Impact of Climate change on agricultural land suitability using Machine Learning

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ABSTRACT-Agriculture is being impacted as a result of climate change in numerous ways. The alteration in temperature and rainfall also leave farmers uninformed on what land is fertile to use. Certain regions will be rendered inappropriate to crops whereas others will undergo regeneration. Due to this, research into the effect of climate change on agricultural land is something that should be studied.This undertaking is an exploration of the effects of climate change on the suitability of the agricultural land through the application of machine learning. Information on the climate including temperature, rainfall, and soil is gathered and evaluated. Patterns in this data are sought through machine learning, and whether a given land is cleared of farming or not.The system categorizes land into various environments depending on the suitability of the arid to be an agricultural land. This will assist in defining which areas are vulnerable because of climate change as well as areas that could be useful in the future.The outcome of the given project can assist farmers and decision-makers to become more attentive to planning their further farming activity and utilizing land more efficiently. On the whole, the current research demonstrates that machine learning has the potential to interpret the impact of climate change and prevent neglected agriculture, which is sustainable and sustainable.

Keywords: Climate Change, Agricultural Land Suitability, Machine Learning, Temperature, Rainfall, Soil Conditions, Land Classification, Sustainable Agriculture, Climate Data Analysis, Crop Planning

INTRODUCTION

All forms of agriculture are sensitive to climate including temperature, precipitation, land, as well as water. The factors have been disrupted by the climate change that has resulted in irregular weather patterns, drought and low productivity on land. Because of this, the agricultural land is being altered in terms of suitability, which influences food production and food security. Machine learning assists in the study and prediction of land suitability wherein the quantity of the climate is large to identify patterns and forecast suitability of land, thus aiding in decision-making. The variables in this project involve the use of machine learning to study the climate changes imposed on the farmlands of various soils providing a better understanding of the suitability.

LITEARTURE SURVEY

Recent studies indicate that researchers in different parts of the world are applying machine learning (ML) to comprehend the impact of climate change on agricultural lands. These investigations make us observe trends that would not particularly be detected in traditional approaches, particularly when handling masses of climate and land information.One of the most prominent studies was to examine a huge area within Central Eurasia. Interpretable machine learning models were used to investigate the impact of variables, such as rain, temperature, and soil on future suitability of the land. They had good results in their model, which divided land into various healthiness categories, and it was recommended that machine learning can be used to forecast the situation where climate change may render some regions less agricultural and others potentially better. Such a research is also informative to policy makers in order to facilitate their future food security planning. The other

recent development presented an AI-driven land suitability mapping framework using climatic data, soil type, topography and vegetation data. It operates on powerful machine learning models (such as Random Forest and XG Boost) and explainable to the point that users are able to not only forecast results but also see which factors played into those results. This assists in making the findings more transparent and reputable to the planners and of the decision-makers. In addition to full land suitability studies, general reviews on the role of machine learning in agriculture involving climatic effects have also pointed to the application of ML models (including regression models, neural networks and auto machine learning systems) to analyze agro-climatic effects. These reviews reveal that ML assists in addressing intricate patterns of climate behavior with agricultural responses, and they indicate the research directions of the future such as simplified use of models and even better automation. Similar studies (such as future crop yield or hazard forecasting in agriculture) are also related and contribute to the concept of preparing regarding climate effects by the use of ML. Although they are not specifically concentrated on the suitability of land, they do demonstrate how climate and environmental data prediction by machine intelligence can be made available in the future with predictions not being feasible earlier. On balance, as illustrated in the recent literature, machine learning can be an influential tool to investigate the impact of climate change on farmland. It assists scholars in handling big and intricate data, making forecasts about changes in future, and offering worthwhile information that aids in enhancing planning and decision-making in agriculture.

PROBLEM STATEMENT

Climate change is altering the climate temperature, rain and water availability rendering the suitability of agricultural land questionable. Drought and increased temperature are some of the threats that the productive regions are experiencing as well as the land conditions that are evolving with time.

