Grenze International Journal of Engineering and Technology, June Issue

Smart Agriculture using ML and AI Algorithms

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***Abstract*— Smart agriculture is a rapidly emerging field that leverages the power of machine learning (ML) and artificial intelligence (AI) to enhance efficiency, sustainability and productivity in the agricultural sector. ML and AI algorithms are employed to analyze vast amounts of data collected from various sources. These technologies provide valuable insights into crop growth, soil conditions, and environmental factors, enabling farmers to detect early signs of crop diseases, predict yield outcomes, and optimize fertilizer and water usage. Additionally, virtual assistants powered by ML and AI can offer personalized recommendations on crop management practices, helping farmers enhance their decision-making process and minimize risks.**

***Index Terms*— Machine learning (ML), Artificial intelligence (AI), crop growth, soil conditions, environmental factors, crop diseases, predict yield outcomes, optimize fertilizer, water usage, virtual assistants powered by ML and AI.**

I. INTRODUCTION

Smart agriculture, also known as precision agriculture or digital farming, is a revolutionary approach that harnesses the power of Machine Learning (ML) and Artificial Intelligence (AI) technologies to enhance various aspects of farming. With the increasing global population and the need to produce more food with limited resources, smart agriculture emerges as a viable solution to improve the efficiency. ML and AI techniques enable farmers to gather and analyze vast amounts of data from multiple sources such as weather conditions, soil moisture levels, crop growth patterns, and more. By leveraging these technologies, farmers can make data-driven decisions, optimize resource utilization, and predict potential risks or crop diseases. This information-driven approach helps to significantly reduce input costs, minimize the use of chemicals, and improve overall crop yield. In conclusion, smart agriculture using ML and AI presents a paradigm shift in modern farming. By harnessing the power of advanced technologies, farmers can optimize resource management, reduce environmental impact, and improve overall crop quality and quantity. This transformative approach has the potential to revolutionize the agriculture industry, ensuring sustainable food production for future generations.

II. LITERATURE STUDIES

Shaikh, T. A., Rasool, T., & Lone, F. R. (2022). Towards leveraging the role of machine learning and artificial intelligence in precision agriculture and smart farming. Computers and Electronics in Agriculture, 198, 107119. The research study conducted by Shaikh, T. A., Rasool, T., & Lone, F. R. (2022) aims to explore the potential of machine learning (ML) and artificial intelligence (AI) in the field of smart agriculture.

Grenze ID: 01.GIJET.10.2.216

Siregar, R. R. A., Seminar, K. B., Wahjuni, S., & Santosa, E. (2022). Vertical farming perspectives in support of precision agriculture using artificial intelligence: A review. Computers, 11(9), 135.Siregar, et al. (2022) provide a comprehensive review of the role of vertical farming in supporting precision agriculture using artificial intelligence (AI). They highlight the potential benefits of implementing AI and machine learning (ML) in smart agriculture systems.

Qazi, S., Khawaja, B. A., & Farooq, Q. U. (2022). IoT-equipped and AI- enabled next generation smart agriculture: A critical review, current challenges and future trends. IEEE Access, 10, 21219-21235.The paper by Qazi, S., Khawaja, B. A., and Farooq, Q. U. (2022) provides a critical review of IoT-equipped and AI-enabled next-generation smart agriculture.

Shaikh, T. A., Mir, W. A., Rasool, T., & Sofi, S. (2022). Machine learning for smart agriculture and precision farming: towards making the fields talk. Archives of Computational Methods in Engineering, 29(7), 4557-4597. Shaikh et al. (2022) present a comprehensive review of machine learning (ML) techniques for smart agriculture and precision farming.

Sharma, A., Georgi, M., Tregubenko, M., Tselykh, A., & Tselykh, A. (2022). Enabling smart agriculture by implementing artificial intelligence and embedded sensing. Computers & Industrial Engineering, 165, 107936. Sharma, Georgi Tregubenko, Tselykh, and Tselykh (2022) explore the implementation of artificial intelligence (AI) and embedded sensing in smart agriculture. They discuss how AI algorithms can analyze data collected from embedded sensors in the field to optimize resource allocation, monitor crop health, and predict weather patterns.

