narasaraopet, India
gsaikalpana@gmail.com

Shaik Nabi Wajiha
Computer Science & Engineering
Narasaraopeta Engineering College
Narasaraopet, India
wajihanabi92@gmail.com

***ABSTRACT*--Agriculture serves as the backbone of our country's economy. However, in recent years, the sector has faced challenges due to unpredictable climate patterns and fluctuating price trends. Farmers often bear the brunt of these uncertainties, leading to crop spoilage and significant financial losses. Moreover, farmers may not always be aware of the most suitable crop types for their land, further complicating their situation. To address these issues, a comprehensive and user-friendly system has been developed. This system leverages Decision Tree Regression predicts crop prices accurately by analyzing rainfall, wholesale price index, month, and year, enhancing agricultural decision-making. By providing advance price forecasts, this system empowers farmers to make informed decisions, thereby increasing their profitability and contributing to the country's economy. In addition to price prediction, this system seamlessly combines weather forecasts, crop and fertilizer suggestions, a shop, chat portal, and guide features effectively. The crop recommendation module suggests suitable crop types based on the land's characteristics, helping farmers maximize their yield. The crop yield prediction module forecasts the expected yield based on various factors, aiding farmers in planning their harvest and resources accordingly. The fertilizer recommendation module suggests appropriate fertilizers based on soil health and crop requirements, optimizing crop growth and quality. Overall, this system serves as a valuable tool for farmers, providing them with essential information and insights to improve their farming practices and increase their profitability. By incorporating advanced technologies such as Machine Learning, this system could transform the agricultural industry, playing a pivotal role in the country's economic advancement and fostering substantial growth in the sector [1,2,3].**

Keywords--Random Forest Algorithm, Crop Recommendation, Crop Yield prediction, Crop Fertilizer prediction, Crop Price prediction, Machine Learning.

1. INTRODUCTION

Agriculture stands as the cornerstone of our country's economy, yet it faces daunting challenges from unpredictable climate patterns and volatile price trends. Uncertainties cause crop spoilage and significant financial losses, posing challenges for farmers' economic stability. Additionally, Farmers may find it challenging to select suitable crop types, compounding their difficulties[1]. To tackle these challenges, We've created an inclusive and intuitive system for users. The system employs

Machine Learning's Decision Tree Regression Algorithm to accurately predict crop prices with precision. Crucial factors like rainfall, wholesale price index, month, and year are analyzed for precise price predictions. By providing advance price predictions, our system empowers farmers to make informed decisions, enhancing their profitability and bolstering the country's economy[3].

To tackle these challenges, we have developed a comprehensive and user-friendly system. Harnessing Machine Learning, notably the Decision Tree Regression Algorithm, this system accurately forecasts crop prices with remarkable precision. The system takes into account essential factors like rainfall, wholesale price index, month, and year for precise price forecasting. By providing advance price predictions, our system empowers farmers to make informed decisions, enhancing their profitability and bolstering the country's economy[1].

To tackle these challenges, We've crafted a comprehensive and intuitive system for users. The system employs Machine Learning's Decision Tree Regression Algorithm to accurately forecast crop prices with precisionCrucial factors including rainfall, wholesale price index, month, and year are analyzed to ensure accurate price forecasts. By providing advance price predictions, our system empowers farmers to make informed decisions, enhancing their profitability and bolstering the country's economy. In addition to price prediction, our system includes modules for weather forecasting, crop and fertilizer recommendations, along with features for shopping, chatting, and guidance. The crop recommendation module analyzes land characteristics to suggest suitable crop types, helping farmers maximize their yield.

Moreover, the fertilizer recommendation module suggests appropriate fertilizers based on soil health and crop requirements, optimizing crop growth and quality.

Overall, our system serves as a valuable tool for farmers, providing them with essential information and insights to enhance their farming practices and profitability. By incorporating cutting-edge technologies like Machine Learning, this integration of advanced technologies has the potential to transform the agricultural sector and drive substantial economic growth nationally, agriculture, various machine learning algorithms play pivotal roles in enhancing productivity and efficiency. Random Forest, a powerful ensemble method, excels in handling large datasets and offers robust predictions[4].

Linear Regression, a fundamental algorithm, is valuable for establishing relationships between variables, aiding in price trend analysis. Lasso and Ridge Regression are effective in handling multi collinearity and feature selection, essential for identifying 88key factors influencing crop prices. K-Nearest Neighbors (KNN) is beneficial for clustering similar data points, aiding in crop classification and recommendation. Decision Trees are intuitive and useful for understanding decision-making processes in crop management, providing insights into factors affecting crop yields and prices. These algorithms, when applied judiciously, can significantly impact agricultural practices, offering valuable insights and predictive capabilities

2. LITERATURE SURVEY

The following studies concentrated on applying machine learning to predict crop prices and present the findings. Prior to planting, the exploration aims to estimate reviewing April 2019 harvest: cost, utility. The curated datasets obtained in this way provide sufficient information to predict appropriate costs and requests in the business sectors [4]. The most lucrative crops and their anticipated price at harvest time, depending on the region, have been forecast by the writers by employing diverse machine learning algorithms for historical dataset predictions. In the analysis work presented by Nishiba [5], it is anticipated that data mining techniques will be used to predict the harvest Production depending on input characteristics for instance average precipitation and land size. The Any customer can use the user-friendly website page designed for predicting crop production by providing the area and typical precipitation levels. Various datasets are subjected to different Data Mining methodologies. Additionally, this paper may have several modules [6] that assist farmers in making decisions made according to harvested area or current market trend.