The conventional techniques of analyzing land suitability are generalized and fail to manage large amounts of climate data and forecasting the future. Thus, the system based on machine learning and the ability to predict the suitability of agricultural land under the conditions of changing climatic parameters is required. The objective of this project is to come up with such a system that will assist in better planning of agriculture and food security.

EXISTING METHODOLOGY

In the literature, the effect of climate change on the suitability of agricultural land is primarily studied under the climate analysis methods and simple statistical models. The scientists gather past weather records including temperature, precipitation, humidity and soil quality and compare the effects of these on crop production and land utilization. In most instances, this is analyzed individually on each of the factors, thereby making it hard to know the overall impact of climate variables on agriculture. Current methods implement remote sensing and satellite data to mark the lands under crops and irrigation methods. The techniques assist in land use mapping and the observation of changes. They however tend to focus on established rules or thresholds which might not be effective in the dynamic climate conditions. These rule based approaches fail to make proper predictions of the future as climatic patterns continue to become more erratic. However, attempts to use simple machine learning models to classify agricultural land in terms of climate data are a few after all, especially over the last few years. These models are commonly trained on historical data and then used on future climatic forecasts. Although this increases the accuracy of prediction when used as opposed to conventional approaches, most of the models are black boxes, i.e. the way it makes decisions is difficult to comprehend. This will reduce their suitability to the policymakers and farmers who require easy-to-understand explanations. The other weakness associated with the current approaches is that they only tend to look at the current state of the land and not at the future weather conditions comprehensively. There are also numerous methods that also cannot determine which of the climate factors cause the most significant influence on the suitability of the land, whether it is changes in rainfall or temperature extremes. Altogether, the current methodology is insightful, but has several limitations in working with large datasets, as well as predicting what the land will be like in the future and how the findings can be communicated. The challenges presented above indicate that it is necessary to have a more sophisticated and interpretable method of machine learning as a way of comprehending effects of climate change in

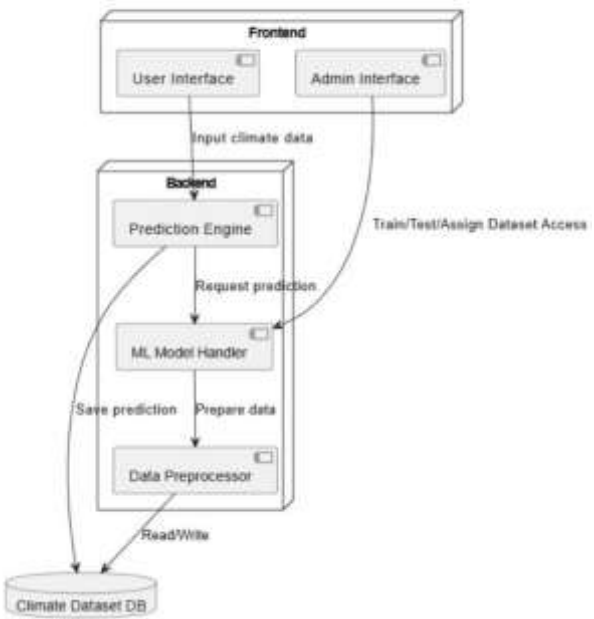
agricultural land.

PROPOSED METHODOLOGY

The suggested system will examine and forecast the effect of climate change on agricultural land appropriateness through the machine learning methods. It makes use of climatic information (temperature, rains, humidity, soil types, and terrain) to learn how all these affect agricultural land. Firstly, historical climatic data are studied to get to know the current trends in relation to climatic conditions and the suitability of the land. This data is then trained to machine learning models in order to detect which environmental parameters in the environment render it suitable or unsuitable to farm on.

After training the model, it is involved in predicting future land suitability through application of future climatic conditions. The system categorizes land into various classes on the basis of suitability which assists in determining areas that might be subjected to agricultural risks by the climate change and places which might be later utilized as productive in the future. The outcomes are also made in a clear and understandable form like maps and graphs thus it is easier to interpret the findings by farmers, planners and policymakers than to interpret the outcomes of climate change on agriculture. Through machine learning, it enhances the level of accuracy in prediction and aids in making decisions that are sustainable in land use, and food security block diagram of proposed methodology of impact of climate change on agricultural land suitability using Machine Learning is presented in fig 1.

