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Interpretable Machine Learning for Predicting Climate Change Effect on Agricultural Land Suitability in Eurasia

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Abstract. Temperature and precipitation patterns are changing quickly due to climate change, which presents significant obstacles to the sustainability of agriculture throughout Eurasia. Effective long-term planning requires accurate forecasting of changes in the suitability of agricultural land. High precision and interpretability are frequently lacking in conventional statistical models. An interpretable machine learning method for evaluating the effects of climate change on the usability of agricultural land is presented in this study. The input features include a variety of climate indicators, soil characteristics, and land-use factors. Prediction is the goal of machine learning models like Random Forest and Gradient Boosting. Standard accuracy and error measures are used to assess the model's performance. Interpretability strategies like SHAP are used to improve transparency. The relative significance of environmental and climatic elements is revealed by these techniques. To find geographical differences, spatial analysis is done.

keywords: Climate Change, Agricultural Land Suitability, Interpretable Machine Learning, Explainable AI, SHAP, Random Forest, Gradient Boosting, Eurasia, Spatial Analysisltural policy and climate adaptation strategies.

I. Introduction

Agriculture is crucial to the Eurasian region's continued economic stability and food security. Agricultural productivity is impacted by significant variations in temperature, precipitation, and extreme weather events brought on by climate change. These climate shifts directly affect soil moisture, agricultural growth cycles, and land suitability. A thorough assessment of site suitability is necessary for agricultural planning to be successful. The reliance of traditional assessment systems on expert judgment and preset standards limits scalability and adaptability. Strong tools for interpreting complex environmental data are provided by recent advances in machine learning. However, many machine learning algorithms are opaque, which reduces the accuracy of their predictions. Interpretable machine learning overcomes this limitation by generating results that are easy to comprehend. This method uses interpretable models to forecast whether agricultural land is suitable under changing climate conditions. The study incorporates data on land use, temperature, and soil from around Eurasia. Feature importance and explanation strategies are used to understand driving elements. The recommended approach promotes informed decisions for climate-resilient agriculture.

II. Literature Survey

The study "Effects of Climate Change on the Suitability of Agricultural Land" was written by Ramankutty et al.

Abstract:

This study looks at how climate change affects agricultural land suitability globally. The authors highlight how crop-growing regions are affected by variations in temperature and precipitation. The study emphasizes how important predictive models are to future agricultural planning.

2. Machine Learning Techniques for Crop and Land Suitability Prediction
This was written by Jeong et al.

Abstract:

This study explores the use of machine learning techniques, such as Random Forest and Support Vector Machines, for agricultural suitability assessments. The results show improved prediction accuracy when compared to traditional statistical methods. The study demonstrates how machine learning may be used to complex environmental data.

3**. Remote Sensing Agricultural Assessment Driven by Climate Data**
Burke and Lobell wrote this.

Abstract:

The authors investigate the potential for incorporating climatic data from satellites into agricultural models. The study claims that remote sensing improves the geographical precision of assessments of land suitability. It highlights the importance of comprehensive climatic records for local studies.

4. Interpretable Machine Learning Models in Environmental Research Lundberg et al.

Abstract:

This work presents SHAP, an interpretability technique for machine learning models. The authors demonstrate how feature contribution analysis improves environmental prediction transparency. The approach enhances the explainability and trust of climate change decision-making processes.

5. Forecasting the Effects of Climate Change on Agriculture using Explainable AI Zhao et al.

Abstract:

This study uses explainable artificial intelligence approaches to investigate how agriculture is affected by climate change. The results identify the primary climate factors affecting land production. The authors emphasize how crucial interpretable models are to the development of sustainable land management and policy.

The Existing System

The foundations of the existing systems for assessing the suitability of agricultural land are rule-based models and conventional statistical methods. These approaches make use of predefined criteria for climate parameters like temperature, precipitation, and soil characteristics. Most conventional models mainly rely on past climate data and regulations established by experts. Although these methods are simple to use, they are not adaptable to rapidly changing weather conditions. Because of their regional uniqueness, many of the existing systems are not scalable over large and diverse regions like Eurasia. Additionally, they have difficulty capturing complex, non-linear relationships between climate components. Prediction accuracy is a key component of many modern techniques that use machine learning models. However, these models often function as "black boxes," offering no insight into the decision-making process. When something is hard to grasp, policymakers and agricultural planners lose faith in it. Current long-term climate impact assessment methods are often limited in terms of their efficacy, scalability, and transparency.

Suggested System

The proposed approach offers an interpretable machine learning framework to predict the impact of climate change on the suitability of agricultural land in Eurasia. It integrates information from multiple sources, including climate parameters, land-use data, and soil characteristics. Advanced machine learning methods like Random Forest and Gradient Boosting capture intricate, non-linear correlations between environmental elements. Unlike traditional black-box approaches, the system leverages interpretability techniques like SHAP to explain model predictions. This enables the identification of the primary meteorological and environmental elements affecting land suitability. Spatial analysis is used to visualize susceptibility patterns and regional differences. The technology supports both classification and regression-based appropriateness assessment. Accuracy and error measurements are used to evaluate model performance in order to ensure dependability. The explainable outcomes improve transparency and user trust. All things considered, the proposed technique provides an approach to climate-resilient agricultural planning that is precise, scalable, and easy to understand.

