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KISSAN-MITRA: An AI-Enabled Web Platform for Crop Disease Detection, Yield Prediction, and Market Intelligence in Indian Agriculture

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***Abstract*— Agriculture is the foundation of India's economy, but farmers continue to face numerous challenges. Farmers face crop diseases and unpredictable weather patterns each year, as well as inefficient fertilizers and fluctuating market rates that can change from day to day. Because small and marginal farmers lack access to unified systems that provide data and insights, this challenge has grown significantly. This article focuses on a "KISSAN-MITRA" which is a full stack web based portal developed to provide farmers with the access of agricultural based data along with the observations and insights which can enable them to make better and accurate decisions along with this KISSAN-MITRA allows farmers to access all the necessary tools digitally.**

KISSAN-MITRA has been tested and has passed all field testing, demonstrating that it provides value to farmers in making informed decisions regarding their crop's health as well as for better allocation of resources based on yield, hence farmers can identify diseases early on, allocate their resources more effectively, and develop marketing plans according to market trends. KISSAN-MITRA incorporates many new technologies into one platform utilizing machine learning to estimate crop yield and deep learning to detect diseases via images, provides real-time weather information, as well as real-time advisories on mandis. As a result of the use of KISSAN-MITRA's technologies and ability to contribute to sustainable agriculture, KISSAN-MITRA has successfully become an important tool for accelerating sustainable agriculture in India.

***Index Terms*— Artificial Intelligence in Agriculture, Crop Disease Detection, Yield Prediction, Smart Farming Systems, Deep Learning, Web-Based Agricultural Platforms.**

I. INTRODUCTION

In India, Agriculture is the primary source of livelihood for a significant portion of the population, making it critical to their survival but the limitation is that despite advances in technology and new methods in other industries, the agricultural industry is still backward and continues to depend heavily upon older technology and processes which result in inefficient resource utilization and the delay in recognition of existing crop diseases which create an economic strain on the nation. The use of old methods places farmers at risk of crop failure due to disease and inaccurate yield predictions, which impact their income and ability to support themselves and their families. This can create financial losses, as well as psychological distress for many farmers across a country.

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The rapid emergence of Artificial Intelligence (AI), machine learning, and internet-based information systems has created new opportunities to increase agricultural productivity by implementing predictive analytics, automation, and providing decision-making support in real time, as well as providing better insights and more knowledge than previously existed. In a recent publication, researchers highlighted the value of utilizing and creating yield prediction models based on data gathered from previous seasons, along with climate and soil data, and how using deep-learning algorithms has enabled researchers to develop models that can identify crop diseases through analysis of images of diseased leaves provided by farmers. However, because the focus of many of the current solutions offered today imposes limitations on farmers, either by being too narrow in scope or too complicated to use due to complex user interfaces and language obstacles, fewer farmers are taking advantage of these new technologies and ultimately suffering losses as a result.

To overcome these hurdles and obstacles to using AI in agriculture, this paper introduces the KISSAN-MITRA platform, which has been developed as an AI-based, web-based platform that supports all types of agricultural practices by providing users with access to the entire process of using AI for their agricultural needs. It's a central hub for everything related to agriculture and offers farmers comprehensive agricultural support and assistance in every way possible.

Numerous agricultural problems can be solved using machine learning, including predicting the weather, determining which fertilizer to apply, estimating crop yields, diagnosing plant diseases, and accessing up-to-date daily prices in local markets. The use of an integrated voice system (multi-lingual) makes it easy for users to operate. These Bote Virtue features further enable individuals with low computer literacy to access elements of the platform through voice commands; therefore, the platform serves farmers, as well as individuals of all ages, demographics, backgrounds, and economic means.

A. This Paper Represents

The first complete software product that applies the power of machine learning to agriculture. An application of deep learning to rapidly diagnose plant diseases based on simple) uploaded to the application. The development of multiple crop yield prediction and fertilizer selection models based on standardized measures of crop yield prediction. Real-time weather forecast information and prices from local markets in the user's immediate vicinity, downloadable as a PDF document. A software platform with support for many Indian languages, therefore, making it easier for Indian farmers to access and use the platform, as well as to provide a means of communication for farmers of all languages.

II. Literature Review

In the last several years, as AI and data have become more prevalent in farming, they are now considered essential for modern-day farmers. AI and data have allowed farmers to monitor the health of their crops, make informed decisions, and predict how much they will produce, all of which allow them to be more successful. The following section will discuss the research that has been conducted thus far regarding smart farming, identifying crop diseases and predicting crop yields, as well as explaining the gaps in knowledge that ultimately led to the development of KISSAN-MITRA.