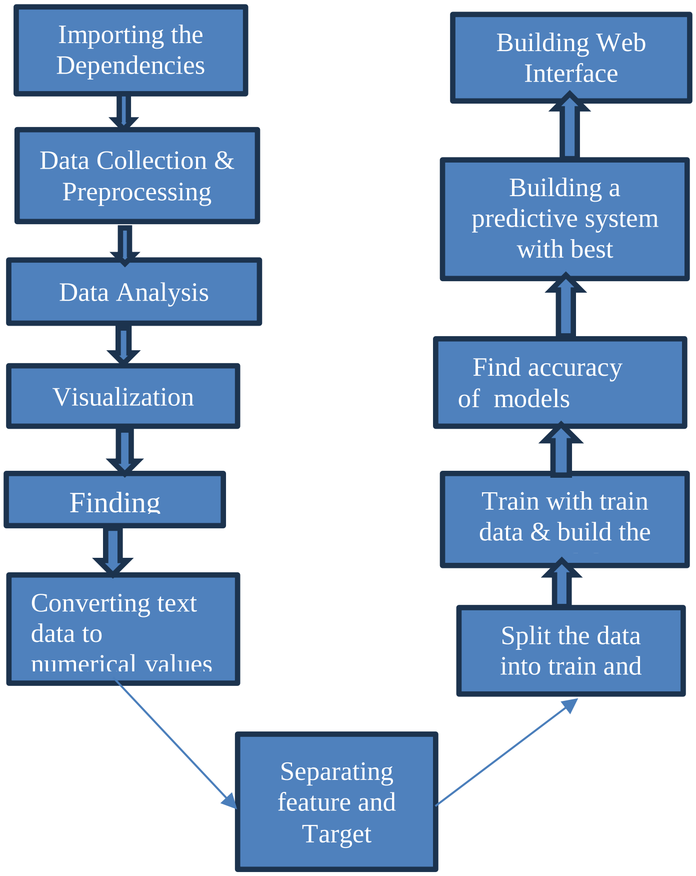
To enable farmers observe the details of nearby district farming, the system can be expanded to visualize crop details on a detailed map. For improved comprehension, the suggested system could be improved by include a graphical representation of the anticipated prices.

The goal of this approach is to assist farmers in anticipating the optimal quantity regarding their crops and in determining the ideal price for these crops. Farmers can use this to verify historical pricing for various commodities. Applying Random Forest, Polynomial Regression, and Decision Tree techniques, the system is able to predict crops [6]. The farmer can feel more secure in the crop and its yield when the best crop and necessary fertilizers are used. Additionally, our system will handle the marketing task by evaluating the crop's entire value based on the prevailing market price [4]. The concept of the system can involve expanded by incorporating a few more functions, such as a nearby shop locator gateway for fertilizer and seed purchases. These studies use effective machine learning algorithms, such as the system incorporates Autoregressive Integrated Moving Average (ARIMA) model, Traditional ARIMA, and Support Vector Regression Algorithm, alongside user-friendly interface, to predict prices and forecasts through web applications. The training datasets [8] that are obtained provide enough information to predict the right price [10] and demand in the markets. Web apps are used to present the results so that low-income farmers can easily access them. By combining Integrating with departments such as horticulture, sericulture, and others in alignment with our nation's agricultural development, models can be enhanced. Currently, different agriculture agencies are dealing with different issues. Not only would their inclusion broaden the breadth, but it will also assist farmers who are unfamiliar with this region of the spectrum.

By creating a framework to recommending agricultural produce and distribute for farmers, their work may be furthered. When employing an autonomous information framework, we should obtain the same accuracy using this framework. can be improved even more by creating an Android application for it.

A.Existing System

The system provides comprehensive support for farmers through its crop recommendation, crop yield prediction, and crop fertilizer prediction features. Using data on soil type, climate conditions, and historical crop performance, the system suggests the most suitable crops for a given piece of land, optimizing yield and profit potential. Additionally, by analyzing historical data, weather forecasts, and soil conditions, the system predicts crop yields[10][12], aiding farmers in planning their harvest and resource allocation. Furthermore, by evaluating soil health, crop requirements, and nutrient levels, the system recommends the appropriate fertilizers for optimal crop growth, ensuring that crops receive the necessary nutrients for improved yields and quality [4]. These features collectively empower farmers with valuable insights and recommendations, empowering them to make informed decisions and improve their agricultural practices.



B. Proposed System:

In our proposed system, we aim to develop a robust crop price prediction model. By leveraging machine learning algorithms and historical data on factors such as rainfall, wholesale cost index, month, and annum, our framework will provide accurate forecasts of crop prices. This information will empowering farmers with insights for crop selection, harvest timing, and pricing strategies, ultimately increasing their profitability and contributing to the stability of the agricultural sector.

3. METHODOLOGY

A. Research Objective: By integrating these elements into your research, you can offer a more holistic analysis of the factors influencing crop production and pricing, helping farmers make informed decisions. The crop recommendation model will Assisting farmers in selecting optimal crops, considering soil quality and land suitability, climate, and historical data. This can lead to improved crop yields and reduced risk of crop failure.[4]

The crop fertilizer prediction model will assist farmers decide on the type and amount of fertilizer needed for optimal crop growth. By considering soil nutrient levels, crop type, and other relevant factors, this model can ensure that farmers apply the right amount of fertilizer, reducing waste and environmental impact. The crop yield prediction model will enable farmers to anticipate their crop yields based on elements like weather patterns, soil health, and crop type. This information can help farmers plan their harvest and allocate resources more effectively, leading to increased efficiency and profitability.

