

AI Driven Decision Support System for Sustainable Agriculture and Zero Hunger

¹Dr. K.L.S.Soujanya, ²Dr. D.V.Latitha Parameswari, ³A.Sirisahasra, ⁴P.Nishitha, ⁵M.Varshini

^{1,2}Associate Professor, Department of Computer Science and Engineering (UG), G. Narayanamma Institute of Technology and Sciences for women, Hyderabad, India

^{3,4,5}Student, Department of Computer Science and Engineering (UG), G. Narayanamma Institute of Technology and Sciences for women, Hyderabad, India

E-mails: [1drklssoujanya@gnits.ac.in](mailto:drklssoujanya@gnits.ac.in), [2dvlatitha@gnits.ac.in](mailto:dvlatitha@gnits.ac.in), [323251a0505@gnits.ac.in](mailto:23251a0505@gnits.ac.in), [423251a0551@gnits.ac.in](mailto:23251a0551@gnits.ac.in), [523251a0521@gnits.ac.in](mailto:23251a0521@gnits.ac.in)

Abstract - Agriculture remains a vital pillar of India's economy, with a substantial portion of the population relying on farming as their primary livelihood. Despite its importance, many farmers continue to face barriers in maximizing crop productivity and maintaining soil health due to limited access to scientific guidance and data-driven tools. To address these challenges, this study presents an AI-based Decision Support System (DSS) designed to deliver personalized, real-time agricultural recommendations. The system encompasses three key modules: a Crop Recommendation Model, a Fertilizer Recommendation Model, and an interactive bilingual Chatbot supporting both Telugu and English. The crop recommendation module identifies optimal crops based on soil nutrient profiles and environmental parameters, while the fertilizer module suggests suitable nutrient combinations for sustainable and efficient soil management. The integrated chatbot functions as a virtual assistant, providing user-friendly support and addressing common queries in local languages, thereby enhancing accessibility for rural farmers.

Powered by machine learning algorithms, the system processes large-scale agricultural datasets to generate context-aware insights that adapt to dynamic environmental conditions and user-specific inputs. This adaptive platform aims to support informed decision-making, improve agricultural efficiency, and encourage sustainable practices, particularly among smallholder and marginal farmers. By integrating artificial intelligence with localized agricultural knowledge, the proposed system offers a scalable solution for enhancing farm productivity, profitability, and rural resilience. The initiative aligns with broader objectives of sustainable agriculture, food security, and socio-economic development in agrarian communities.

Keywords: Artificial Intelligence, Machine Learning, Decision Support System.

I. INTRODUCTION

Agriculture constitutes the backbone of the Indian economy and is the sole source of income for the vast majority, mainly in rural India. With the world facing an ever-growing population, food security has become the most important issue in the modern age. For this reason, conventional farming has been giving way to technology-based methods aimed at increasing productivity while ensuring sustainability. In this technology advancement, artificial intelligence (AI) has been a tool that provides the ability to empower farmers with data-driven, real-time insights.

The project involves the use of AI to improve agriculture techniques. By anticipating the changes possible using AI in this important industry, the research aims to develop a solution to the decades-old challenge of helping Indian farmers make better decisions and get good agricultural advice or tips, potentially leading to more productive, sustainable, and financially fruitful agriculture.

1.1 Background

Agriculture is a major contributor to the economy of India and a primary source of income for millions of people, especially rural communities. As the world population has been on the rise, food security has become a crucial challenge. The conventional cultivations are being increasingly replaced by technology-driven practices to increase productivity and sustainability. Artificial Intelligence has come to be a major tool to assist farmers with real-time, data-driven choices. This project is aimed at the use of AI for improving agricultural practice with a final goal of helping to achieve Zero Hunger, one of the United Nations Sustainable Development Goals (SDGs).

The majority of the farmers in India are still facing serious problems in making wise decisions in choosing crops, fertilizers management, and availability of quality agricultural advice. Subsistence farming methods, with no prior knowledge of new technologies, typically result in low yields, soil degradation, and reduced profitability.

Machine Learning enables systems to learn from farm data, find patterns, and make recommendations based on the data. Given inputs such as nutritional value of the soil and weather, ML algorithms can suggest the most suitable crops and fertilizers for highest yield and a healthy state of the soil. Also, through the application of NLP and translation software, chatbots can now communicate with Telugu-farming community and English-farming community members virtually, eliminating barriers to communication and bringing technology within reach of rural masses.