A. AI-based Crop Disease Identification

Early detection of plant disease is critical in order to prevent large-scale crop losses. There have been numerous studies and research conducted utilizing deep learning and machine learning techniques for the identification of diseased crops through photographing leaves. These methods have yielded some excellent results. Convolutional Neural Networks (CNNs) perform exceptionally well with this data type, as CNNs can automatically learn the valuable attributes from the input images. Studies have shown that when trained with representative images of crops, CNNs can accurately detect crop diseases in controlled settings and environments.

Currently, the majority of all systems experience obstacles when implementing them in a real-world setting since many systems have limitations that include small amounts of data to train, unbalanced sets of data and general differences between images in relation to quality and other things (such as weather conditions, seasonal changes, soil types, etc.) would be important to consider when using an image-based disease-detecting system.

B. Machine Learning for Crop Yield Prediction

For more than just a few decades, agricultural scientists and researchers have developed various methodologies for predicting the harvest of crops, including Regression Techniques, Time Series Analysis, and Ensemble Learning Techniques. The methodologies take into account various types of historical harvested crop data, climatic conditions, and previous harvest yields. Current research indicates that when sufficient amounts of data become available to researchers, Machine Learning techniques can provide a target forecast and provide a high degree of accuracy.

Despite being able to give acceptable predictions, the majority of the Machine Learning crop yield prediction models are still utilized in a stand-alone mode without being integrated into a real-world farming application, which has not been optimally developed or scaled for rapid implementation and deployment across diverse agricultural markets. Furthermore, these modelling tools do not have the capability of rapidly adjusting their predictions based on evolving local conditions, and most of them also do not make use of continual or real-time data to make crop yield predictions. Recognizing the difficulties farmers face in making informed decisions regarding their farming operation, an Intelligent Decision-Making Support System, which is a multi-faceted, comprehensive, user-friendly integrated platform of multiple smart farming units, has been developed.

The Integrated Intelligent Decision-Making Support System brings together all of the main components (weather forecasts, crop disease detection, yield prediction models, fertiliser recommendations, and market information) so farmers may make informed and timely agronomic decisions at each stage of a crop's growth cycle. An added advantage is an integrated Artificial Intelligence (AI) based chatbot, providing farmers with further usability by providing them with personal guidance, step-by-step help, and real-time answers to questions in a variety of local languages, thus allowing them to reduce their reliance on technical expertise.

C. Intelligent Decision Support Systems

Several Smart Farming platforms have been developed to assist farmers by providing real-time digital information on various aspects, such as global and local weather patterns, crop monitoring, and the agricultural environment. Many Smart Farming platforms focus on a small set of features, primarily weather and market information, and are specialized for certain types of farming operations. While these Smart Farming platforms provide easy access to a wide range of agricultural information related to your location and needs, they still lack a centralized system where all of this information can be found in a single place.

Additionally, many users of these specific Smart Farming platforms face challenges, including not being able to speak the language, the complexity of the user interface, and limited (if any) support for new users. According to many articles and Case Studies, Digital Agricultural Tools must have a simple-to-use application, provide access to multiple languages, and make it easier for New Users to connect to the platform and access the Digital Agricultural Tools available to them. These items are critical to the successful adoption of Smart Farming Technology by Small Holder Farmers in Rural Areas, and the continued growth of India's Agricultural Industry.

D. Research Gaps

From a literature review, we identified three gaps in our current understanding -

A Lack of a dedicated online platform, a lack of prescriptive AI systems,

Inadequate availability of support in many languages with accessible voices.

This leaves the marketplace for such products open to development and commercialisation.

Most importantly, to address these gaps, we developed KISSAN-MITRA, a one-stop AI-based web tool that bridges the gap between all three technical areas of interest with the application of machine learning technologies and real-time data services in a simplified format, allowing Indian farmers to easily access and utilize the full range of technology at their own pace.

III. METHODOLOGY

KISSAN-MITRA has a notable design that is likely to grow easily and be able to change quickly and adapt as new information is presented to it, resulting in a greater ability to do different things. KISSAN-MITRA is intended to provide Farmers with up-to-date, real-time farming data and metrics, allowing them to act appropriately. KISSAN-MITRA uses cloud-based and AI technologies for assessing crops, monitoring crop health, diagnosing plant diseases, estimating final yield, and providing decision support through collaborative community resources. KISSAN-MITRA is built on a simple web-based front-end interface using a REST-style API with an associated set of AI models. These technologies are designed to integrate to provide a secure and simple interface to facilitate easy information sharing, foster collaboration, and enhance the productivity of the primary users (Farmers) of Kissan-Mitra. KISSAN-MITRA aims to provide Farmers with quick access to relevant information and support for improved Farm Performance and Livelihoods through the application of AI and through a thoughtful step-by-step process by the analysis of Agricultural Data and the use of Blockchain Technologies.