Mitra, A., Vangipuram, S. L., Bapatla, A. K., Bathalapalli, V. K., Mohanty, S. P., Kougianos, E., & Ray, C. (2022). Everything you wanted to know about smart agriculture. arXiv preprint arXiv:2201.04754. The paper titled "Everything you wanted to know about smart agriculture" by Mitra et al. (2022) provides a comprehensive overview of the application of machine learning (ML) and artificial intelligence (AI) in the field of smart agriculture.

Javaid, M., Haleem, A., Khan, I. H., & Suman, R. (2023). Understanding the potential applications of Artificial Intelligence in Agriculture Sector. Advanced Agrochem, 2(1), 15-30. The reference title, "Understanding the potential applications of Artificial Intelligence in Agriculture Sector," signifies a research article published in 2023. This article is likely to delve into the exploration of the diverse possibilities for implementing artificial intelligence (AI) within the agricultural industry.

Foster, L., Szilagyi, K., Wairegi, A., Oguamanam, C., & de Beer, J. (2023). Smart farming and artificial intelligence in East Africa: Addressing indigeneity, plants, and gender. Smart Agricultural Technology, 3, 100132. The reference title, "Smart farming and artificial intelligence in East Africa: Addressing indigeneity, plants, and gender," signifies a research article published in 2023.

S. Senthil, M. R. Kumar, R. S. Kumar, A. K. Jabakumar and K. Madhan, "Design and Implementation of Smart Agriculture Management Intelligent Things Using NB-IOT," 2022 Third International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE), Bengaluru, India, 2022,pp.1-5,doi: 10.1109/ICSTCEE56972.2022.10100320. S. Senthil, M. R. Kumar, R. S. Kumar, A. K. Jabakumar, and K. Madhan are the authors of the paper titled "Design and Implementation of Smart Agriculture Management Intelligent Things Using NB-IOT." The paper focuses on the use of Machine Learning (ML) and Artificial Intelligence (AI) techniques in the field of smart agriculture, specifically in smart agriculture management systems.

Chen, Q., Li, L., Chong, C., & Wang, X. (2022). AI-enhanced soil management and smart farming. Soil Use and Management, 38(1), 7-13. The reference title, "AI-enhanced soil management and smart farming," denotes a research article published in 2022 that investigates the integration of artificial intelligence (AI) technologies in agriculture. The article explores how AI enhances the management of agricultural soil, encompassing soil analysis, nutrient optimization, and irrigation control.

III. MOTIVATION

The motivation behind implementing smart agriculture using machine learning (ML) and artificial intelligence (AI) stems from the urgent need to address various challenges faced by the agricultural industry. ML and AI technologies can help farmers optimize their operations, leading to increased efficiency and productivity. By automating tasks such as crop monitoring, irrigation, and pest management, farmers can maximize yields while minimizing resource usage and labour costs. Farmers face various risks, including unpredictable weather patterns, pests, diseases, and market fluctuations. ML and AI algorithms can analyse vast amounts of data to provide insights into potential risks and help farmers make data-driven decisions to mitigate them. This includes predicting weather patterns, identifying disease outbreaks, and optimizing crop selection and rotation. Sustainable agriculture practices are essential for preserving the environment and ensuring long-term food security. ML and AI technologies enable farmers to adopt sustainable practices such as precision farming, organic farming, and agroforestry. By optimizing resource usage, reducing chemical inputs, and promoting biodiversity, smart agriculture contributes to environmental conservation and resilience. ML and AI technologies empower farmers by providing them with valuable insights and decision support tools. By leveraging data analytic and predictive modelling, farmers can optimize their farming practices, improve crop quality, and increase profitability. Additionally, these technologies bridge the gap between traditional knowledge and cutting-edge science, enabling farmers to make informed decisions based on both local expertise.

IV. PROBLEM DOMAIN

Smart agriculture utilizing AI and ML encompasses a multifaceted approach to revolutionize traditional farming practices. This transformative technology integrates advanced algorithms and data analytics to address various challenges within the agricultural domain. In this two-page exploration, we'll delve into key aspects such as precision farming, crop disease detection, yield prediction, soil health monitoring, and efficient irrigation management.