1.2 Objectives

This project shall directly benefit Telugu-speaking and English-speaking farmers by developing three essential resources: a bilingual crop recommender tool to help in choosing the most appropriate crops for their specific conditions, a bilingual fertilizer recommender tool to help in making the appropriate and optimal use of nutrients, and a bilingual chatbot readily accessible to answer their diverse agronomical questions and provide timely assistance.

II. LITERATURE REVIEW

Over the past few years, the marriage of Artificial Intelligence (AI) and the Internet of Things (IoT) has had a revolutionary impact on the formulation of Decision Support Systems (DSS) for intelligent agriculture. Multiple studies have discussed the strength and weaknesses of such an integration, especially in enhancing productivity, sustainability, and real-time decision-making for farmers. In [1],[10] a proposal of an AI-IoT-based system for facilitating Smart Sustainable Agriculture (SSA) was made. The study mentioned equipment such as drones, AI sensors, and automated greenhouses as having the potential to transform agriculture. However, the framework remains mostly conceptual with minimal empirical confirmation or focus on smallholder concerns. An AI-based chatbot that was integrated with IoT was developed in [2],[13] which would be deployable on platforms like Telegram and Messenger. It utilizes Natural Language Processing (NLP) so that it can provide intelligent responses. Though it is new technology, the system lacks the drawback of requiring robust IoT infrastructure and performs badly with variations in dialects and complex queries. A DSS based on SMS for yellow corn farmers was presented in [3][11], which employs DSSAT

software and weather information to provide climate-resilient recommendations through text messages. This method is useful for farmers without smartphones, but its reliance on external institutions and absence of smartphone capabilities restrict its scalability. The FARM prototype DSS tool developed in [4],[14] helps small farmers through a web dashboard and API interfaces. Manual data entry is supported, along with visual trend analysis. No real-time integration of sensors and over-reliance on manual input reduce its efficiency and accuracy. In [5],[12] an IoT-based system integrating machine learning models such as MobileNetV2 and VGG16 recorded high accuracy in soil classification and anomaly detection. Though technically robust, the study does not cover practical deployment concerns in resource-constrained environments. The Krushi chatbot in [6],[15] was implemented with the RASA X framework and trained on actual farmer questions. It is multilingual and weather-enabled but only accepts text input at present, without multimodal capabilities such as voice or image input. A multimodal approach was investigated in [7],[16] where a chatbot employs CNN-based image processing to detect plant diseases and is hosted on the Heroku cloud. The system has a feedback loop for ongoing improvement, but needs internet access and compatible hardware, thus being less suitable for remote field deployment.

In [8], a prototype AI rover for farm monitoring was constructed utilizing an ESP32 camera and CNN models with real-time notifications using the Blynk platform. While promising, it is still a prototype and has no proof of efficacy on massive farms. Lastly, an extensive survey in [9] surveyed several AI-powered agriculture technologies such as drone technology, computer vision, and IoT. It mentioned case studies such as the Hands-Free Hectare and weed detection technology. Nonetheless, it also emphasized ongoing challenges such as cost, unavailability of datasets, digital illiteracy, and privacy issues that hinder intensive adoption.

Taken together, these studies demonstrate the advances and gaps in leveraging AI and IoT for smart agriculture. As prototypes and pilot tools become more advanced, their deployment in real-world settings needs to overcome infrastructural, educational, and economic barriers. Future research should prioritize inclusivity, field-level use ability, and localized development to make a greater impact.

III. METHODOLOGY

This chapter explains the methodology that we used in creating our intelligent agricultural decision support system. It explains the data that we utilized for recommending crops and fertilizers, the process we followed to clean and prepare the data, and how we trained a Decision Tree model to

recommend these. We explain the datasets, how we processed them, and why we selected our model.

3.1 Dataset

This study utilizes two separate datasets from Kaggle to address the purposes of fertilizer and crop recommendation.

3.1.1 Crop Recommendation Dataset: The Crop Recommendation dataset, which is obtained from <https://www.kaggle.com/datasets/atharvaingle/crop-recommendation-dataset>, contains 2200 instances of data, each characterized by 8 features. The primary goal associated with this dataset is the prediction of the most suitable crop to cultivate based on some soil conditions and weather conditions. The target variable to be predicted is the "Label" feature, which specifies the crop type. Missing (NULL) values were reported not to be present in the dataset.