B. Data Description: Getting the data is a crucial step in any machine learning endeavor, as the quality of the data affects how well the model works. In this study, we obtained our data from Kaggle, a popular website where data scientists share datasets. After collecting the data, which comprised over 7418 records and 9 different pieces of information[8], we uploaded it to Google Colab, an online platform for analyzing data and performing machine learning tasks. We utilized four datasets from Kaggle, each containing a different number of records

.

- **Fertilizer Dataset:** This dataset consists of 100 records and 9 columns, providing information on the types and quantities of fertilizers suitable for different crops.[12]

- **Crop Price Dataset:** This dataset consists of 7418 records and 9 columns, providing information on the types and quantities of Crop Price suitable for different crops.[9]

- **Yield Prediction Dataset**: With 120 records and 6 columns, this dataset contains information Utilized for forecasting crop yield considering weather, soil, and crop type factors.[8].

- **Crop Recommendation Dataset:** This dataset comprises 2201 records and 7 columns, offering recommendations for suitable crops based on factors like soil quality, climate, and historical data [9].

C. Pre-processing of Dataset

Before we could use the data, we had to clean it up by getting rid of any missing information and unusual values. This makes the data ready for training and testing our models.

D. Data Visualization

We used graphs and charts to look at the data and see if there were any patterns. In below figure (1) we divided the dataset by states on one side and rainfall in different states.it was use analyzing average in every state.[21]

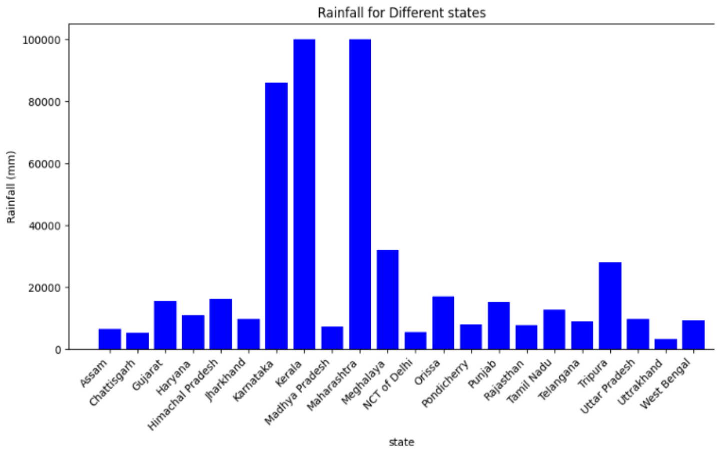


Fig (1): Rain for different states

We used graphs and charts to look at the data and see if there were any patterns. In below figure (2) we divided the dataset by varieties on one side and rainfall in different states. It was use analyzing average in every districts [12].

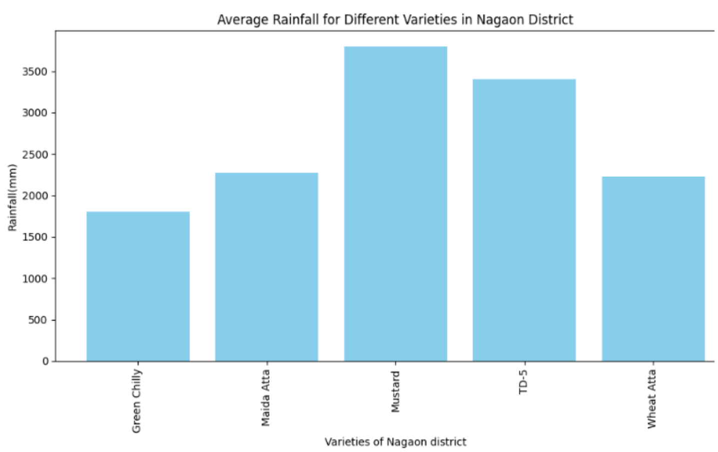


Fig (2): Average rain fall for different varieties in particular district

We used graphs and charts to look at the data and see if there were any patterns. In below figure (3) we divided the dataset by varieties on one side and Croptype in different crops . It was use analyzing average phosphorous on soi [12]l.

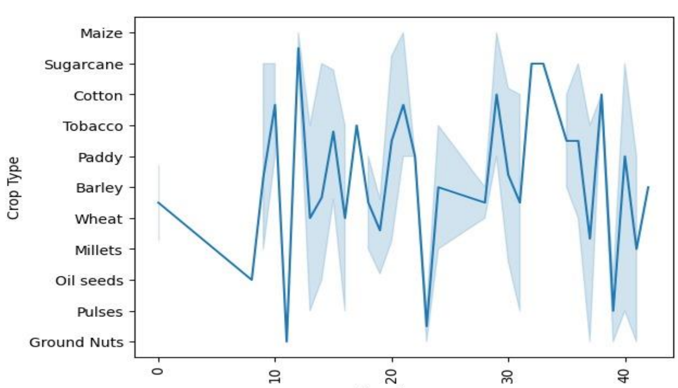


Fig (3): Phosphorous levels in different crops

We used graphs and charts to look at the data and see if there were any patterns. In below figure (4) we divided the dataset by varieties on one side and Crop type in different crops . It was use analyzing average Nitrogen on soil [8].

