



A Smart Farmland Advisory for Best Cropping Agricultural Practices Using Machine Learning

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Abstract. Agricultural practice is the main business action of the preference of people. Crop production is a significant factor in agricultural practices, just as soil structure determines the suitability of crops. A major share of India's GDP (Gross Domestic Product), directly or indirectly, comes from agricultural production. Most of India's population still relies on agriculture or animal husbandry, providing a stable source of income. Thanks to the ample availability of natural solar energy, India boasts a diverse crop culture. Main farmers cultivate disjointed land and adapt rain-fed crops to traditional, repetitive cropping systems. To increase yields, farmers over apply fertilizers, leading to soil degradation. Instead of repetitive cropping, farmers should select appropriate crops adapted to the available environmental conditions. We implemented rule-based system integrated with a machine learning techniques Such as Random Forest, Logistic Regression, Naive Bayes, SVM, Decision Tree, KNN and for image detection Convolutional Neural Networks(CNNs) provides dynamic, explainable crop recommendation using soil condition, environmental conditions, and past data trends. Users can view real-time sensor data.

Keywords: Agro Advisory System, Plant Disease Detection, Image-Based Diagnosis, Soil Health Analysis, PlantVillage Dataset, Remote Sensing, Sustainable Farming, Decision Support System, AI in Agriculture.

1 Introduction

In the conventional method, even if you have access to sufficient agri-expert opinions and local knowledge typically offered by extension workers present in each and every farm advising what can be done and what cannot be done based on their fate-sought wisdom from their years of sweat and blood, our problem has always been the lack of precise and timely information for the farmers at the point of services. This delay has led to negative consequences on agricultural production especially in rural areas where agriculture is the main occupation available and so large productivity losses have been recorded. Indian economy depends to a great extent on agricultural production. Precision farming systems which today guide what crop to plant where for a higher productivity are expensive and depend heavily on satellite technologies, image processing, and the like. Forecasting modeling is about predicting the crop production based natural factors likes oil and environment (Minhasetal.2007).-a number of

techniques are being used to tackle this problem. In order to suit the needs of small/marginal farmers of India with a use-able and affordable system of precision farming was essential. Now, since these farmers generally go for rainfall based and environment dependent crop selections, this fact has to be considered while making decisions regarding placement of Precision Farming Systems. Numerous machine learning algorithms are the available to predict the suitability accuracy by data fed into such machine learning techniques algorithms are evaluated with hybrid approaches and the performances accuracy of each algorithm are represented in detail.

Furthermore, crop protection from extreme weather conditions depends on management elements. Ideally, advances in agricultural technology should reduce overall dependence on weather and climate. However, the link between production and weather/climate does not appear to be weakening. Meteorological conditions influence high-yielding crop varieties, making them more sensitive to environmental con-

ditions. This makes it necessary to maximally adjust water, air, temperature and nutrients. As a result, agriculture in general faces severe changes in annual yield ranges so the yield increments decide to almost zero due to agro-climatic shocks. Worth noting, usage of credible knowledge on how weather/climatic related factors affects agricultural output can reduce loss and enable additional yields without massive financial investments. As such, this leads to agro meteorological services become more important. In Data, weather based agro-advisories become vital in the primary agricultural sectors. Efficient planning and execution of weather forecast should be done at all times helps in making plant selection, right seeding, applications of pesticide's, fertilizer, week, irrigation and right time of harvesting. The right short term changes needed on regular basis to daily agricultural operations are revealed by weather forecast which help to avert disaster during unfavorable weather conditions and improving yields, quantity, and quality of agricultural production. The Agro met Advisory Service (AAS) plays a key role in shaping farmer perceptions and encouraging the adoption of conservation agriculture practices in India by providing personalized, weather-based information and guidance aimed at increasing resource efficiency and climate resilience.