V. PROBLEM DEFINITION

The objective of our project is to develop an integrated system that utilizes machine learning and artificial intelligence techniques to optimize various aspects of agriculture, including crop management, irrigation, pest control, and resource allocation. The goal is to enhance productivity, reduce resource wastage, and mitigate risks by providing real-time insights and decision support to farmers. Through predictive analytics and automated processes, the project aims to revolutionize traditional farming practices, making them more efficient, sustainable, and resilient in the face of environmental challenges. The project aims to revolutionize agriculture through the integration of machine learning and artificial intelligence. By leveraging advanced technologies, the system seeks to optimize crop yield by analysing factors like soil health and weather conditions, enabling precise resource management to minimize water and fertilizer usage. It will employ AI models to detect and prevent pests and diseases, while also providing accurate weather forecasts for proactive risk management. A user-friendly interface will empower farmers with personalized recommendations, promoting sustainable practices and environmental stewardship. Scalable and adaptable, the platform will foster collaboration and knowledge-sharing among farming communities, driving innovation and resilience in agriculture.

VI. STATEMENT

Our project, aims to revolutionize traditional farming practices by integrating cutting-edge technologies to enhance productivity, sustainability, and resilience in agriculture. Through the application of machine learning and artificial intelligence techniques, our system will optimize crop management, resource allocation, and risk mitigation strategies. By providing real-time insights and decision support to farmers, we seek to maximize crop yield while minimizing resource usage and environmental impact. Our user-friendly interface will empower farmers with personalized recommendations, fostering collaboration and knowledge-sharing within the agricultural community. Ultimately, our project strives to create a more efficient, sustainable, and resilient agricultural ecosystem for the benefit of farmers and society as a whole.

VII. INNOVATIVE CONTENT

The project integrates Geopy for precise field mapping and delineation, leveraging spatial data to create accurate representations of farm plots. Building upon this foundation, we incorporate advanced machine learning techniques for comprehensive crop management. Our system includes features such as crop yield prediction, crop history analysis, and crop recommendations using algorithms like Random Forest. To enhance crop health monitoring, we propose the integration of a Convolutional Neural Network (CNN) for plant disease prediction. By analyzing images of crops, this model can accurately identify diseases and pests, enabling proactive intervention. Moreover, our project addresses crucial aspects of irrigation and pest management. We envision an advanced irrigation system that utilizes machine learning algorithms to optimize water usage based on crop needs, soil moisture levels, and weather forecasts. This precision irrigation approach minimizes water wastage while maximizing crop productivity. Additionally, our system incorporates intelligent pest management strategies. By integrating real-time pest data with historical records and environmental factors, we can develop targeted pest control measures, reducing the reliance on chemical pesticides and minimizing environmental impact.

VIII. Problem Formulation Or Representation Or Design

System architecture is the blueprint that defines how a computer system is structured and designed. The architecture determines how different components interact and collaborate to achieve specific objectives. It involves decisions related to the choice of operating system, organization of software modules, and implementation of communication protocols. A well-designed system architecture is critical for ensuring system performance, scalability, reliability, and maintainability. It plays a crucial role in the successful development and operation of intricate computer systems. Collecting data is crucial for training machine learning (ML) and artificial intelligence (AI) models. The first step in this process is to identify and select the key features from the collected data that will be used for training the ML and AI models. These key features can include parameters such as temperature, humidity, soil moisture, sunlight duration, crop growth stage, and pest infestation levels. By analysing and extracting these key features, the ML and AI models can learn patterns and correlations, enabling them to make accurate predictions and actionable recommendations for farmers. Additionally, other important factors, such as weather forecasts, historical data, and crop management practices, can also be considered as key features. The models are continuously trained and improved by incorporating new data and refining the algorithms to accurately predict key parameters crucial for successful farming, such as irrigation scheduling, pest and disease identification, optimal planting and harvesting times, and yield forecasting.