KISSAN-MITRA is focusing on scalability and reliability, while offering those functions that allow the platform to handle an ever-increasing number of users and an increasing number of sources for user-provided data. The platform will support the integration of new AI models, new datasets, and new sources for user-provided data (e.g., government advisories, satellite imagery, and IoT-based sensor data) into the existing platform. The modular and extensible architecture for KISSAN-MITRA enables it to grow along with advances in technology in agricultural science. It ensures that farmers in various agricultural regions and crop types have consistent results and data accuracy on the KISSAN-MITRA platform.

KISSAN-MITRA is committed to providing secure access to data, transparency and trust through the use of Blockchain. Blockchain will allow farmers to share agricultural data in a secure manner, establish an immutable record of transaction records, and track their agricultural data (e.g., crop records, advisory logs) throughout the supply chain. In addition, Blockchain will help to establish a greater level of trust and collaboration between all players in the agricultural supply chain (e.g., farmers, agronomists, wholesalers, suppliers, and government agencies). KISSAN-MITRA will also provide the possibility for farmers to make informed decisions about their crops based on AI-based intelligence and a secure digital infrastructure for data sharing and collaboration, which will ultimately lead to greater sustainability and the long-term resilience of the agricultural ecosystem.

A. System Architecture

The scalable architectural stack of the KISAN-MITRA system will support future growth and evolution of the KISAN-MITRA system with minimal cost. The system consists of four layers:

Frontend (React.js): The User Interface presents a responsive design that is multi-lingual, developed with React.js and Tailwind CSS, which also uses the ShadCn library for ease of use and responds to users via smartphones and web browsers.

Backend (Node.js and Express.js): The Back-End API is responsible for managing API routing, user login flow, API post request validation, and facilitating communication between the front-end of the application and the AI models via the most efficient and scalable API possible.

Database (MongoDB): The Data Storage element consists of a MongoDB database and is used to store user data, crop data, predictions, state-specific data, district-specific data, disease report data, and community-specific data.

Machine Learning and Artificial Intelligence Layer:Finally, the Machine Learning element is responsible for processing data using machine learning algorithms to determine crop yield and fertilizer recommendations, crop prediction, and identifying crop disease through image recognition using deep learning techniques.

External Services: The app takes advantage of many third-party services (APIs) such as OpenWeather for the latest weather information, the mandi price data API from data.gov, and uses cloud storage services (Cloudinary) for storing media, etc.

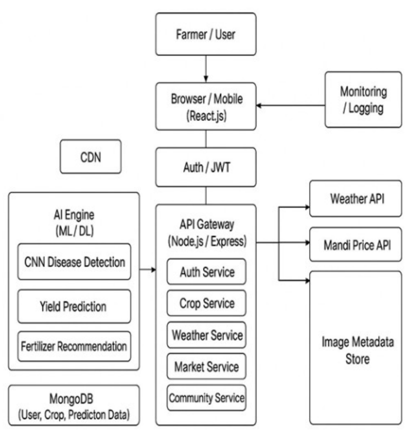

Figure. 1 Detailed System Architecture of Kissan-Mitra

B. Operational Flow

The platform operates in a clear and highly flexible manner, as outlined below:

- The user first signs up and logs into the system.
- The user location automatically gets fetched.
- The user can upload crop images for disease checking if needed or required in the situation.

- The AI engine takes all the inputs and does the following:
- Finds crop diseases
- Predicts crop yield
- Gives fertilizer suggestions
- Crop Prediction
- The platform additionally brings weather updates and market price trends in real time for the nearest mandi.
- All the results and recommendations are shown to the user in many languages and also with voice help.
- Users, if interested, can take part in the community forum to share knowledge and discuss problems they are facing, ensuring the clearance of any issues or doubts through community building.

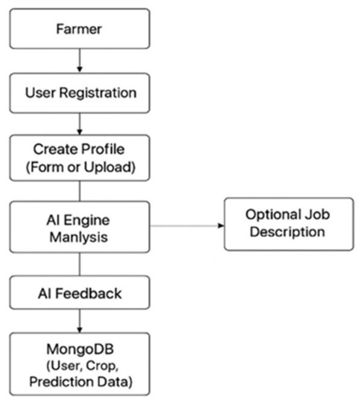

Fig. 2 Detailed Operational Flow of Kissan-Mitra

C. Functional Modules

The KISSAN-MITRA system has the following main module:
Crop Disease Detection Module: This module uses CNN models to find crop diseases by studying actual leaf images.
Yield Prediction Module: This module uses supervised learning methods to guess and predict the expected crop yield by using soil information like the content of phosphorus, Nitrogen, pH, and environmental conditions.
Fertilizer Recommendation Module: This module gives the best fertilizer-related suggestions based on the crop type, crop name, farmer's needs, and environmental conditions.
Weather and Market Information Module: This module delivers current weather updates using already fetched user location and mandi price information, mainly through government APIs.
Community and Advisory Module: This module lets farmers share information, ask questions about facing issues, and get advice from other farmers or from the system admin.
ChatBot Module: This module lets farmers ask questions he/she is facing, and get advice from chatbots in multiple languages with the help of TTS and STT features.