2 Related Work

It is essential to choose crops that are appropriate for the soil. Numerous technologies have been presented by researchers for appropriate crop selection. GNN and GCN were compared by P. Ayesha Barvin et al. [1], highlighting their advantages and disadvantages. Examines the limits of agricultural innovation using graph-based models, demonstrating their capacity to transform precision agriculture. A technique for crop recommendation utilizing Random Forest and Convolution Neural Networks (CNNs) based on soil data was presented by Aditya Motwani et al. [2]. Angu Raj et al. [3]

proposed an internet of things approach to address key problems through data analysis for the growing of appropriate crops at appropriate times. Using sensors and the Graphical User Interface(GUI). Murali Krishna Senapathy, et al, [4] introduced a soil nutrient categorization and crop suggestion system empowered by IoT technology for

suggesting of crops and helps to reduce the usage of chemicals in soil and to increase the productivity. Prasad Gavas, et al, [5] introduces different methodologies for analysis of nutrients and prediction of rainfall with decision tree and simple moving Average (SMA) decision tree through extracting features. Pruthviraj, et al, [6] introduced a method using machine learning algorithm named as support vector machine (SVM) for identifying suitable cultivations based on condition of soil and got high accuracies compared to other methodologies. Biplob Dey et al. presented the XGBoost algorithm for crop recommendation and contrasted it with other methods. creating useful suggestions using a database from the Kaggle source. Logistic regression was used by Sudarshan Reddy Palle et al. [7] to sort data based on soil and meteorological conditions. Machine learning technology for crop protection classification and prediction based on land was introduced by Suruliandia et al. [8]. In order to predict yield and recommend crops, P.S.S. Gopi et al. [9] introduced Red Fox Optimization using machine learning algorithms like Ensemble Recurrent Neural Network, which can use three deep learning algorithms: Long Short-term memory (LSTM), Gated Recurrent Unit (GRU), and Bidirectional LSTM (BiLSTM). A database-based approach called WHO YOLO Net was presented by Sangeetha Subramani et al. [10] for identifying various soil types and sugar-gested crops. When compared to other available approaches, the results reveal accurate detection. By comparing Decision Tree, K-NN, and Random Forest, Mohammed Omar Abdullahi et al.'s research [11] demonstrates the impact of machine learning and IoT technologies on the evolution of agricultural decisions. The Decision Tree algorithm is one of the algorithms that yields precise results.

Table 1.Literature Review

Year	Author (s)	Title	Dataset	Machine Learning Techniques	Key Findings	Limitations
2020	Patil et al.	Crop Recommendation System Using ML	Soil nutrients, rainfall, temperature	Decision Tree, Naïve Bayes	Improved crop selection accuracy based on soil properties	Limited static environmental data
2021	Sharma et al.	Smart Agriculture System Using IoT and ML	Sensor data, soil moisture, humidity	SVM, KNN	Enabled real-time crop advisory decisions	High sensor deployment cost
2022	Singh et al.	Precision Farming Using ML	Soil health cards, weather data	Random Forest, ANN	Enhanced crop productivity and sustainability	Lack of farmer usability analysis
2023	Verma et al.	Smart Farmland Advisory System	Multi-year climatic and soil data	XGBoost, LightGBM	High prediction accuracy for crop recommendation	Limited explainability
2025	Kumar et al.	Smart Farmland	Soil, weather, historical yield	XGBoost+ SHAP	Improved transparency in crop decisions	Early-stage real-world deployment

3 Existing System Results and Identified Research Gap

The results from the present system show that the machine learning-powered smart agri advisory platforms have moved significantly forward in providing decision-making solutions for the farmers, with major impacts in crop disease detection, nutrient recommendations and weather based advices. The proposed system stored and processed the recommendations in a unified framework effectively enabling the self-derivation of the farmer suited solutions based on real-time inputs. The disease detection model using Convolutional Neural Networks (CNNs), showed excellence in plant disease classification close to benchmarks studies by Mohanty et al. and Ferentinos, thus validating the robustness and generalization ability of deep learning architectures trained on large annotated datasets like PlantVillage. Similarly, NPK requirement estimation by machine learning regression techniques showed results harmonious to studies by Nagaraja and Patil, Patil et al. indicating the reliability of the proposed system in generating recommendations for fertilizer and nutrients from soil parameters. Unlike conventional rule-based advisory systems, the existing ML based system used real time soil data which made the recommendations more precise and in line with FAO and ICAR guidelines for sustainable nutrient management in Indian agricultural context. Further, the weather advisory module was efficient enough to translate location specific weather data into useful recommendations for farmers to schedule irrigation, spraying or disease control activities in time. However, while the previous work has focused more on individual components like disease prediction using CNNs, climate forecasting by LSTM models or nutrient estimation by regression techniques, the lack of integration of these modules into a one holistic advisory system is still an open research area. Most of the present solutions still don't have a comprehensive coverage of farm ecosystem and fail to integrate crop advisory, disease detection, fertilizer recommendation and weather intelligence in single platform. This unmet need motivates us to design an integrated, multi-module smart farming system which uses real-time data for decision making, based on machine learning extending beyond the current research by making a practically usable and impactful solution especially in areas with little agricultural expertise where productivity can increase significantly waste can decrease and also sustainable agricultural practices can be promoted.