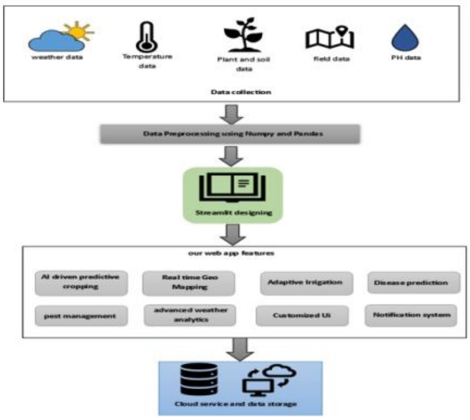


Fig: 1 Architecture diagram

VIII. Solution Methodologies Or Problem Solving

GeoJSON : Efficiently processes and visualizes geographical data, allowing for precise field delineation and area calculations. The features include points (therefore addresses and locations), line strings (therefore streets, highways and boundaries), polygons (countries, provinces, tracts of land), and multi-part collections of these types. GeoJSON features need not represent entities of the physical world only; mobile routing and navigation apps, for example, might describe their service coverage using GeoJSON.

Shapely: Provides tools for the manipulation and analysis of planar geometric objects, enabling accurate distance measurements and area calculations for fields. Shapely is a Python package for set-theoretic analysis and manipulation of planar features using functions from the well-known and widely deployed GEOS library.

Geopy: Computes geodesic distances between points, aiding in the accurate measurement of field boundaries. Geopy makes it easy for Python developers to locate the coordinates of addresses, cities, countries, and landmarks across the globe using third-party geocoders and other data sources.

Pandas for Data Management: Offers powerful data structures for efficient manipulation and analysis, streamlining crop history recording and input usage. Matplotlib and Seaborn for Data Visualization: Provides comprehensive libraries for creating static, animated, and interactive visualizations, enhancing the graphical representation of input usage and crop history.

Streamlit Designing: Streamlit is an open-source app framework (a Python package) that gives us the power for creating nice-looking apps without any front- end development knowledge.

Random Forest: Random Forest in crop recommendation utilizes an ensemble learning approach, aggregating predictions from multiple decision trees. Random Forest enhances the accuracy and robustness of crop recommendations, aiding farmers in making informed planting decisions for improved yield and sustainability.
Convolutional Neural Network: CNN models in disease prediction for plants leverage deep learning techniques to analyze images of plants and identify signs of diseases. By learning hierarchical representations of features from images, CNNs can detect subtle patterns indicative of diseases such as discoloration, lesions, or unusual growth. This enables early detection and targeted interventions, facilitating timely treatment to prevent crop losses and ensure agricultural sustainability.
The home page of our web app “Farm Management System” is created using streamlit. The sidebar is used to select an option on various features. This page shows information about the features that are available.

Fig 2.Home Page

fig 3.field mapping

The feature Field Mapping is shown. This is done by giving the GPS Coordinates and then exporting and uploading GeoJSON file to view the area more precisely.
The crop planning is done by getting inputs from the farmer. T6he inputs like name of the crop, crop area, crop pod count, grain count and weight, month in which crop is planted are gathered from farmer. So the crop yield is calculated.

Fig 4: Crop Planning

fig 5: Input usage

The Input usage data are collected from the farmer and gets stored as the CSV File. The usage of fertilizer, pesticides and water is collected and plot is made for the comparison of all the input usage.
The Crop is predicted using the Random Forest algorithm. It gives result based on the parameters like phosphorous, nitrogen, potassium, temperature, humidity, Ph and rainfall is required to analyse the crop yield.

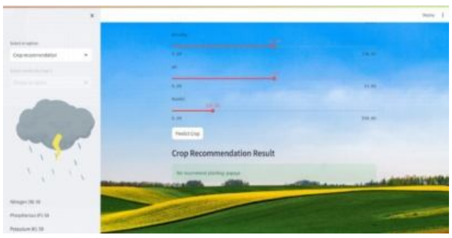


Fig 6: crop recommendation

fig 7: disease prediction

The Disease of the plant is predicted using the convolutional neural network model as soon as user uploads the diseased leaf image it predicts the disease and gives brief description and steps to overcome the disease.
By giving the city’s name and selecting the dates that we want to track weather . The table is shown for the following days that are selected.

