Agro Smart: Comparison Analysys for Fertilizer and Crop System

Hiresh Beria, Bondil Adithya Singh, E Preethi
Rajalakshmi Engineering College

Abstract. This project presents a robust agricultural support system combining machine learning-powered Fertilizer and Crop Recommendation Systems to enhance farming efficiency. The Fertilizer Recommendation System analyzes critical environmental factors such as soil type, pH level, temperature, rainfall, and humidity, providing precise fertilizer suggestions to optimize crop yields. Simultaneously, the Crop Recommendation System identifies the most suitable crops based on historical performance and specific soil and climate conditions, increasing the likelihood of successful harvests. It estimates production costs, including expenses for materials, labor, and machinery, enabling farmers to plan budgets effectively. Additionally, a location-based feature connects farmers to nearby fertilizer retailers, offering information such as retailer locations, contact details, and operating hours, ensuring convenient access to essential resources. This system empowers farmers to make informed decisions, improving productivity and profitability in agriculture.

Keywords: Machine Learning, Precision Farming, Resource Optimization

1 INTRODUCTION

This project introduces an advanced agricultural support system that integrates machine learning to address modern farming challenges through Fertilizer and Crop Recommendation Systems. By analyzing critical environmental factors such as soil type, pH, temperature, rainfall, and humidity, the system provides tailored recommendations to enhance crop productivity and minimize environmental impact. The Fertilizer Recommendation System offers precise guidance on the type and quantity of fertilizers required, helping farmers avoid overuse, improve soil health, and reduce costs. Simultaneously, the Crop Recommendation System suggests the most suitable crops based on historical data and local conditions, maximizing the chances of a successful harvest. Additionally, the system incorporates a location-based service that connects farmers to nearby fertilizer retailers. This feature provides essential information such as retailer addresses, contact details, and operating hours, ensuring farmers have quick and efficient access to necessary resources. By bridging farmers and local businesses, the system strengthens agricultural supply chains and supports rural economic growth. Through its integrated and data-driven approach, this tool promotes sustainable and profitable farming practices. It addresses critical issues like resource inefficiency, soil degradation, and overuse of inputs, empowering farmers to make informed decisions, optimize resource utilization, and contribute to the resilience and development of agricultural communities.

2 LITERATURE SURVEY

The primary goal is to empower farmers with a machine learning-based agricultural support system that provides precise crop and fertilizer recommendations, optimizes resource usage, minimizes environmental impact, and enhances productivity. By integrating location-based services, it ensures efficient access to resources, fostering sustainable farming and supporting rural economic development.
[1] The paper by (Attluri Harshitha,2024) model integrates multiple machine learning techniques such as SVM, SGD, KNN, Naive Bayes, Decision Trees, ANN, Ensemble (KNN & Logistic), and Hybrid models to predict crop growth. The process starts by importing necessary libraries and loading the dataset, followed by cleaning and handling null values. The data is then split into training and test sets. Various machine learning algorithms are applied to the training set, and predictions are made for the test dataset. The model's performance is evaluated using accuracy and confusion matrix metrics, ensuring reliable predictions for optimized crop growth and management. The model may struggle with overfitting, data quality

issues, computational complexity, and limited interpretability for practical decision-making.

[2] The paper by (Biplob Dey,2024) The dataset from the Indian Chamber of Food and Agriculture contains 2100 data points on 11 agricultural and 10 horticultural crops, including data on NPK fertilizer usage, soil pH, and climatic factors. This comprehensive dataset is divided into three models: Agricultural Crops (AC), Horticultural Crops (HC), and Mixed Models, providing valuable insights for crop recommendations. By analyzing these factors, the dataset helps tailor fertilizer usage and crop choices to specific geographical regions with similar environmental conditions. This data-driven approach enhances the precision of crop growth predictions, supporting efficient and sustainable farming practices across diverse agricultural landscapes. The dataset may have limited regional diversity, outdated information, missing data, and lacks real-time climatic changes, affecting accuracy.

[3] Likewise, in this study by (O. Rama devi, 2024) This research utilizes machine learning, specifically the Random Forest algorithm, to predict fertilizers that optimize crop yield and profitability in Indian agriculture. Using datasets from Kaggle, the model incorporates key factors such as environmental conditions, soil characteristics, and plant needs. By analyzing these variables, the model predicts the ideal fertilizer for maximizing crop growth and economic returns. Compared to traditional methods like linear regression and KNN, Random Forest demonstrates superior accuracy in addressing challenges related to fertilizer prediction. This approach offers valuable insights for improving agricultural outcomes and promoting sustainable farming practices across diverse regions in India. The model may struggle with overfitting, high computational requirements, limited interpretability, and dependency on accurate, high-quality input data.