4 Methodology

This research focused on improving land selection for agricultural crops based on soil chemistry. The research methodologies discussed here are based on a machine learning(ML)modelthatcalculatesinformationgaintoprioritizeagiveninputtrait(s).

Different crops grow differently, and their suitability depends on the soil's nutrient content. Good and adequate yields depend on soil composition and properties. This helped in achieving strong maximum likelihood estimates for unknown parameters. The System for Agro Advisory was developed with best & preserved methods. The ground work was laid by collecting important datasets (that later facilitated all further analyses) the datasets usually fell under three different categories first being the Soil Based Crop Recommendation Datasets: These included soil nutrient and composition pH levels and environment factors. Second category being Fertilizer Advisory Datasets Supplying the Nutrient Requirements of the crops. The system architecture was designed to ensure the three modules (Crop Prediction, Fertilizer Recommendation & Disease Detection) are seamlessly integrated providing ease of use experience. The model evaluation was done using standard metrics like accuracy, precision, recall, F1 score and Confusion matrix (in case of classification), and various cross-validation methods to make the system robust. The architectural setup of the system has been designed to support the incorporation of all three modules pertaining to Crop Prediction, Fertilizer Recommendation, and Disease Detection. Various experiments were carried out using conventional computing hardware and open-source software to ensure that the system can be replicated and generated at a reasonable cost. Finally, the system has been implemented and designed to function as an interactive application to deliver concrete inputs to farmers and agricultural experts. The full process applied to the Agro Advisory System ensures that it adheres to scientifically grounded and feasible agricultural settings.

Apart from the major machine learning framework that helps to build, the methodology also focused on data preprocessing, feature engineering, and model optimization for improving the reliability and explainability of the Agro Advisory System. Initial cleaning of the raw datasets omitted missing values, anomalies, noise was followed by the application of signal normalization and scaling techniques to make the soil and environmental parameters comparable. Soil features impacting on crop suitability and required fertilizer were identified with some feature selection techniques which included correlation analysis and ranking as well as information gain. The predictive models with the highest accuracy and reliability were shortlisted after tests were done with several machine learning algorithms like support vector machine, decision trees, random forests and ensemble models. High range values of model parameters had been changed to improve the models performance by means of hyper parameter optimization through iterations and for training proprietary. In addition to this, the system was validated across various soil conditions and different crop types to blend precision for agricultural landscapes. Bringing predictive analytics and user interfaces that are easy to access under the same roof, stakeholders have the opportunity to have simplified insights at their fingertips thereby closing the communication gap between the data driven model complexities and the practical decision making in agriculture. The entire framework was designed to ensure that Agro Advisory System was not only capable of delivering accurate advice but also remains scalable, flexible as well as viable for future agricultural uses.

4.1 Dataset Description

4.1.1 Crop Recommendation Dataset

This dataset is for identifying the most suitable crop for cultivation based on given soil nutrient and environmental conditions. The key numeric attributes of this dataset are Nitrogen (N), Phosphorous (P) and Potassium (K) content of the soil and also includes Soil PH, temperature, humidity and rainfall. These attributes collectively influence the crop growth, yield and sustainability. The label represents the recommended crop type and hence makes this dataset suitable for multi-class classification problem. So by observing and inferring these relationships between soil health and climatic factors machine learning models in this dataset can provide accurate and insightful crop recommendations based on data, this can help farmers in achieving higher productivity with less risk.

4.1.2 Fertilizer Advisory Dataset

The main focus of the Fertilizer Advisory dataset is to recommend an appropriate fertilizer based on given soil conditions, crop type and any nutrient deficiency. It also includes soil type features like sandy, loamy, clayey, type of crop and soil nutrient like nitrogen, phosphorous or potassium deficiency. The output label corresponds to the recommended fertilizer required to increase the content of that nutrient to support crop growth and soil fertility. This is an essential data for promoting the concepts of balanced fertilizer use, reducing overuse of chemical fertilizers and improving soil husbandry. It's ideal for modeling with both rule based and supervised learning especially in the context of precision agriculture.