3.1.2 Fertilizer Prediction Dataset: The Fertilizer Prediction dataset at <https://www.kaggle.com/datasets/gdabhishek/fertilizer-prediction> consists of 99 data samples with each sample described by 9 features. For this dataset, the task is to yield the appropriate fertilizer recommendation using given soil and crop conditions. The "Fertilizer Name" feature has been utilized as the target variable, which is the type of fertilizer recommended. Missing (NULL) values were reported not to be present in the dataset.

3.2 Preprocessing

Both Crop Recommendation and Fertilizer Prediction datasets undertook the following steps in pre-processing:

Data Cleaning: Established presence of no missing data and removed duplicate records to ensure data integrity.

Data Normalization: Normalized numeric features (e.g., Nitrogen, Phosphorus, Potassium) with the help of Standard Scaler.

Label Encoding: Transformed categorical target features ("Label" for crop and "Fertilizer Name") to numeric form through Label Encoder to facilitate compatibility with machine learning algorithms.

Data Splitting: Scaled every dataset into a test set and training set in 80/20 ratio to test model performance on unseen data.

Model Selection: Applied Decision Tree Algorithm on both Crop Recommendation and Fertilizer Recommendation.

3.3 Algorithms Used

The algorithms that have been experimented are SVM and DTC. Training can be slow, especially on large tabular datasets. Major details of each algorithm have been defined in Table 1.

Table 1: Summary of Algorithms Used

Feature	DTC	SVM
Interpretability	Easy to visualize and explain	Difficult to interpret, especially with kernels
Preprocessing requirements	Minimal	Requires careful preprocessing
speed	Often faster to train and test on medium-sized tabular data.	Training can be slow, especially on large tabular datasets.
Handling of Mixed Types	Naturally handles both numerical and categorical columns	Can handle only numeric and properly scaled.
Overfitting Tendency	High (if not pruned)	Less

This table summarizes the algorithms comparison of SVM and DTC.

3.4 Model

The crop and fertilizer recommendation model training process involved a formalized and optimized machine learning pipeline. First, the dataset of agricultural parameters including NPK values, pH level, temperature, humidity, and soil type was preprocessed by managing missing values and feature normalization for model stability. Supervised learning algorithms, i.e., Decision Tree and Support Vector Machine (SVM), were utilized to train multi-class classification model models. Training data was separated into training data and testing data in the ratio of 80:20, and training was performed iteratively with a batch size of 32. Hyperparameter tuning was carried out through grid search and cross-validation to improve the accuracy of the model. Decision Tree classifier was used for its interpretability, whereas SVM model was used due to its high-dimensional feature space robustness. To avoid overfitting, early stopping as well as monitoring of performance using a validation set were used. After completion, models were tested with performance metrics such as accuracy, precision, recall, and F1-score. Decision Tree achieved accuracy of 99%, and SVM model achieved

accuracy of 96%, thus proving the effectiveness of the method in making smart suggestions for smart agriculture.

3.5 Evaluation Metrics

To comprehensively evaluate the models, several performance metrics were calculated, as summarized in Table 2.

Table 2: Evaluation Metrics for Model Performance

Metric	Definition
Accuracy	The proportion of correctly classified instances.
Precision	The ratio of true positives to the sum of true positives and false positives.
Recall	The ratio of true positives to the sum of true positives and false negatives.
F1-score	The harmonic mean of precision and recall.
AUC	Area under the ROC curve, indicating model discrimination ability.

This table 2 outlines the evaluation metrics used to assess the performance of the models, providing definitions for each metric.

Chatbot:

It has a chatbot which accepts farmers' queries and gives relevant recommendations on the basis of needs. It features a crop recommendation system, which, depending on user input, suggests the most suitable crops for best growth. It has a system for fertilizer recommendations, which facilitates increased soil fertility by suggesting fertilizer recommendations.

- The backend is created using Flask, which is a web application to handle the user inputs and sends the chatbot responds back to the user.
- The chatbot is powered by the Gemini API, which is used to respond to the user's queries related to agriculture and give responses in voice and text format in the language which the user has selected.
- For supporting a wide range of users, the Google Translate library (googletrans) is integrated to provide seamless translation services from English to Telugu.
- Frontend voice input is enabled by integrating the native browser Web Speech API (SpeechRecognition) so that the user's voice is translated into text and then passed on to the backend as the user's query.