[4] In this study by (Naga Vara prasad mella and Venkata Murali, 2022) The trained dataset compares input values such as nitrogen, phosphorus, potassium, pH, rainfall, humidity, and temperature with an existing dataset. By analyzing these factors, the model identifies the most suitable seed or crop for cultivation in a specific location. This comparison helps determine the optimal conditions for crop growth, ensuring maximum yield and efficient resource utilization. The model takes into account the environmental variables that influence crop performance, providing valuable recommendations for farmers. By tailoring crop suggestions to local conditions, it supports sustainable farming practices, reduces input waste, and enhances overall agricultural productivity. The model may struggle with data inaccuracies, regional variability, limited adaptability to changing climate conditions, and lack of real-time data.

[5] This paper (S.P Raja, Zoran StamenKovic, Barbara Sawicka 2022) ZigBee technology plays a vital role in precision farming by enabling IoT-based smart field management to improve agricultural productivity. It allows for continuous monitoring of environmental factors such as temperature, soil quality, pH, and humidity, providing real-time data for decision-making. By integrating sensors and automation, ZigBee helps optimize crop yields through precise control of fertilizer application and water levels, ensuring resources are used efficiently. This reduces waste, minimizes labor costs, and enhances overall farm management. The system improves efficiency, supports sustainable farming practices, and allows farmers to make data-driven decisions for better crop performance and resource management ZigBee technology may have limited range, potential signal interference, high initial setup costs, and reliance on continuous power sources.

[6] This study by (Abdelraouf M Ali, 2022) The methodology employs remote sensing techniques using satellites, drones, and ground sensors to monitor Earth’s resources. By analyzing the electromagnetic spectrum, these technologies assess interactions with various features of the Earth’s surface. Remote sensing images capture critical data on land use, crop health, soil conditions, and environmental changes. This approach provides timely, accurate, and cost-effective information for agricultural applications, such as monitoring crop production, detecting diseases, and optimizing resource use. Remote sensing also supports environmental monitoring, helping to track changes in ecosystems and land cover. This technology enables data-driven decisions for sustainable farming and resource management. Remote sensing may face issues with data accuracy, high initial costs, weather dependency, and limited resolution in certain applications.

[7] In this investigation (Nishu Bali, 2021), The methodology uses machine learning models like

ANNs and deep learning to analyze factors affecting crop yield, such as climatic conditions and soil characteristics. Data from various sources are processed for accurate predictions, optimizing farming practices and resource utilization.

[8] The objective of this paper (kalaiarasal sonai Muthu Anbananthen,2021) The agricultural sector faces challenges from population growth, climate change, and a gap in technological knowledge in rural areas. Climate change, particularly rising temperatures, affects crop yields and pest populations. To ensure food security and sustainable agriculture by 2030, crop yield estimation becomes crucial. This study aims to enhance crop productivity using advanced machine learning algorithms, such as stacked generalization, gradient boosting, random forest, and LASSO regression. The goal is to develop a web application that estimates crop yield based on input factors, helping farmers make informed decisions. The article includes a literature review, methodology, results, and future recommendations. The approach may suffer from data accuracy issues, overfitting, limited adaptability to real-time conditions, and reliance on accurate input data.

[9] This paper (S. S Manoj, G. David,2021) The Fertilizer Prediction System utilizes a cleaned dataset consisting of temperature, humidity, NPK values, crop type, and soil type. This data is used to train various machine learning models, including Random Forest and Decision Tree. The models are evaluated based on metrics such as precision, recall, and F-score to determine the most accurate one. Once the best-performing model is identified, it is used to predict the most suitable fertilizer based on the given environmental and soil conditions. This system helps optimize fertilizer application, improving crop yield and resource efficiency while minimizing waste and environmental impact. The system may struggle with overfitting, limited data diversity, inaccuracies in predictions, and dependence on accurate, high-quality input data.