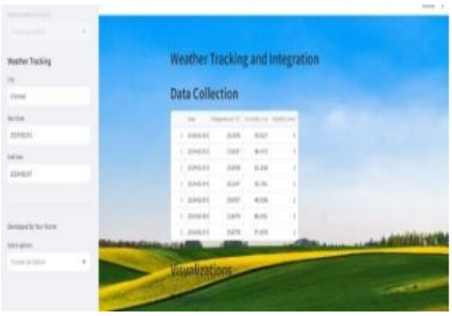


Fig 8: weather tracking

fig 9: irrigation management

The moisture level and water flow level is monitored and provides the data for zone wise and gives the notification regarding the wastage of water.

X. Features And Results Of The System

Field mapping and delineation

Effortlessly map and delineate your fields using Farm_era's intuitive interface. Visualize your land boundaries and effectively manage your fields. Field mapping is an increasingly important way to both monitor your land and manage future activities. Here we Used the GPS coordinates latitude and longitude as an input coordinate that creates map using the folium algorithm. We had drawn the map using the drawing tool and display the map. We exported the map as GEOJSON file and uploaded it to see the field more precisely.

Crop planning and rotation management

Plan your crop planting schedules and manage rotation cycles with ease. To track of different crop varieties and maintain optimal soil health for improved yields. By processing crop-specific data, the system can provide predictions and insights into potential yields, helping farmers make informed decisions. Using historical data, a user predicts the yield of a particular crop for the upcoming season.

Input usage and crop history

Record and track the usage of fertilizers, pesticides, water, and other inputs. Maintain. a detailed crop history for compliance and better resource management. Leveraging pandas, matplotlib, and seaborn, the platform offers robust data recording capabilities, coupled with visually appealing graphs and charts to represent historical crop data.

CROP recommendation

Crop recommendation with ML, utilizing algorithms like Random Forest, integrates data on soil quality, climate, and crop characteristics to suggest suitable crops for a given area. Random Forest leverages ensemble learning, aggregating predictions from multiple decision trees to provide robust recommendations, enhancing agricultural productivity and sustainability.

Disease prediction

Disease prediction for plants using CNN models entails training on images of diseased and healthy plants to discern subtle visual cues indicative of infections. CNNs excel in capturing spatial patterns, enabling precise identification of diseases like blight or powdery mildew. Leveraging this technology aids in early detection promoting crop health and yield optimization in agriculture.

Pest and disease management

Receive timely alerts and recommendations for pest and disease control. Access integrated databases to identify and address issues promptly, safeguarding your crops. It involves employing various strategies, including cultural practices, biological control, and chemical treatments. This approach optimizes resource allocation, minimizes chemical usage, and fosters sustainable agriculture while safeguarding crop yields.

Weather tracking

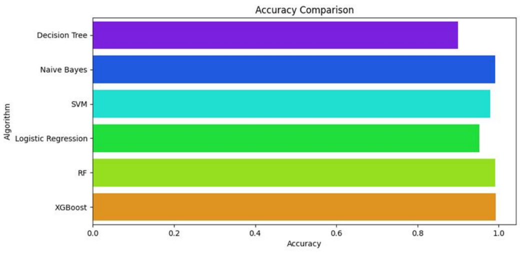
Weather tracking in agriculture involves monitoring meteorological parameters like temperature, humidity, rainfall, and wind speed. By integrating weather data with crop models, farmers can make informed decisions regarding planting, irrigation, and pest management. Accurate weather forecasts enable proactive measures, optimizing yields and mitigating risks in agricultural production.

Irrigation scheduling and monitoring

Analyze factors such as soil moisture, weather data, and plant growth stage. By integrating sensors and data analytics, precise irrigation schedules are created, optimizing water usage and promoting plant health. Real-time monitoring enables adjustments, ensuring plants receive adequate hydration while minimizing water wastage, enhancing agricultural sustainability.

XI. Justification Of The Results

ML and AI can be utilized to analyze soil data, weather patterns, and plant characteristics in real-time, enabling farmers to make data-driven decisions regarding irrigation, fertilization, and pest control. This not only increases crop yields but also minimizes the use of water, fertilizers, and pesticides, thereby reducing environmental impact.