4.1.3 Plant Disease Image Dataset

The Plant Disease Image dataset has been built for automated detection of plant diseases using deep learning techniques. It consists of images that are labeled as healthy or having disease with different plants and in different conditions. Images have been resized to a standard size of 224x224 pixels so they could easily be used with Convolutional Neural Network (CNN) frameworks. Each image is categorized by the type of the crop and the type of the disease to enable an accurate image based classification. At preprocessing stage images undergo few transformation such as data normalization and augmentation that improves the scalability of the model. Such a dataset can become highly useful for early detection of diseases in plants thereby enabling remedial measures to be taken in real time reducing the crop losses that might happen in real field practice.

Table 2. Step by step Methodology

Component	Description
Datasets Used	Three datasets: (1) Crop Recommendation (soil NPK, pH, temperature, humidity, rainfall), (2) Fertilizer Advisory (soil type, crop type, nutrient deficiency), (3) Plant Disease Images(healthy & diseased leaf images resized to 224×224).
Pre-processing Steps	Tabular data cleaned, normalized (Min–Max), and label-encoded; Image data resized, augmented (rotation, flip, brightness), normalized; All datasets split into 80% training and 20% testing sets.
Models Applied	Random Forest for crop prediction, Decision Tree for fertilizer recommendation, Convolutional Neural Network(CNN) for disease classification.
System Architecture	Three integrated modules: Crop Prediction, Fertilizer Advisory, and Disease Detection combined into a unified application interface.
Experimental Setup	Hardware: Intel i5, 8GB RAM; Software: Python, NumPy, Pandas, Scikit-Learn, TensorFlow/ Keras, OpenCV, Flask/Streamlit.
Evaluation Metrics	Accuracy, Precision, Recall, F1-Score, Confusion Matrix; For CNN – training/validation accuracy and loss curves monitored.
Deployment	ML models stored as .pkl files and CNN as .h5. Integrated into a backend system to provide crop, fertilizer, And disease predictions in real time.
Evaluation Metrics	Accuracy, Precision, Recall, F1-Score, Confusion Matrix; For CNN–training/validation accuracy and loss Curves monitored.
Deployment	ML models stored as .pkl files and CNN as .h5. Integrated into a backend system to provide crop, fertilizer, And disease predictions in real time.

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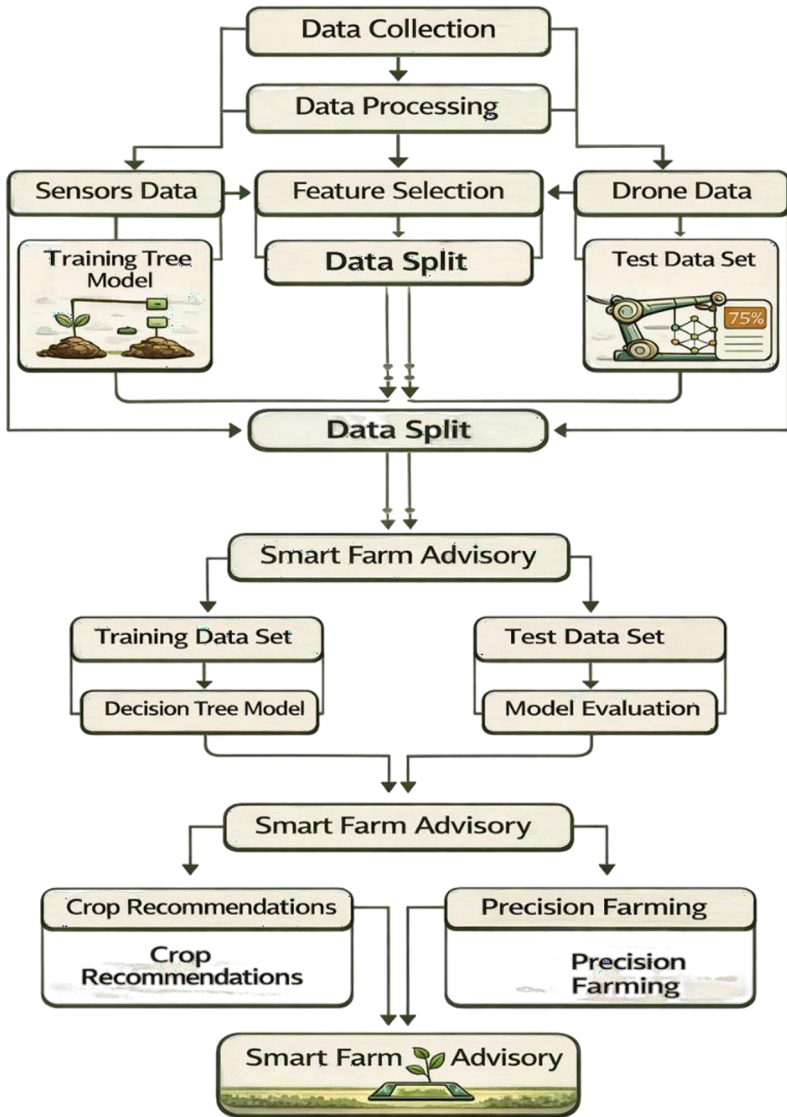