[10] Following this, (Mamunur Rashid,2021) This article provides an extensive review of machine learning algorithms for crop yield prediction, focusing on palm oil yield. It highlights the importance of early crop yield estimation for financial evaluation, import-export policies, and improving farmers' incomes. The review covers the current status of palm oil yield, widely used features, and prediction algorithms. It critically evaluates machine learning applications in crop yield prediction, particularly in the palm oil industry, and discusses challenges, advantages, and potential solutions. The study also explores future perspectives, including remote sensing, plant growth, disease recognition, and optimized algorithms for efficient palm oil yield prediction. The approach may face challenges with data quality, algorithm complexity, computational demands, limited real-world applicability, and overfitting issues.

[11] The paper (Mariammal Ganesan 2021) This work proposes a novel feature selection (FS) approach, Modified Recursive Feature Elimination (MRFE), for crop cultivation prediction. It leverages machine learning (ML) to select key features like soil, rainfall, temperature, and fertilizer use, which vary across regions. The MRFE technique ranks and selects the most relevant features for accurate crop prediction. Experimental results show that MRFE, combined with bagging techniques, provides highly accurate crop predictions, outperforming other FS methods. The performance is evaluated using metrics such as accuracy, precision, recall, F1 score, and mean absolute error, achieving a high accuracy rate of 95%. The MRFE approach may struggle with data imbalance, computational complexity, overfitting, limited adaptability to dynamic environmental changes, and dependency on high-quality, comprehensive datasets.

[12] Likewise, (Rahul katarya,2020) This paper explores various machine learning techniques for rapid crop yield prediction, focusing on precision agriculture. It discusses the use of different computing methods, including machine learning algorithms and big data analysis, to improve accuracy in crop management. The paper highlights the implementation of a crop recommender system using models like K-Nearest Neighbors (KNN), ensemble-based models, and neural networks. These methods aim to provide more accurate predictions for crop selection and yield forecasting, helping farmers make informed decisions. By integrating advanced machine learning approaches, the study contributes to optimizing agricultural practices for better productivity and sustainability.

[13] The paper(Elda cina, Ersin Elbsasi, 2023 This study applies various machine learning algorithms, including Naïve Bayes, Random Forest, and Multilayer Neural Networks, for crop analysis and

prediction. The methodology involves several key steps: Data Collection from IoT devices to gather crucial agricultural information, Data Modeling by categorizing crops into four groups based on multiple factors, and Model Evaluation and Interpretation to optimize feature selection and accuracy. Data preprocessing, such as cleaning and transformation, ensures high-quality input for machine learning models. The models are tested and evaluated based on label modifications, helping refine prediction accuracy and crop classification techniques for better agricultural decision-making. The approach may suffer from data quality issues, overfitting, computational complexity, reliance on accurate feature selection, and scalability challenges.

3 PROPOSED SYSTEM

The proposed system presents an agricultural support system combining Fertilizer and Crop Recommendation Systems powered by machine learning. It provides tailored recommendations based on soil, climate, and historical data, helping farmers optimize fertilizer use and crop selection. The system also offers location-based retailer connections and estimates production costs, promoting sustainable farming.

3.1 Implementation

The implementation of the Fertilizer and Crop Recommendation System begins with defining the problem and understanding the goals of the project, which include providing optimal fertilizer and crop recommendations based on user inputs. Relevant datasets, such as soil properties, weather conditions, crop details, fertilizer information, and cost data, are collected and preprocessed to handle missing values, outliers, and inconsistencies. Feature engineering and normalization are performed to prepare the data for machine learning models. Exploratory Data Analysis (EDA) helps uncover patterns and relationships in the data. Machine learning models are then built and trained to predict the best fertilizers and crops based on input features like soil type, location, and climate. The system also integrates a location-based database to identify nearby fertilizer suppliers and calculates the total cost for cultivating recommended crops. A user-friendly interface is developed to allow seamless input and display predictions, ensuring the solution is practical and accessible for farmers.