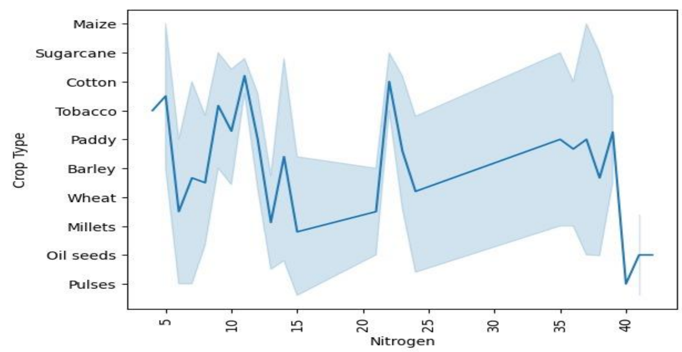


Fig (4): Nitrogen levels in different crops

Algorithms	MSE	MAE	R2
Linear Regression	303135.38	201.74	0.98
Decision Tree	649697.80	231.29	0.96
Lasso	302983.22	201.74	0.98
Ridge	303131.32	201.14	0.98
Random Forest	**431052.62**	**195.00**	**0.97**
KNN	481440.23	220.14	0.97

We used graphs and charts to look at the data and see if there were any patterns. In below figure (5) we divided the dataset by varieties on one side and Crop Yield in different crops. It was use analyzing average Cost on every Crop [8].

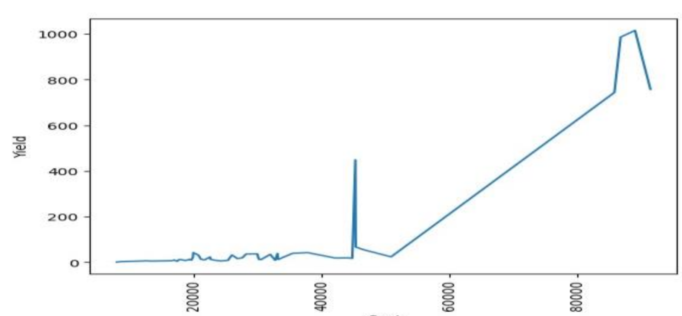


Fig (5): Analyzing yield and cost

We used graphs and charts to look at the data and see if there were any patterns. In below figure (6) we divided the dataset by varieties on one side and Crop Yield in different crops. It was use analyzing Different States on every Crop [9].

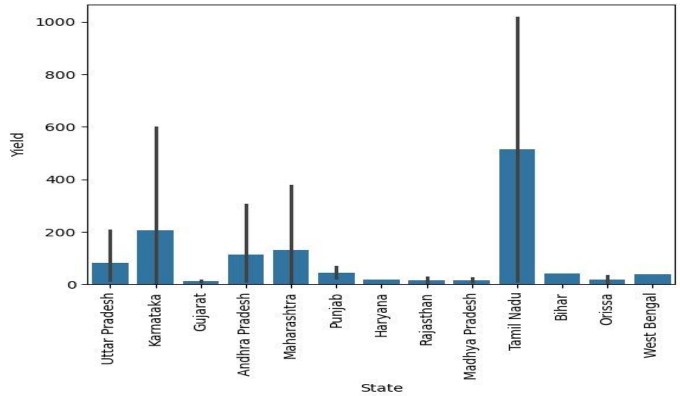


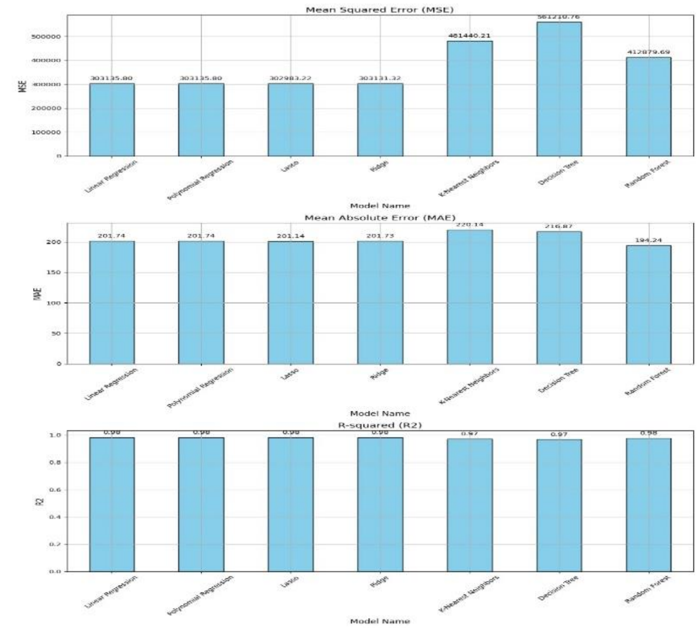
Fig (6): yield production in different states

E. Separating and Splitting the Data

Separating the input features and target data. Then, we split the data into two parts: one part, which was 80% of the data, was used for training our models, and the other part, which was 20% of the data, was used to see how well the models worked.

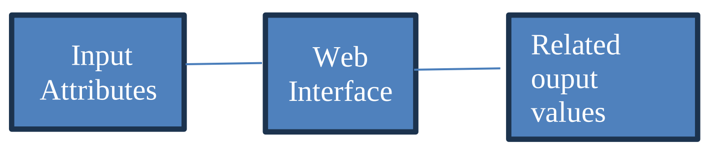
F. Model Assessment and Selection

By using K-Fold Validation we tested four various machine learning algorithms —Ridge, Lasso, Decision Tree, Random forest, linear regression, and KNeighbors Regressor regression—to see how well they could predict maximum crop price. After conducting testing, the models will undergo evaluation based on their scores obtained through performing 10 iterations of K-fold validation. The model exhibiting the highest mean score in predicting the target variable is chosen as the optimal model. Additionally, prediction Performance metrics including Mean Square Error (MSE), R-Squared (R2), and Mean Absolute Error (MAE) are utilized for additional evaluation of model performance. The model exhibiting the lowest prediction errors will be deemed the most suitable choice.