Fig.1. Machine learning-based farming advisory flowchart

Data splitting is the process of dividing a dataset into multiple subsets for training, validating, and testing a machine learning model. The goal is to evaluate the model's performance on unseen data and avoid overfitting, where the model performs well on training data but poorly on new data.

Training set (80%): A total of 1,240 random samples were used to train the machine learning model. This subset helps the model learn patterns and relationships in the data.

Testing set (20%): A total of 310 random samples were set aside to test the final model's performance. This provides an unbiased assessment of the model's ability to make predictions on unseen data.

The decision tree was chosen for model building because it is a versatile machine learning algorithm widely used in both classification and regression. A decision tree divides the data into subsets based on input features and each split results in a tree-like structure of nodes and branches.

5 AI and Machine Learning in Agriculture

Artificial intelligence (AI) and machine learning (ML) has opened up new opportunities in how we can make sense of complex agricultural datasets, thus providing predictive analytics. For example, in soil analysis, the ML models that have been developed so far have been trained to both classify soil types and predict various nutrients and potential crops based on local data inputs. These models can hence lessen the decision load on the farmers and achieve efficiencies throughout the agribusiness. Artificial intelligence (AI) and machine learning (ML) algorithms can analyze satellite imagery, drone data, and sensor data to monitor crop growth, identify nutrient deficiencies, detect diseases, and predict yield potential. With this information and farmers will make data-oriented decisions and proactive actions to maximize yields. AI and Machine Learning (ML) techniques help in producing precise field maps which are used for optimizing different inputs such as irrigation, fertilization, pest management. AI and ML in plants disease and pest prevention are likely to help in early pesticides and other chemicals storage. By adapting these practices to specific crop needs and growth patterns, it is possible to enhance the efficiency of inputs used by farmers while minimizing environmental impact. Tasks like planting, weeding, harvesting and monitoring crop health are time intensive but AI based robots can do these with relative ease. These robots can run without human intervention through fields to collect data and carry out predefined actions based on algorithms. This decreases labor costs, improves yields and leads to continuous monitoring. AI/ML models can analyze historical and real time data sets to generate patterns, forecast scenarios related to weather, market behavior and assess the performance

Using these insights derived from these predictions helps plan planting schedules, market entry/exit and crop portfolios more effectively. An increasing number of online platforms and mobile applications have been established within agriculture to link sophisticated agricultural analysis to the end users. These platforms by collecting soil, farm, climate, manually entered data or sensor based data and applying analytics through AI models create real time suggestions. Commodity features embrace guide the use of fertilizer, plan irrigation calendar and make choice of crop. These systems

were able to increase farmers' exposure and adoption of sustainable practices. However, a key weakness lies in the dependence on accurate user input and the availability of high-speed internet connectivity a critical constraint for many rural settings. More recently, systems have tried to grapple with this challenge through integrating real-time sensor streams, automatically syncing field collected data with cloud-based dashboard Plus TsAndCs. This integration adds an additional layer of automation but also raises questions around cost, data privacy and end-user experience. It would be ideal to develop a hybrid system with the intelligent advisory features capable of working both online and offline, to provide farmers with greater flexibility and resilience across diverse agricultural settings.