- Additionally, for improved accessibility, the gTTS (Google Text-to-Speech) library is utilized to transform the chatbot's text-based responses into voice speech, providing an alternative method of interaction for users of use and accessibility. Users can choose their language of preference, English or Telugu, for interaction. Input can be conveniently given by typing or voice. All responses are in both text and audio form. An audio symbol is attached to each response, clearly specifying that the user can listen, read, or both.

IV. RESULTS

Within the paper, we have conducted a comparison of the efficiency of two algorithms that are SVM, DTC for classification of crop and fertilizer. Each algorithm was trained and tested upon a dataset consisting of diversified samples of crop and fertilizers, such that we were able to assess their efficacy in appropriate classification of crops and fertilizer. We used metrics such as accuracy, precision, recall, F1-score, to compare their performances. We present those results in the following section.

4.1 Model Performance Metrics

Table 3 Testing performance metrics of each of the models. We tabulate that all three models performed very well, and we see that DenseNet121 obtained the highest precision, recall, and F1-score.

Algorithm	Accuracy (%)	Precision (%)	Recall (%)	F1-Score
Decision Tree	0.99	0.98	0.98	0.98
SVM	0.96	0.95	0.96	0.96

The table 3 presents Decision Tree and SVM algorithm evaluation with respect to top performance metrics. The Decision Tree has consistently good scores of 0.98 on all of the metrics, reflecting its sound and well-rounded performance. SVM also performs very well, scoring slightly lower but still showing that it is a safe alternative to the Decision Tree but not nearly as precise.

The below Figure 1 shows the comparison graphs between DTC and SVM.

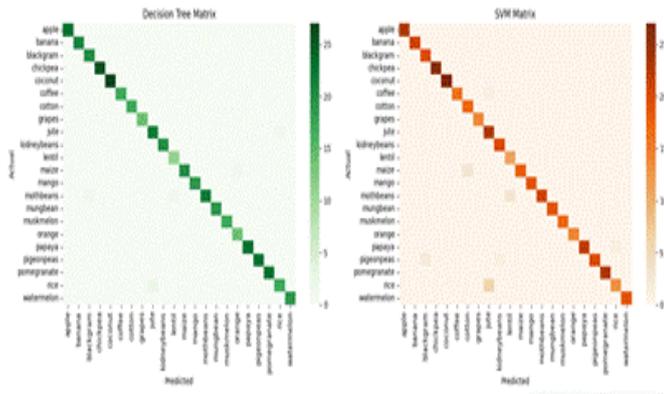


Figure 1: Comparison graphs between DTC and SVM

V. CONCLUSION

In conclusion, this project offers farmers with smart tools to enable enhanced crop planning, efficient utilization of resources, and well-informed farm management decisions. By applying machine learning, the system provides suggestions that can have the impact to improve agricultural productivity and sustainability to a large extent.

The Crop Recommendation Model, developed with the Decision Tree algorithm, recorded an outstanding accuracy of 98.4%, effectively assisting farmers in choosing the most appropriate crops depending on soil and climatic conditions.

Equally, the Fertilizer Recommendation Model, developed based on the Decision Tree algorithm, also had a staggering accuracy of 99.9%, thus making accurate fertilizer recommendations that ensure soil well-being and high production. In addition, with the inclusion of an AI chatbot, the site became more accessible and user-friendly. The chatbot offers support in real time, responding to farmers' questions regarding agriculture practices, pest control, government schemes in easy-to-understand language.

ACKNOWLEDGEMENTS

The authors are grateful to the management and principal of G. Narayanamma institute of Technology and science for women (GNITS) for the facilities and support that made this research possible. Special thanks to the department Head Dr A. Sharada and research mentors for their guidance and encouragement and support throughout the project. This work is done under the center of Excellence Advanced AI, GNITS.

