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Intelligent Soil Health Prediction for Regenerative Farming . A Machine Learning Approach to Sustainable Agriculture

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Abstract: *Soil health is a critical factor in ensuring sustainable agriculture and environmental conservation. This project aims to develop an intelligent soil health prediction model using machine learning techniques to optimize soil classification accuracy. By leveraging key environmental parameters such as soil biodiversity, carbon sequestration, water retention, and overall fertility, we propose a data-driven approach to categorize soil health. Various machine learning models, including Random Forest, Gradient Boosting, Logistic Regression, SVM, and KNN, are evaluated to achieve high classification accuracy. Additionally, model performance is analyzed using key metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Train R^2, Test R^2, and Adjusted R^2. Visualizations like confusion matrices, scatter plots, and model comparison charts will be used to support sustainable decision-making for farmers.*

The research emphasizes the importance of feature selection and hyperparameter tuning to enhance predictive performance. By analyzing the impact of different soil attributes on classification outcomes, we identify the most influential parameters in determining soil health. The model is trained on a diverse dataset that includes real-world and synthetically generated agricultural data, ensuring robustness across varying environmental conditions. Cross-validation techniques are applied to prevent overfitting and improve generalization, making the model adaptable to different soil types and regions.

The findings of this study contribute to precision agriculture by offering an AI-powered tool that assists farmers and agricultural experts in monitoring and managing soil health effectively. The integration of machine learning in soil classification enhances efficiency, reduces manual effort, and promotes environmentally sustainable farming practices. By providing accurate and timely soil health predictions, this approach supports improved crop yield, resource conservation, and long-term agricultural sustainability.

Keywords: Soil health