D. Data Sources

The system uses data from various sources to create personalized recommendations and enhance the prediction accuracy related to a specific problem faced by a farmer.

Source	**Type of Information**	**Purpose in Project**
Weather APIs	Real-time weather data	Support farming decisions
Agricultural Market APIs	Mandi Price data	Enable market awareness
User-uploaded images	Crop leaf image	Train and validate disease detection
Historical agricultural data	Yield and Crop Pattern	Train prediction models
Government agricultural datasets	Crop and Soil Information	Improve AI accuracy

Figure 3. Data sources for recommendation system

IV. Results and Discussion

In this section of the report, the results of testing the KISSAN-MITRA platform through use cases that tested the functionality, usability, performance, and overall usefulness of the platform are mentioned. The various different modules of KISSAN-MITRA were tested for usability by checking how well they are integrated and how much time they take to produce results.

A. Evaluation of Functionality

Key modules such as finding disease in the crops, predict the crop yield, suggest fertiliser, weather forecasting, and the chat response system were tested both on its own and in combination during the testing phase to make sure of the proper functioning. Functional validation focused on observing how these modules communicated with each other in the platform. The testing results showed that when each module operated without integrity issues, they integrated smoothly, allowing the platform to function as a unified and compatible system without performance conflicts.

The crop disease detection module classifies crop images into the applicable disease categories and suggests fitted remedial measures for the affected crops. The yield prediction module estimates seasonal crop output using farmer-provided inputs such as environmental conditions and nutrient levels, helping farmers plan their activities more effectively. Also, The market price and weather modules timely and consistently delivered real-time information, enabling farmers to make timely and informed decisions.

B. System Responsiveness/Usability

The main system here is working nicely even with limited rural internet and supports local languages, allowing the lots to move easily between sections of the platform ensuring smooth nav across all pages and made the system accessible to a wider range of people and users.

Support of regional language made the application especially usable for mainly lots who are new to digital tools, ensuring that those from different backgrounds and levels of technical knowledge could benefit equally from the platform.

C. Performance Analysis Through Observation

When it is compared to actual old and conventional approaches and methods used to help all the farmers with any crop related helpful information, the given application here demonstrated a very clear as well as apparent improvement in time. The main identification of issues is fairly quicker, and applicable help was delivered without any delay.

The key difference between this use of AI and our traditional model was that the dataset we worked with was rather limited, and that the AI was operating within established environments. The performance evaluation of the system was largely conducted by examining and viewing the results and did not include a large number of tests using numerical methods. The deep learning disease detection aspect had a consistent pattern recognition of the most common crop diseases in the images examined.

D. The Analysis

Based upon the results of this study, the KISSAN-MITRA system is an adequate option; however, the system must undergo further field testing with a significantly larger number of samples and greater testing size to be used effectively.

Together with this newly developed system, the KISSAN-MITRA program is intended to provide a strong basis for the development of smart farming support platforms in developing regions. The KISSAN-MITRA program is exceptionally well integrated and provides a single-source platform for a wide range of supportive services for farms.

V. Conclusion and Future Work

KISSAN-MITRA helps farmers in India by combining several methods of decision-making into one platform or tool using AI technology.

KISSAN-MITRA allows farmers to access the most up-to-date information on the status of their crops, how to best use resources for optimum yields, and what the competition is doing, so they can develop successful agricultural strategies. The system shows the potential of combining ML with real world data to improve agricultural activities. Support of Indian regional languages and voice support makes it easier for any farmer to use this system.

According to the current testing results of the KISSAN-MITRA, the system has the level and potential to do well. However, it will be important to continue testing the system by collecting larger amounts of crucial and important data over time to increase the accuracy and success of the KISSAN-MITRA.

Future Enhancements of KISSAN-MITRA will include:

Combining crop images from different regions of India along with the soil types across various seasons.

Increase the number of Indian regional languages supported by the system along with the offline or low-internet modes to help rural users.

Making a voice-related help system more efficient so it can give actual guidance about crop health, fertilizer use, and market choices.

Integrate satellite images and map-based data to keep check on the crop and land, and find early signs of stress on a large scale.

Using IoT sensors to measure moisture, temperature, nutrients, and other properties to support farming.

Setup a large community-based knowledge sharing platform along with the expert help system.

Improve production by smart, intelligent, and simple analysis and side by side continuing to support sustainable farming practices.

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