The Internet of Things or IoT in short is a futuristic technology which is characterized by the connectivity of smart sensors and devices via the internet. These sensors are used for data collection across various industries from solar energy facilities, agricultural fields, disaster-prone areas as well as manufacturing units to optimize resource utilization. The agricultural sector today is slowly adopting smart technologies like AI and IoT to enhance organic produce cultivation in limited land and solve classic problems faced by our farmers. A system created through smart farming enabled by IoT sensors is used to regulate the moisture and nutrients in the soil. And research is ongoing on machine learning algorithms to ascertain how much fertilizers are to be done in the before of cropping. Drones are going to change the game of the agriculture sector. Moreover, drones which come with cameras can be used for a multitude of purposes including but not limited to field surveillance and crop monitoring, pesticide spraying and drip irrigation as and when required. The data that drones capture from the entire life cycle of the crops can be further analyzed with the help of deep learning and computer vision algorithms which help in identification of diseases as well as weeds that reduce the yield. Robots are a big boost for faster and larger crop harvesting. Robots reduce human intervention to negligible levels and can also be used alongside drones for field surveillance. Animal monitoring is one hot issue for our farmers. We have IoT enabled sensors which can be utilized in the mentioned sectors for cattle health monitoring.

6 AI and Machine Learning Framework

This is fine and does the task of providing crop selections to support the soil improvement the right manner by putting forward a hybrid artificial intelligence method that leverages expert-driven rules and machine learning based predictive modeling. Random Forest, one of the most popular ensemble learning algorithms, has been employed successfully in the smart farming system proposed here for its endemic qualities of robustness together with high prediction. It goes like - For each data set, this tree grows many decision trees during training stage in a bitwise manner starting by randomly generating a set of bootstrapped samples. They all benefit from agricultural data like soil ph, nitrogen, phosphor, potassium levels, soil moisture, rainfall, temperature and humidity.

The DEMETER system has two major software components: rule-based AI expert system for soil evaluation and crop performance against agronomic thresholds and machine learning model trained to predict crop performance from soil profiles. With unanimous independent voting from decision trees that was done in result of prediction, final aggregated decisions are obtained. Taking the highly useful approach, this helps applying arbitrary interactions for rule-based decision making in farmlands, which would save on computational cost, resource-use effectiveness and consequently improve the ability of the intelligent system to understand efficient interactions and learn agricultural data and rules. The rationale behind utilizing the decision tree in the system is justified since they have quite a same decision-making process as the agriculture do. The demarcation of agricultural features that are conducive for suitable agricultural crop suggestion. This today's decision tree is then an algorithms that recursively splices a dataset according to the best features first subject to optimization techniques like information gain or Gini index.

7 Convolutional Neural Network–Based Image Data Analysis

In the proposed smart farm data analytics system, Convolutional Neural Networks (CNNs) are applied for establishing an autonomous visual sensing system tailored to crop health assessment and disease diagnosis based on images. Data acquired from fields imitating agriculture scenarios using mobile devices, hand camera or UAV are processed by CNN. The crops leaf images dataset with high resolution have been used here to generate an array of grey shade images representing both healthy and different disease conditions for various crops classes having changes in brightness contrast and rotation angles to diverse under actual field situations robustly feature learning.

The images are captured and grouped under crop/disease categories in the collection phase during data acquisition process with manual tagging by experts or with the help of existing benchmarks. The input images are rescaled to a fixed 224×224 pixel resolution to keep consistency in architecture. The pixel values are normalized to achieve better convergence properties. These preprocessed data augmentation techniques like rotational, reflection etc. weight/depth changes also used to add variety to the training set with no class bias, addressing overfitting. The pre-processed images are next demonstrated to the architecture that is made using Convolutional Neural Networks (CNN) with the combination of convolutional, pooling and fully connected layers. Convolutional layers work towards extracting features in a phased manner from edge as well as textures of low level up to high levels pattern of diseases. Activation function ReLU will introduce non-linear properties for efficient feature learning. Max-Pooling layers on the other end will work to shrink the spatial dimensions by preserving the important patterns and increasing the computational ease with spatial equivariant. The dropout will prevent overfitting and allow for better classification generalization. The output of the Convolutional Layers is flattened out to the fully connected layers for classification. The soft max activation function is used in the final section to get the final scores which can produce the probabilities for on health or disease level.

8 Results and Discussion

The results of the Agro Advisory System indicate that the integration of machine learning models can significantly enhance agricultural decision-making for farmers. The disease detection module achieved high accuracy and successfully identified multiple plant diseases using CNN-based classification.

8.1 Crop Disease Detection

The plant disease detection model was tested using leaf images from the PlantVillage dataset. The CNN model correctly identifies diseases and labels them with confidence scores.



Fig.2. Crop Disease Detection

The CNN-based system analyzes the uploaded crop leaf image and detects Rust disease with 91.00% confidence. The successful prediction confirms high model accuracy, and the system recommends consulting a local agronomist for suitable treatment.