REFERENCES

[1] Ahmad Ali Alzubi and Kalda Galyna, "Artificial Intelligence and Internet of Things for Sustainable Farming and Smart Agriculture" 2023,doi: <https://ieeexplore.ieee.org/document/10190626>

[2] Venkata Reddy P. S., Nandini Prasad K. S., and Puttamadappa C. , "Conversational AI Bot Based on IoT Knowledgebase for Smart Agriculture" 2024,doi: <https://ieeexplore.ieee.org/document/10616582>

[3] Rhia Trogo, Jed Barry Ebardaloza, Delfin Jay Sabido IX, Gerry Bagtasa, Edgardo Tongson, and Orlando Balderama "SMS-based Smarter Agriculture Decision Support System for Yellow Corn Farmers in Isabela" 2015,doi: <https://ieeexplore.ieee.org/document/7238049>

[4] Evangelia Vanezi, Maria Anastasiou, Christos Mettouris, Aliko Kallanou, Marijana Dimitrova, and George A. Papadopoulos,"FARM: A Prototype DSS Tool for Agriculture"2024,doi: <https://ieeexplore.ieee.org/document/10193124>

[5] Mohammad Aldossary, Hatem A. Alharbi, and Ch Anwar Ul Hassan "Internet of Things (IoT)-Enabled Machine Learning Models for Efficient Monitoring of Smart Agriculture"2024,doi: <https://ieeexplore.ieee.org/document/10537161>

[6] Mihir Momaya and colleagues, "Krushi – The Farmer Chatbot",doi: <https://ieeexplore.ieee.org/document/9510040>

[7] Dr. T.M. Geethanjali "Agroinsights Chatbot: Ai-Driven Precision Farming For Optimal Yields, Crop Selection, And Disease-Free Harvests",doi: <https://ieeexplore.ieee.org/document/10774802>

[8] N. Shivaanivarsha, "Farming Using AI Technology" doi: <https://ieeexplore.ieee.org/document/10059618>

[9] Satyanarayana Nimmala,"A Recent Survey on AI-Enabled Practices for Smart Agriculture",2024,doi: <https://ieeexplore.ieee.org/document/10581009>

[10] Latha, C.M., Bhuvanewari, S. and Soujanya, K.L.S. (2022) 'Stock Price Prediction using HFTSF Algorithm', in 2022 Sixth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC). IEEE, pp. 1053–1059. Available at: <https://doi.org/10.1109/I-SMAC55078.2022.9987378>.

[11] Latha, C.M., Bhuvanewari, S. and Soujanya, K.L.S. (2024) 'Optimized FOREX Rate Prediction Using Hybrid Machine Learning Algorithm', in, pp. 31–41. Available at: https://doi.org/10.1007/978-981-97-5412-0_3.

[12] ASHA. P, HEMAMALINI. V, POONGODAI. A, SWAPNA. N, SOUJANYA. K. L. S, VAISHALI GAIKWAD (MOHITE) 'Human Emotion Recognition Based on Machine Learning Algorithms with low Resource Environment', ACM Transactions on Asian and Low-Resource Language Information Processing [Preprint]. Available at: <https://doi.org/10.1145/3640340>.

- [13] Reddy Madhavi, K. et al. (2025) Brain Tumor Classification and Segmentation Using Transfer Learning from MRI Images, International Journal of Computer Information Systems and Industrial Management Applications. Available at: <https://learnopencv.com>.
- [14] Latha, C. M. (2020). Digital technology for farmers through cmm system. International Journal of Psychosocial Rehabilitation, 24(5), 2072-2080. <https://doi.org/10.37200/ijpr/v24i5/pr201905>
- [15] Devi, Y.S. and Kumar, S.P. (2024) ‘Diabetic Retinopathy (DR) Image Synthesis Using DCGAN and Classification of DR Using Transfer Learning Approaches’, International Journal of Image and Graphics, 24(05). Available at: <https://doi.org/10.1142/S0219467823400090>
- [16] Latha, Ch.M. (2020) ‘Intrusion Detection on Smart Hotel through HISI Approach’, Journal of Advanced Research in Dynamical and Control Systems, 12(SP8), pp. 393–401. Available at: <https://doi.org/10.5373/JARDCS/V12SP8/20202537>.

Citation of this Article:

Dr. K.L.S.Soujanya, Dr. D.V.Latitha Parameswari, A.Sirisahasra, P.Nishitha, & M.Varshini. (2025). AI Driven Decision Support System for Sustainable Agriculture and Zero Hunger. In proceeding of Second International Conference on Computing and Intelligent Systems (ICCIS-2025), published in *IRJIET*, Volume 9, Special Issue ICCIS-2025, pp 172-177. Article DOI <https://doi.org/10.47001/IRJIET/2025.ICCIS-202528>