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Decision Tree --> 0.9
Naive Bayes --> 0.990909090909091
SVM --> 0.9795454545454545
Logistic Regression --> 0.9522727272727273
RF --> 0.990909090909091
XGBoost --> 0.9931818181818182
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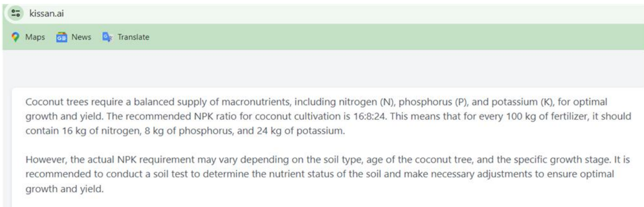
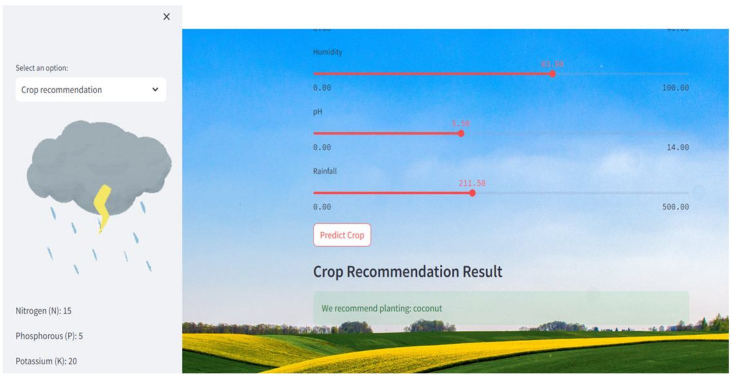
Comparing our model result with KissanAI:
Crop recommendation comparison:



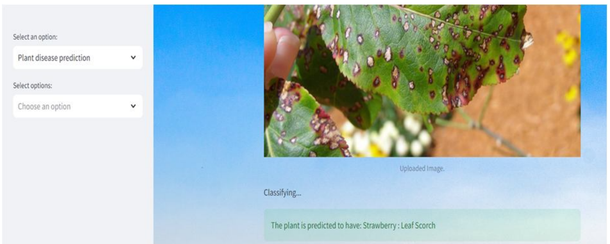
Our result:



Disease prediction comparison:
kissanAI result:

Yes, strawberry plants can be affected by leaf scorch disease. Leaf scorch is a fungal disease that affects the leaves of strawberry plants, causing them to turn brown and dry out. The disease is caused by the fungus Diplocarpon earliana and is most common in areas with high humidity and rainfall. Symptoms of leaf scorch include brown spots on the leaves, which eventually turn into large brown patches. The disease can be controlled by removing infected leaves and applying fungicides. It is important to maintain good plant hygiene and avoid overhead irrigation to prevent the spread of the disease.

Our result:



XII. CONCLUSION

In conclusion, the application of machine learning (ML) and artificial intelligence (AI) in smart agriculture has the potential to revolutionize the industry. ML and AI can be utilized to analyze soil data, weather patterns, and plant characteristics in real-time, enabling farmers to make data-driven decisions regarding irrigation, fertilization, and pest control. This not only increases crop yields but also minimizes the use of water, fertilizers, and pesticides, thereby reducing environmental impact. Additionally, ML algorithms can be employed to predict and prevent crop diseases and pests, aiding in early detection and targeted interventions. Autonomous robots equipped with AI capabilities can revolutionize farming operations by performing tasks such as planting, harvesting, and monitoring crop health with precision and efficiency. Furthermore, ML and AI can enable predictive analytics for market trends, allowing farmers to optimize their production strategies and make informed decisions about pricing, distribution, and supply chain management. Overall, the integration of ML and AI in agriculture holds tremendous promise in addressing the global challenges of food security, sustainability, and efficiency.

FUTURE WORK

AI has the tools to address the challenges posed by climate change, environmental concerns, and an increasing demand for food. It will revolutionize modern agriculture by improving efficiency, sustainability, resource allocation on top of real-time monitoring for healthier and higher-quality produce. However, you can't just buy AI and start using it. AI is not something tangible. it's a set of technologies that are automated through programming. In essence, an AI algorithm mimics the way people think. it learns first, then solves problems based on data. AI-driven transformation of agriculture will require changes in the industry. Farmers need to be educated and trained in how to use AI-powered solutions.

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