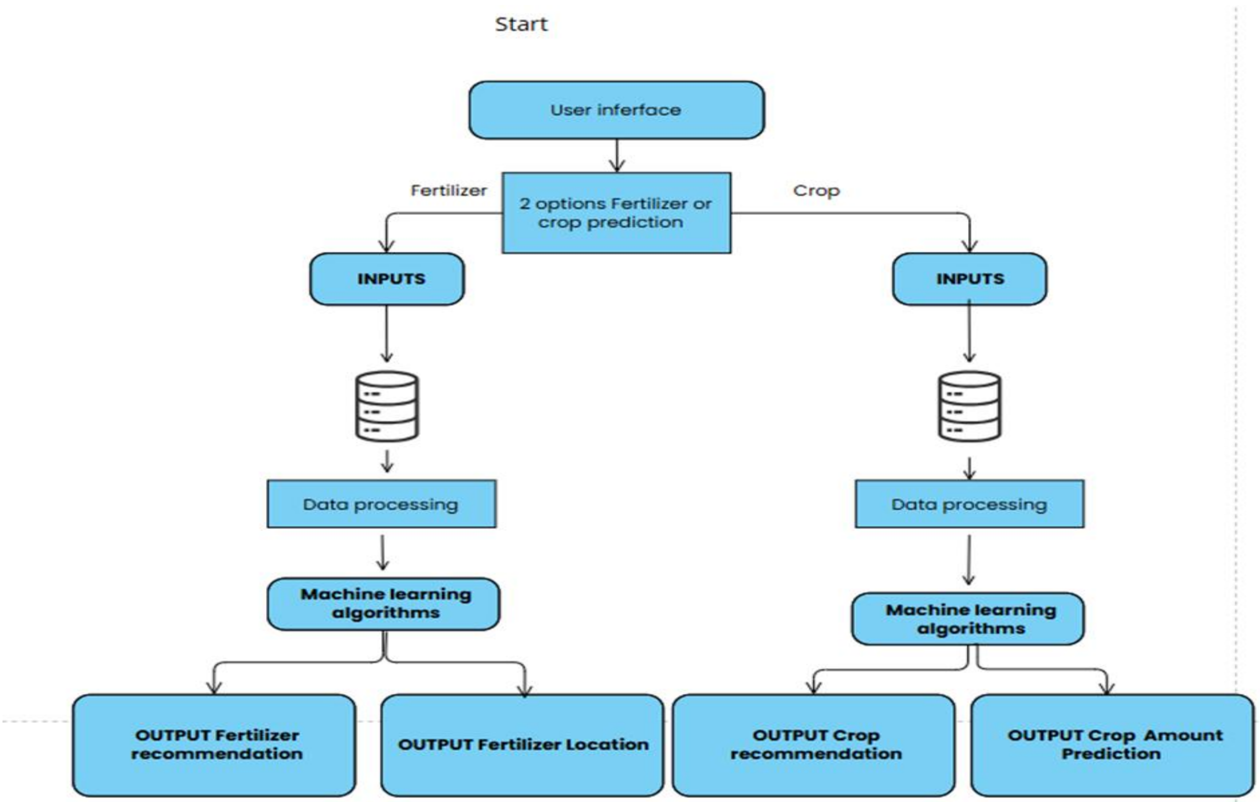

Fig. 1. Activity Diagram

3.2 Crop module

Collects inputs details like soil type, climate, and location, the system processes the data using machine learning algorithms to predict the most suitable crop for the area. It considers factors like yield potential, soil compatibility, and environmental conditions. Additionally, the system calculates the total cost of cultivation for the recommended crop, including expenses for seeds, fertilizers, and other inputs. This provides farmers with actionable insights into crop selection and financial planning, supporting profitable and efficient farming practices with a user-friendly interface for easy accessibility.

3.3 Fertilizer module

Collects inputs data such as soil type, crop, and location, the system processes this information using machine learning algorithms. It predicts the best fertilizer suited for the crop and soil, considering nutrient requirements. The system also checks the availability of the recommended fertilizer in nearby locations using a location-based database. This ensures that farmers receive both an optimal fertilizer recommendation and practical information on where to procure it, simplifying decision-making and supporting sustainable farming practices. The interface is designed for ease of use, ensuring accessibility for all users.

4 CONCLUSION

The conclusion of the Fertilizer and Crop Recommendation System emphasizes its role as a transformative tool for modern agriculture. By harnessing the power of machine learning, the system delivers precise recommendations for fertilizers and crops tailored to soil properties, climate, and location, promoting sustainability and profitability. It simplifies decision-making by providing the availability of fertilizers in nearby locations and estimating the total cost of cultivation for recommended crops. This ensures optimal resource usage, improved yields, and reduced wastage. The system's user-friendly interface makes it accessible to farmers of all scales. Future enhancements, such as a mobile application and advanced features like crop disease management, hold the potential to extend its reach and impact, further revolutionizing agricultural practices.