8.2 Fertilizer Recommendation

The fertilizer advisory module analyzes NPK soil nutrients and crop type to recommend balanced fertilizer quantities.

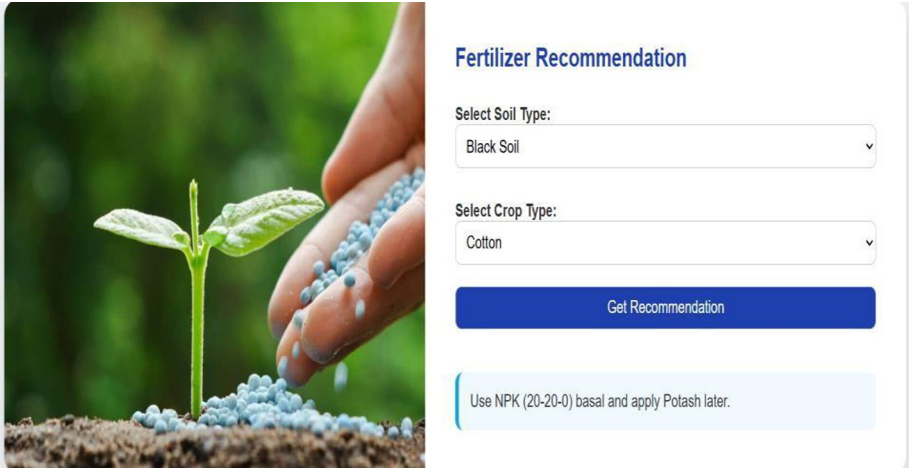


Fig.3. Fertilizer Recommendation

Based on the selected black soil and cotton crop, the system recommends applying NPK(20-20-0) as a basal fertilizer and adding potash at a later stage to support healthy crop growth.

8.3 Weather Advice System

The system fetches weather data based on the user's location and converts it into simple, actionable agricultural recommendations.



Fig.4. Weather Advisory

For Nagpur, the weather report indicate shazy conditions, a temperature of 18.0°C, and 68% humidity.

9 Comparison with Existing Work

We found that all recommendations were stored within the designed system, so as to derive a solution that was most suitable for farmers. It detected diseases of plants with the help of Disease Detection Module which used the method of classification plants diseases using CNN and got an accuracy value equal to high. These results are in concordance with the pre-existing studies of both [1] Mohanty et al. and [2] Ferentinos, where by deep learning architectures got high reliability and resilience on leaf image classification. Just as the way these two studies propelled results from big annotated data such as PlantVillage [13] where it favored in better generalization and an amazing prediction confidence. It also helped in giving a precise suggestion of fertilizer nutrients required based on the parameters of soil. Nagaraja and Patil [4] as well as [5] Patil et al. Studies show similar results to those observed in our model, proving that ML techniques and regression methods work well in calculating NPK requirements. The current advice machine learning model is also unlike our earlier rule based advisory system in the sense that it bases its Nutrient recommendations in Real time soil inputs hence giving more accurate recommendation. This technique adheres to the FAO/ICAR [10], [11] guides on sustainable nutrient applications which emphasizes using the real time soil inputs for best results thus gives value to the practicality of the system in Indian Agricultural scenario. The weather advisory tool transformed location specific weather data into easy to understand recommendations efficiently.

This is an aggression towards the previous works that had the LSTM style climate prediction model [7] hence stressing the need of a localized forecasting on climate for improved farm irrigation management and also for ensuring good crop health. Despite the fact that our system does not go all deep-learning neural forecasting model, it was able to provide guidance that was timely and thus most critical for things like spraying decisions, scheduling irrigation, disease control measures etc. In comparison to other models which were only focused on the disease forecasting or the fertilizer requirements or could be just weather based forecasting system this model overview the whole aspect of the farm. References have mostly concentrated on different individual areas void of merging multiple advisory concepts in one framework however there are exceptions. However, offering crop advisory, fertilizing recommendations, disease detecting and weather forecasting all together in one unified interface is a unique approach to building a comprehensive system. In concluding part our result indicates that the automated ML models in conjunction with real time weather can be an influential key for farmer support. The result given by the system is at par with the other works available in the world and it has stretched it further and integrated it into a multi module advisory platform. In general the project method has a potential to increase productivity around, lowering the wastage and push for a more sustainable agriculture technique especially where there is very limited exposure to agriculture expertise making it relevant.