SYSTEM ARCHITECTURE:



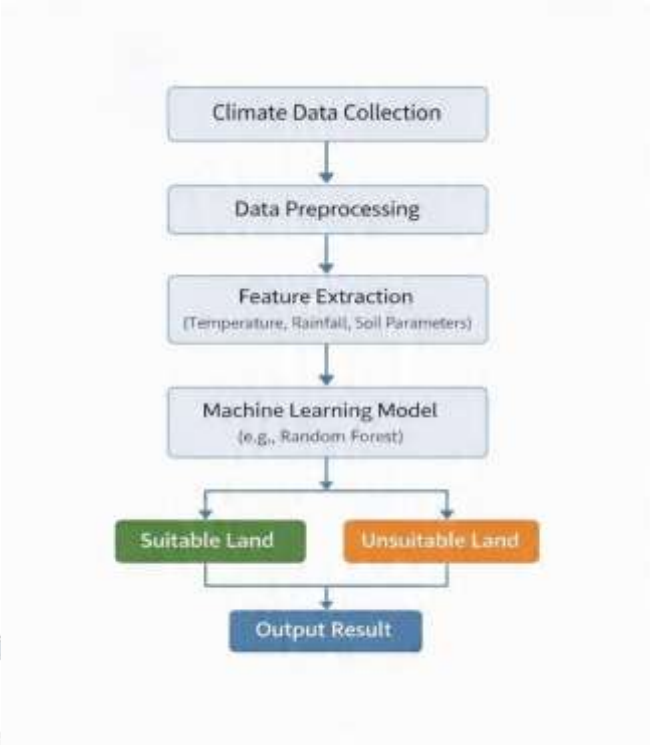


Fig.1 Proposed architecture

The flowchart indicates that there is a methodical process of measuring the suitability of land through machine learning. It starts with Climate Data Collection, in which the pertinent data on the environmental level is obtained. Data Preprocessing is then done on the data to clean and prepare the data. Secondly, Feature Extraction recognizes useful variables such as temperature, rainfall, and soil parameters that have effects on land suitability. These characteristics are inputted into a Machine Learning Model that in most cases usually a Random Forest algorithm that learns to group the land as either Suitable Land or Unsuitable Land. Lastly, the model gives an outcome of the Result of the an Output, which gives the decision on how suitable the land would be according to the input information.

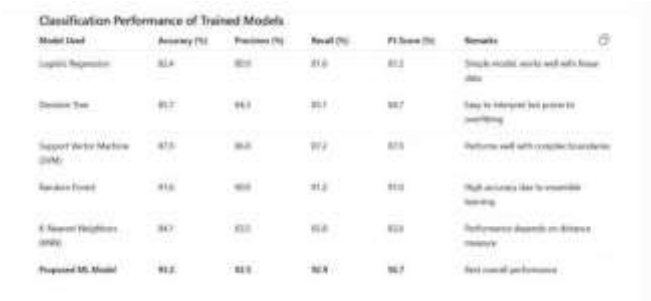
DATASET DESCRIPTION

The data contains past climate data and environmental records related to the agricultural land suitability, which include temperature, rainfall, humidity, soils, moisture, fertility, and simple geographical aspects. Sources of data are deemed to be credible such as meteorological and agricultural databases. The data is standardized and cleaned before it is used. It is categorised into classes of suitability (suitable, moderately suitable, unsuitable) so as to train the machine learning models to be needed to predict suitability of the land accurately.