G. Building Web Interface

To build the web interface using Flask framework, we will create a template with a menu bar containing four buttons for crop price prediction, crop yield prediction, fertilizer prediction, and crop recommendation. Each button will link to a respective route in our Flask app. When the user inputs the required attributes for each prediction or recommendation, the interface will provide the related output. Through rigorous testing and evaluation, we will determine the most effective predictive model based on metrics such as MSE, RMSE, and MAE, ensuring reliable crop price predictions for the user.



H. Findings and Discussion

In the results section, we will analyze the accuracy of models trained on both past and current data, examine various types of errors encountered, present bar charts illustrating the accuracy of different algorithms, and provide visual representations of evaluation metrics for each algorithm. Additionally, we will showcase the predicted results from our web Interface and compare our findings to recent studies in the field.

4. Model Accuracies of Different Models

We conducted a thorough assessment of our models using K-fold cross-validation with 10 iterations, a widely-used technique in machine learning evaluations. This approach provides robust validation, ensuring reliable performance assessment. The accuracy and reliability of our models can play a crucial role in providing users with meaningful and actionable insights. For example, in a crop price prediction interface, crop recommended prediction interface, crop fertilizer prediction interface & crop Yield prediction interface users would benefit from accurate predictions to make informed decisions about crop cultivation, pricing strategies, and market trends. By displaying this information in a straightforward and user-friendly interface, individuals can readily understand and utilize the predictions according to their unique requirements, thereby enhancing the usability and effectiveness of the application. Across all models, we observed consistently high accuracies, highlighting their effectiveness. Specifically, Decision Tree achieved an impressive average accuracy of 95.76%, while Random Forest performed even better with an average accuracy of 98%. These results underscore the reliability and effectiveness of these models in predicting Maximum crop price. The high accuracies make them well-suited for implementation in web applications, ensuring reliable and effective predictions. The bar graph below illustrates the average accuracies of the regression algorithms, providing a visual representation of their performance.

Table -1 Accuracy of different algorithms

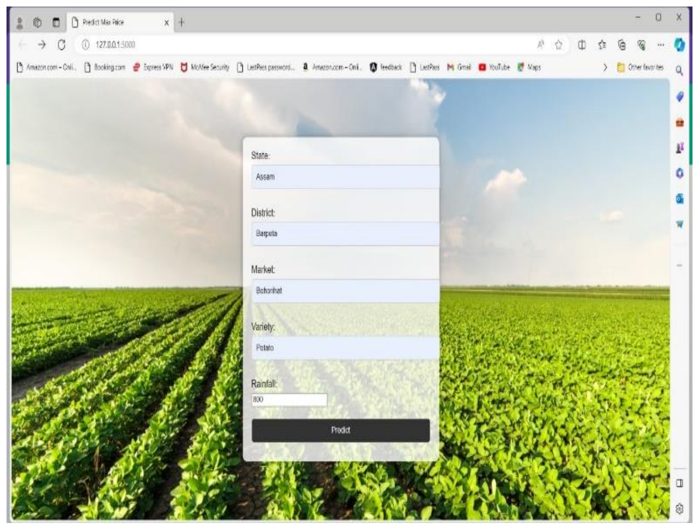
Algorithms	Accuracy
Random Forest	0.98
Decision Tree	0.95
Lasso	0.57
Ridge	0.57
Linear Regression	0.57
KNN	0.75

The performance of various algorithms was evaluated based on their accuracy scores for a specific task. Random Forest proved to be the most effective, attaining an accuracy of 0.98. Following closely was the Decision Tree algorithm with an accuracy of 0.95, indicating its suitability for the task. In contrast, the linear models including Lasso, Ridge, and Linear Regression all displayed similar accuracy scores of 0.57, which, although lower than the tree-based models, can still be valuable in certain contexts. K-Nearest Neighbours (KNN) achieved an accuracy of 0.75, respectable but falling behind the ensemble methods. These results emphasize the effectiveness of ensemble methods for the task, particularly Random Forest and Decision Tree, while also highlighting the importance of considering other factors such as interpretability, computational efficiency, and scalability when choosing an algorithm for a specific application. Random Forest, with its impressive accuracy of 0.98, stands out as the top performer in his evaluation.

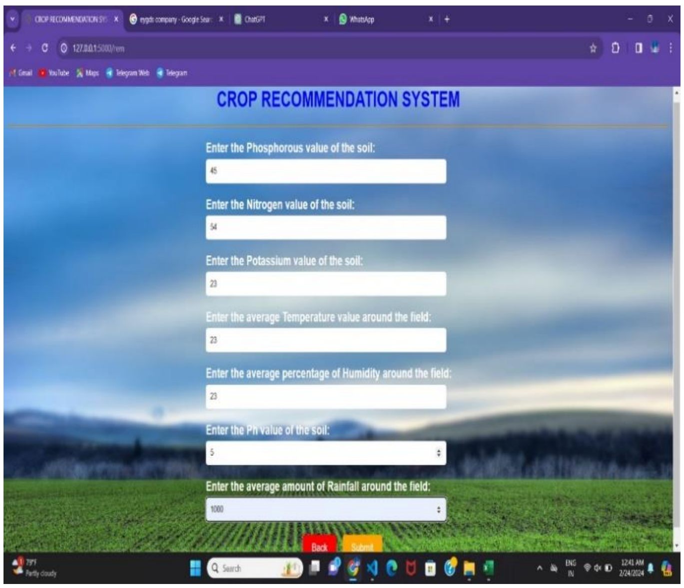
6. WEB INTERFACE (RESULT)