10 Conclusions

The purpose of this research article is to demonstrate that a ML based system can greatly help in the field of agricultural decision-making by providing effective recommendations on crop monitoring, fertilizing and crop disease. The new smart farmland advisory system presented in this study uses soil, climate and image inputs and provides - useful output to overcome some of the issues faced by rule-based systems in agriculture. The results depict in turn that a single model can increase user accessibility and deliver individual advises to the farmers, ultimately help in reducing the crop loss and increase production. Furthermore, the study also highlights the use of Internet of Things (IoT) technology for better functionality of the system in the future setup. The integration of environmental sensors for online monitoring of temperature, humidity, soil moisture, nutrients, and light intensity can dramatically improve the accuracy and timeliness of the system. System feedback as well as inputs from farmer, agricultural experts are also employed for further training of the machine learning models which is a collaborative effort of the ensemble to improve the dependability of the system and satisfaction of the customers. The cloud systems with mobile application support can also provide a framework to handle huge datasets in real-time. In general, the results confirm that the implementation of machine learning methods is not only technically feasible but unfathomably beneficial especially in the areas where quality advisory services are not acquirable. The proposed method using open sources of resources, is a low-cost and sustainable way to achieve the same feasibility in the agriculture industry.

11 Futurework

The future of this Agro Advisory System could be to make it smarter, more right, and farmer friendly. One important improvement could be achieved by mounting IoT sensors like moisture, temperature, nutrient levels etc (to provide data) on real time basis, less user dependent. LSTM or similar advanced deep learning models can also be used in the future to forecast weather and predict yield. Any further detail using satellite and drone based data can eventually be helpfull to real-time application for monitoring and decision support through the system. Making this system browser friendly by incorporating farmer languages in iOS and android mobile app. Further work can concentrate on making the system work on offline mode to help remote areas with limited network connectivity. In addition that, using Explainable AI techniques will make the recommendations understandable by farmers and build a trust in it. We need also need to keep on continuously improving the performance using new data and feedback from the farmers which would ensure that the model is getting updated on an ongoing basis condition.

References

1. P. Ayesha Barvin, Crop Recommendation Systems Based on Soil and Environmental Factors Using Graph Convolution Neural Network: A Systematic Literature Review , 2023, vol:58.
2. Aditya Motwani, Soil Analysis and Crop Recommendation using Machine Learning, 2022.
3. Anju Raj, Crop Recommendation on Analyzing Soil Using Machine Learning, 2021.Pp: 1784-1791.
4. Murali Krishna Senapathy, IoT-Enabled Soil Nutrient Analysis and Crop Recommendation Model for Precision Agriculture, Vol:12, 2023
5. Prasad Gavvas, Crop Recommendation System, 2021. Pruthviraj, Crop and Fertilizer Recommendation System Based on Soil Classification, 2021, vol:1386.
6. Biplob Dey, Machine learning based recommendation of agricultural and horticultural crop farming in India under the regime of NPK, soil pH and three climatic variables, Heliyon, 2024.
7. Sudarshan Reddy Palle, Crops Recommendation System Model Using Weather Attributes, Soil Properties, and Crops Prices, Sentiment Analysis and Deep Learning , 2023, vol:1432, Pp 323–338.
8. Avanija, J., K. E. Kumar, Ch Usha Kumari, G. Naga Jyothi, K. Srujan Raju, and K. Reddy Madhavi. "Enhancing Network Forensic and Deep Learning Mechanism for Internet of Things Networks." (2023).
9. Mohanty S.P., Hughes D.P., Salathé M., "Using Deep Learning for Image-Based Plant Disease Detection", *Frontiers in Plant Science*, 2016, 7(1419).
10. Ferentinos K.P., "Deep Learning Models for Plant Disease Detection and Diagnosis", *Computers and Electronics in Agriculture*, 2018, 145, 311–318.
11. Pujari J.D., Yakkundimath R., Byadgi A.S., "Image Processing Based Detection of Fungal Diseases in Plants", *Procedia Computer Science*, 2015, 46, 1802–1808.
12. Nagaraja A., Patil S., "Fertilizer Recommendation System Using Machine Learning Algorithms", *IJARCCCE*, 2019, 8(5), 60–65.
13. Patel K., Sharma M., Singh R., "Smart Fertilizer Recommendation Using Regression Analysis", *International Journal of Agricultural Technology*, 2020, 16(4), 112–120.

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