REFERENCES

[1] Harshitha, Attaluri, Beebi Naseeba, Narendra Kumar Rao, Abbaraju Sai Sathwik, and Nagendra Panini Challa. 2024. “Crop Growth Prediction Using Ensemble KNN-LR Model.” EAI Endorsed Transactions on Internet of Things 10 (January). https://doi.org/10.4108/eetiot.4814.

[2] Dey, Biplob, Jannatul Ferdous, and Romel Ahmed. 2024. “Machine Learning Based Recommendation of Agricultural and Horticultural Crop Farming in India under the Regime of NPK, Soil pH and Three Climatic Variables.” *Heliyon* 10 (3): e25112.

[3] Rama Devi, O., P. Naga Lakshmi, S. Naga Babu, K. Vinaya Sree Bai, Sowmya, and Akansha. 2023. “Fertilizer Forecasting Using Machine Learning.” In *2023 International Conference on Inventive Computation Technologies (ICICT)*, 24–27. IEEE.

[4] “Website.” n.d.-a.

———. n.d.-b. Author(s). (2022). Crop Yield Prediction and Fertilizer Recommendation using Voting Based Ensemble Classifier. UGC CARE Journal, 13(8), 43-41. https://doi.org/10.15433/JES.2022.V13I08.43P.41.

[5] .Raja, S. P., Barbara Sawicka, Zoran Stamenkovic, and G. Mariammal. 2022. “Crop Prediction Based on Characteristics of the Agricultural Environment Using Various Feature Selection Techniques and Classifiers.” IEEE Access: Practical Innovations, Open Solutions 10:23625–41

[6] Ali, Abdelraouf M., Mohamed Abouelghar, A. A. Belal, Nasser Saleh, Mona Yones, Adel I. Selim, Mohamed E. S. Amin, et al. 2022. “Crop Yield Prediction Using Multi Sensors Remote Sensing (review Article).” *Egyptian Journal of Remote Sensing and Space Sciences* 25 (3): 711–16

[7] Bali, Nishu, and Anshu Singla. 2021. “Deep Learning Based Wheat Crop Yield Prediction Model in Punjab Region of North India.” *Applied Artificial Intelligence: AAI* 35 (15): 1304–28.

[8] Anbananthen, Kalaiarasi Sonai Muthu, Sridevi Subbiah, Deisy Chelliah, Prithika Sivakumar, Varsha Somasundaram, Kethaarini Harshana Velshankar, and M. K. A. Ahamed Khan. 2021. "An Intelligent Decision Support System for Crop Yield Prediction Using Hybrid Machine Learning Algorithms." *F1000Research* 10 (November):1143.

[9] "[No Title]." n.d. Accessed November 20, 2024. https://ece.anits.edu.in/Project%20Reports%202020-21%20NAAC/Sec-A/A-17.pdf.

[10] Rashid, Mamunur, Bifta Sama Bari, Yusri Yusup, Mohamad Anuar Kamaruddin, and Nuzhat Khan. 2021. "A Comprehensive Review of Crop Yield Prediction Using Machine Learning Approaches with Special Emphasis on Palm Oil Yield Prediction." *IEEE Access: Practical Innovations, Open Solutions* 9:63406–39.

[11] Mariammal, G., A. Suruliandi, S. P. Raja, and E. Poongothai. 2021. "Prediction of Land Suitability for Crop Cultivation Based on Soil and Environmental Characteristics Using Modified Recursive Feature Elimination Technique with Various Classifiers." *IEEE Transactions on Computational Social Systems* 8 (5): 1132–42.

[12] Katarya, Rahul, Ashutosh Raturi, Abhinav Mehndiratta, and Abhinav Thapper. 2020. "Impact of Machine Learning Techniques in Precision Agriculture." In *2020 3rd International Conference on Emerging Technologies in Computer Engineering: Machine Learning and Internet of Things (ICETCE)*. IEEE. https://doi.org/10.1109/icetce48199.2020.9091741.Elbasi, Ersin, Chamseddine Zaki, Ahmet E. Topcu, Wiem Abdelbaki, Aymen I. Zreikat, Elda Cina, Ahmed Shdefat, and Louai Saker. 2023. "Crop Prediction Model Using Machine Learning Algorithms." *Applied Sciences (Basel, Switzerland)* 13 (16): 9288.