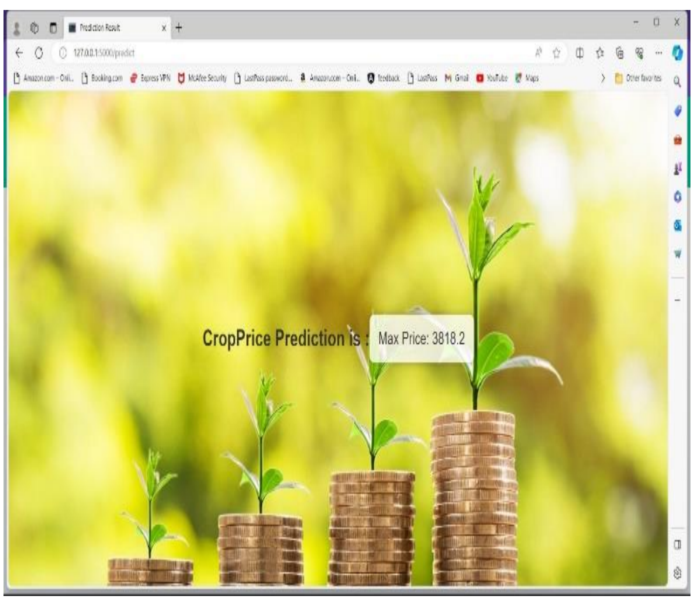
A. Crop Price

The image shows the cost prediction of the crops on various aspects like state, district and so many factors. Here the main point is the prediction of the crop is different from one state to another state and also different from one district to another district, And crop prediction can be different from on the basis of variety of crops and also based on the market range of crops. We can see the prediction of the cost on the crop also depends on the rainfall.



Now we can see the how the crop prediction is working the major states of the crops can be seen by using this technique of cost prediction. For example we have taken the random state Assam in which the cost prediction and the yield of the crop is different. And his price varies from one state to another state. Here we have also tried crop prediction on different states like as Andhra Pradesh, Kerala, Tamil Nadu and etc.





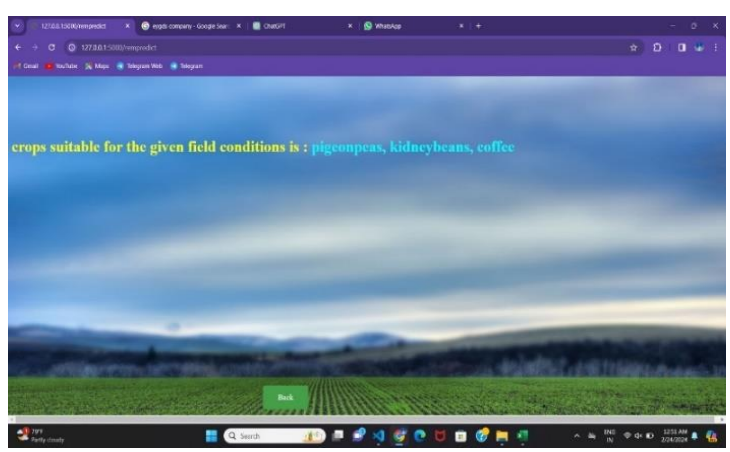
We see that the complete cost prediction of the crop that is potato crop in the Assam state is sold out for in the market is approximately maximum price of 3818.2. But this cost cannot be the same in any other state and it is completely different. The cost of the each crop varies from one state to another state. The process of growing each crop differs from one crop to another crop and the cost of crop also varies. The cost price of potato in Assam state is 3818.2 but the same price cannot be repeated in any other states. This is called the cost prediction of crops.

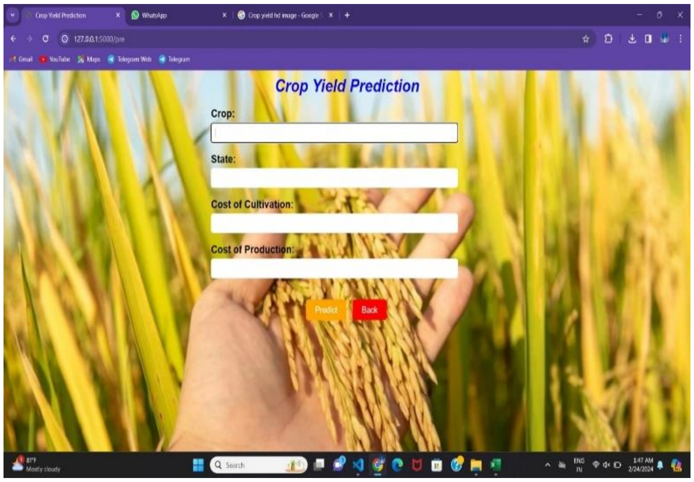
B. Crop Recommendation:

The above image shows the recommendation of the crops on various aspects like value of nitrogen in soil, value of phosphorous and so many factors. Here the main point is the prediction of the crop recommendation is different from one soil type to another soil type and also different from one PH to another PH value of crop prediction can be different from on the basis of variety of crops and also based on the market range of crops. We can see the prediction of the recommendation on the crop also depends on the soil type