II. System Architecture

A dual-layer secure data transport system that combines steganography with cryptography is depicted in the diagram. To guarantee confidentiality, the original communication is first encrypted using a symmetric key (AES-128). The LSB (Least Significant Bit) steganography technique is then used to embed this encrypted message into a cover media (such as a picture), creating a stego media that hides the presence of the secret data. The opposite procedure is used during receipt: the original message is recovered by first extracting the encrypted message from the stego medium and then decrypting it using the same symmetric key. This process guarantees data invisibility and confidentiality while offering robust defense against unwanted access and interception

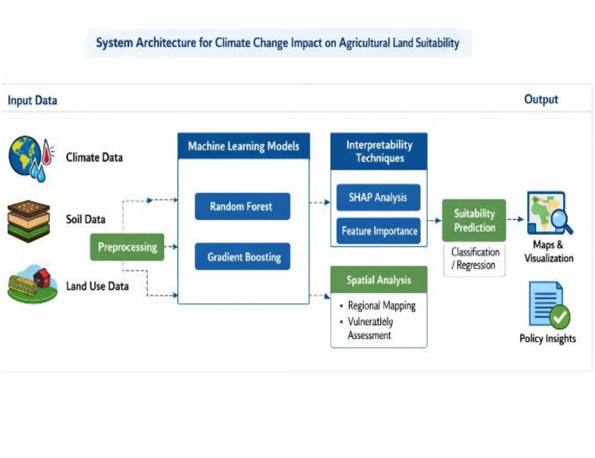

Fig 5.1: System Architecture

III. Implementation

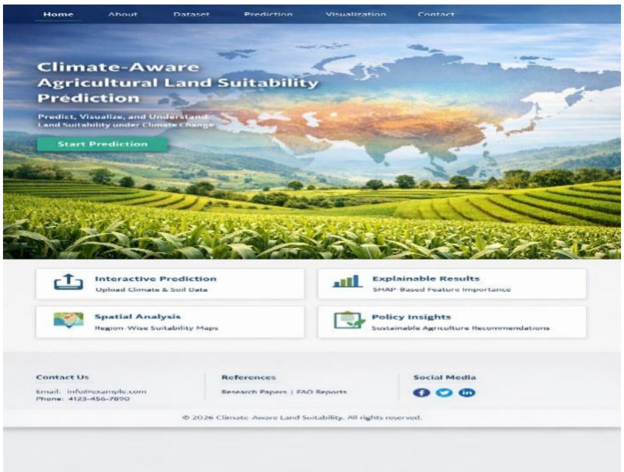

Fig 6.1: Home page

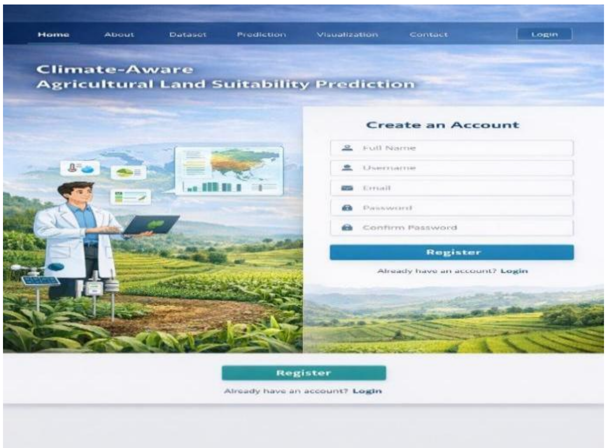

Fig 6.2: Register page

Fig 6.3 login page

IV. Conclusion

This study effectively illustrates the use of interpretable machine learning algorithms to forecast the effects of climate change on the suitability of agricultural land throughout Eurasia. The suggested method successfully captures the intricate linkages influencing agricultural productivity by combining climate, soil, and land-use data. Prediction accuracy is increased when machine learning models like Random Forest and Gradient Boosting are used in place of more conventional techniques. By providing succinct justifications for model predictions, interpretability techniques like SHAP boost utility and confidence. Areas that are both resilient and vulnerable to climate change might be found via spatial analysis. Making educated planning and policy decisions for sustainable agriculture is made easier using this method. All things considered, the suggested method provides a clear, scalable, and accurate option for climate-resilient agriculture.

The Future's Scope

The suggested approach provides a number of elements for efficiently forecasting and assessing the possible effects of climate change on the suitability of agricultural land. It facilitates the integration of data from multiple sources, such as soil, land use, and climate. To increase model accuracy, the system preprocesses the data by cleaning, standardizing, and choosing attributes. Land suitability levels can be classified and regressed using machine learning-based prediction. Through feature importance analysis, interpretable AI algorithms offer concise explanations of model results. Geographic mapping makes it possible to see how suitability varies throughout Eurasia. Important climate conditions that affect agricultural productivity are identified by the system. By employing predetermined parameters, performance evaluation guarantees dependability. In the future, the structure might be scaled and modified to accommodate various climates and geographical areas. All things considered, the feature scope improves the accuracy, transparency, and data-drivenness of agricultural decision-making.

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