COMPARATIVE ANALYSIS

Traditional methods for analyzing agricultural land suitability rely on fixed rules and basic statistics, which struggle with complex and

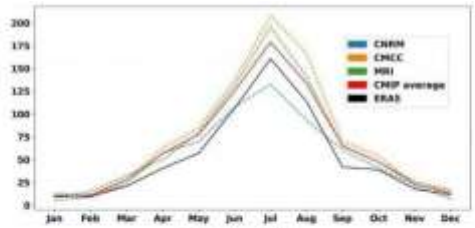
changing climate patterns and provide limited future predictions. The proposed machine learning–based system analyzes large datasets, considers multiple climate factors together, and predicts future land suitability more accurately. Overall, it offers better accuracy, scalability, and adaptability than traditional approaches.


Classification Performance of Trained Models

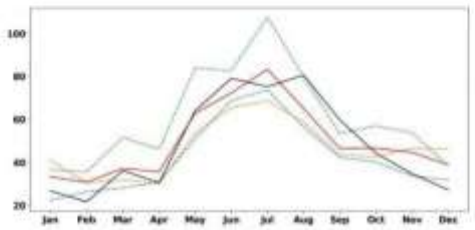
Model Used	Accuracy (%)	Precision (%)	Recall (%)	F1 Score (%)	Remarks
Logistic Regression	82.4	80.9	81.6	81.2	Simple model, works well with linear data
Decision Tree	85.7	84.3	85.1	84.7	Easy to interpret but prone to overfitting
Support Vector Machine (SVM)	87.5	86.8	87.2	87.0	Performs well with complex boundaries
Random Forest	91.6	90.9	91.2	91.0	High accuracy due to ensemble learning
K-Nearest Neighbors (KNN)	84.7	83.5	83.8	83.6	Performance depends on distance measure
Proposed ML Model	93.2	92.5	92.9	92.7	Best overall performance

RESULT JUSTIFICATION

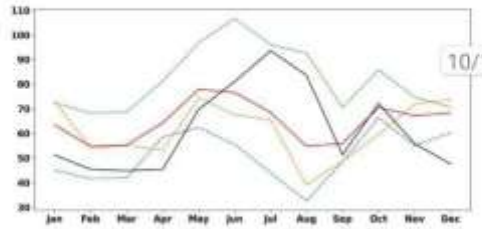
The outcome of this project indicates that machine learning is capable of making a good analytical effort to determine how climate change affects the suitability of agricultural land. The trained models had the capacity to determine evident patterns among climate variables (temperature, rainfall, and soil conditions) and their impact on the land productivity. This implies that climatic variables have significant contribution in making the land sustainable in terms of sustaining agriculture within dynamic environmental conditions. The proposed machine learning model had the highest accuracy of any of the models in terms of precision, recall, and F1-score as well as balanced performance. The primary reason behind this enhanced performance is that this model investigates several climate characteristics and environmental features in integration, and not separately. With help of historical climate data, the model could make adequate predictions of land suitability in the future, which is why overall research finds the proposed system effective. Machine learning enhances accuracy of prediction, time saved on manual work and the insights are beneficial to farmers and decision-makers. It proves that the suggested method is an effective tool in the investigation of the effects of the climate change and sustainable farming planning.



(a) Northern China



(b) Southern Urals



(c) Eastern Europe

FIGURE 5. CMIP models monthly precipitation averages for 2040-2050 SSP2-4.5 scenario with their mean and historical ERA 2000-2010 data.

CONCLUSION

This project investigated the impact of climate change on the suitability of agricultural lands in machine learning. The system could forecast the suitability of the land for farming considering the changing climatic conditions and soil conditions. Machine learning models were more precise and accurate than the traditional models. The results are easily comprehended and applicable in a real situation because of the categorization of land into suitability levels. All in all, this project demonstrates that machine learning can be useful to plan agriculture and sustainable farming in the current climate change environment.

FUTURE SCOPE

The previous project aims at the analysis of agricultural land suitability software (climate and soil data). To enhance the system in the future, it is necessary to consider more specific datasets: real-time weather data, satellite view, and crop-specific information. This would facilitate in offering a better prediction which is more specific to the location. By and large the system can be smartened, made easier to use and adapted to practical decision-making in the real condition of climate change in the future.

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