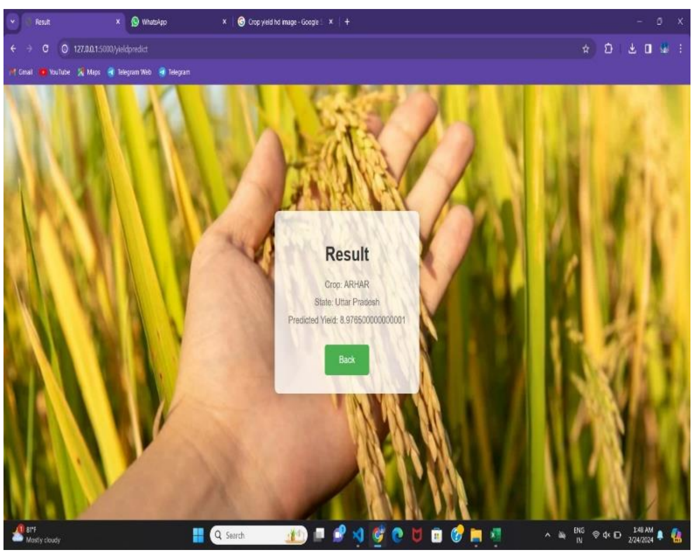
Crop recommendation systems utilize diverse soil and environmental factors, including potassium and nitrogen levels in the soil, pH value, phosphorus value, temperature, and rainfall amount, to advise farmers on the most suitable crops for cultivation in a specific area. By analyzing these factors, the system can make informed predictions, optimizing agricultural productivity and sustainability. For instance, based on the input parameters provided, such a system might recommend coffee and kidney beans as the ideal crops for a given location. This approach not only aids in maximizing yield but also supports sustainable farming practices by aligning crop selection with the prevailing environmental conditions.

C. Crop Yield Recommendation:



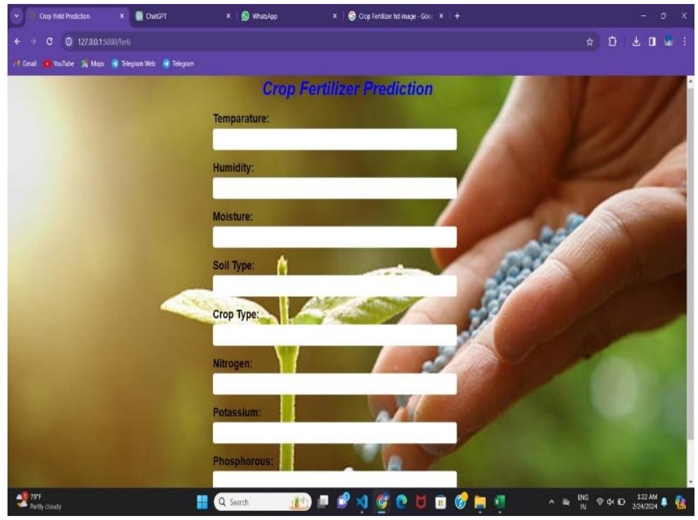


The above image shows crop yield prediction model takes into consideration four key attributes: the name of the crop, the state in which it is cultivated, the expenses related to cultivation and production. By analyzing these parameters, the model can predict the yield of a specific crop, providing valuable insights that help farmers and agricultural planners optimize their resources and strategies for maximum efficiency and profitability.

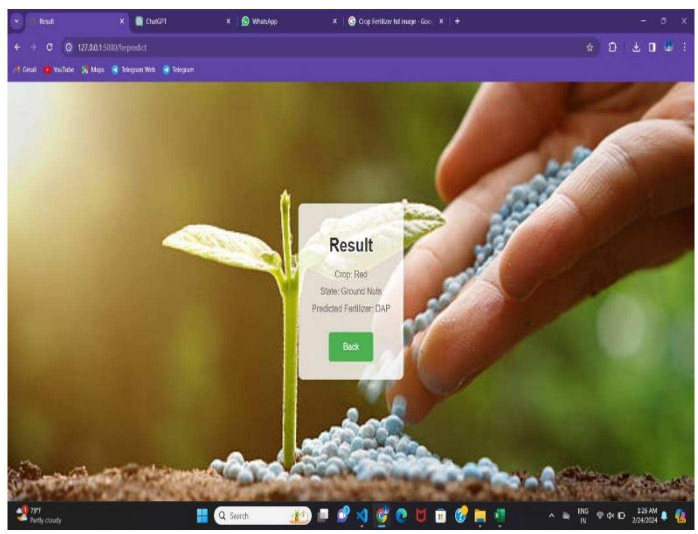


The image showcases the results of a crop yield prediction, displaying critical information such as the crop name, the state where it was cultivated, and the total yield production measured in hectares. This output provides essential insights, enabling farmers and agricultural stakeholders to understand the potential productivity of different crops across various states, thereby facilitating informed decision-making for future cultivation strategies and resource allocation.

D. Crop Fertilizer Prediction:



The image illustrates the output of a crop fertilizer prediction model, which evaluates four crucial attributes: humidity level, soil type, moisture content, and crop type. By examining these factors, the model is capable of predicting the optimal fertilizer requirement for a specific crop. This analysis offers invaluable insights, assisting farmers and agricultural planners in fine-tuning their resource management and cultivation strategies to enhance efficiency and increase profitability.



The image displays the outcome of a crop fertilizer prediction model, highlighting the recommended fertilizer for a specific crop based on its soil type. This result provides critical information, including the name of the crop, the type of soil it thrives in, and the optimal fertilizer to use. Such detailed insights empower farmers to select the most suitable fertilizer for their crops, ensuring healthier growth and potentially higher yields by aligning agricultural practices with precise soil and crop needs.

CONCLUSION AND FUTURE SCOPE

Throughout this extensive project, the utilization of machine learning algorithms, particularly Random Forest, has revolutionized agricultural practices. The project's core focus was to evaluate the performance of various algorithms—KNN, Random Forest, Linear Regression, Ridge, Lasso, and Decision Tree—for predicting crop yields. Among the algorithms utilized, Random Forest proved to be the most effective, achieving an impressive accuracy rate of 98%. This high level of accuracy is particularly beneficial for predicting yields of extreme crop types, providing valuable insights into previously unexplored cultivation opportunities.

Beyond yield prediction, the project explored the versatility of machine learning models in predicting crop prices, recommending suitable crops for cultivation, and determining optimal fertilizer requirements. These applications are instrumental in streamlining farming processes, empowering farmers with tailored insights for maximizing crop yield and profitability. By leveraging machine learning algorithms, farmers can make informed decisions that enhance agricultural productivity and sustainability.

A key highlight of the project was the development of a user-friendly web application, designed to provide seamless access to machine learning predictions. With a testing accuracy exceeding 98%, the application demonstrates the reliability and effectiveness of machine learning in predicting crop yields. This high level of accuracy instills confidence in farmers, encouraging the adoption of technology-driven practices for improved agricultural outcomes.

The implications of this project are profound, offering a glimpse into the future of agriculture. By harnessing the predictive power of machine learning, farmers can optimize their crop selection, resource allocation, and cultivation practices. This not only leads to higher yields and profitability but also promotes sustainable agricultural practices.

To conclude, this project underscores the transformative possibilities of machine learning within agriculture. By providing accurate predictions for crop yields, prices, and fertilizer requirements, machine learning empowers farmers to make informed decisions that drive agricultural innovation and durability. As the agricultural industry advances, the adoption of machine learning technologies evolves alongside it promises to revolutionize farming practices, ensuring a future for agriculture that is stronger and more productive..

4. REFERENCES

[1] L. M. Gladence, K. R. Reddy, M. P. Reddy, M. P. Selvan and Refonaa, "A Prediction of Crop Yield using Machine Learning Algorithm", *2021 5th International Conference on Trends in Electronics and Informatics (ICOEI)*, pp. 1072-1077, 2021.

[2] D. Paudel, H. Boogaard, A. de Wit, S. Janssen, S. Osinga, C. Pylianidis, et al., "Machine learning for large-scale crop yield forecasting", *Agricultural Systems*, vol. 187, pp. 103016, 2021.

[3] Vishal Kumar, Raushan Kumar, Shubham Kumar and Ajinkya, "Soil Analysis for Suitable Crop Prediction using Machine Learning and Image Processing", *Proceedings of International Journal of Advanced Research in Science Communication and Technology*, vol. 4, no. 2, pp. 2581-9429, April 2021.

[4] K. Sowmya Fathima, S. Barker and S. Kulkarni, "Analysis of crop yield prediction using data mining technique", *International Research Journal of Engineering and Technology (IRJET)*, vol. 07, no. 05, May 2020.

[5] Rohith R, Vishnu R, Kishore A, Deeban Chakkarawarthi, Crop Price Prediction and Forecasting System using Supervised Machine Learning Algorithms, International Journal of Advanced Research in Computer and Communication Engineering, March 2020.

[6] Dhivya Elavarasan and PM Durairaj Vincent, "Crop yield prediction using deep reinforcement learning model for sustainable agrarian applications", *IEEE access*, vol. 8, pp. 86886-86901, 2020.

[7] N. Bali and A. Singla, "Deep learning based wheat crop yield prediction model in punjab region of north india", *Applied Artificial Intelligence*, vol. 35, no. 15, pp. 1304-1328, 2021.

[8] https://www.kaggle.com/code/niteshhalai/crop-price-dataset/

[9] https://www.kaggle.com/code/niteshhalai/crop-recommendation-dataset/

[10] D. Paudel, H. Boogaard, A. de Wit, S. Janssen, S. Osinga, C. Pylianidis, et al., "Machine learning for large-scale crop yield forecasting", *Agricultural Systems*, vol. 187, pp. 103016, 2021.

[11] https://www.kaggle.com/code/mahmoudmagdyelnahal/crop-yield-prediction-99/input

[12] https://www.kaggle.com/datasets/gdabhishek/fertilizer-prediction?resource=download

[13] F. Martínez, F. Charte, M. P. Frías and A. M. Martínez-Rodríguez, "Strategies for time series forecasting with generalized regression neural networks", *Neurocomputing*, vol. 491, pp. 509-521, 2022.

[14] Abhinav Sharma, Arpit Jain, Prateek Gupta and Vinay

Chowdary, "Machine Learning Applications for Precision Agriculture: A Comprehensive Review", *Proceedings of IEEE*, 2020..

[15] L. M. Gladence, K. R. Reddy, M. P. Reddy, M. P. Selvan and Refonaa, "A Prediction of Crop Yield using Machine Learning Algorithm", *2021 5th International Conference on Trends in Electronics and Informatics (ICOEI)*, pp. 1072-1077, 2021.

[16] P. S. Khatoon and M. Ahmed, "A Crop Selection Framework using K Nearest Neighbour for IoT Semantic Interoperability Applications", *2021 8th International Conference on Computing for Sustainable Global Development (INDIACom)*, pp. 262-267, 2021.

[17] K. Sowmya Fathima, S. Barker and S. Kulkarni, "Analysis of crop yield prediction using data mining technique", *International Research Journal of Engineering and Technology (IRJET)*, vol. 07, no. 05, May 2020.

[18] H. Chen, "A hybrid model for crop recommendation based on machine learning and expert knowledge. information processing in agriculture", *Information Processing in Agriculture*, vol. 9, no. 1, pp. 153-168, 2022.

[19] D. Li, Y. Miao, S. K. Gupta, C. J. Rosen, F. Yuan, C. Wang, et al., "Improving potato yield prediction by combining cultivar information and uav remote sensing data using machine learning", *Remote Sensing*, vol. 13, no. 16, 2021.

[20] Utpal Barman a and Ridip Dev Choudhury, "Soil texture classification using multi class support vector machine", *Journal on Information processing in Agriculture*, vol. 7, no. 2, pp. 1-13, 2020