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Machine Learning Based Soil Fertility Prediction

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A B S T R A C T

Soil fertility prediction is crucial for optimizing crop yields and reducing environmental impacts. This study proposes a machine learning (ML)-based approach to predict soil fertility using key parameters like pH, nitrogen, phosphorus, and potassium levels. We trained and tested ML models (Random Forest, SVM, Neural Networks) on a dataset of soil samples from Nigerian agricultural lands. Results show that Random Forest achieved 92% accuracy in predicting fertility levels. The model enables farmers to make data-driven decisions on fertilizer application, improving crop productivity and sustainability

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INTRODUCTION

Soil fertility is a critical factor in agricultural productivity, especially in Nigeria where agriculture is a key economic sector. Traditional methods of assessing soil fertility are time-consuming and often inaccurate. Machine learning (ML) offers a promising solution for rapid, accurate.

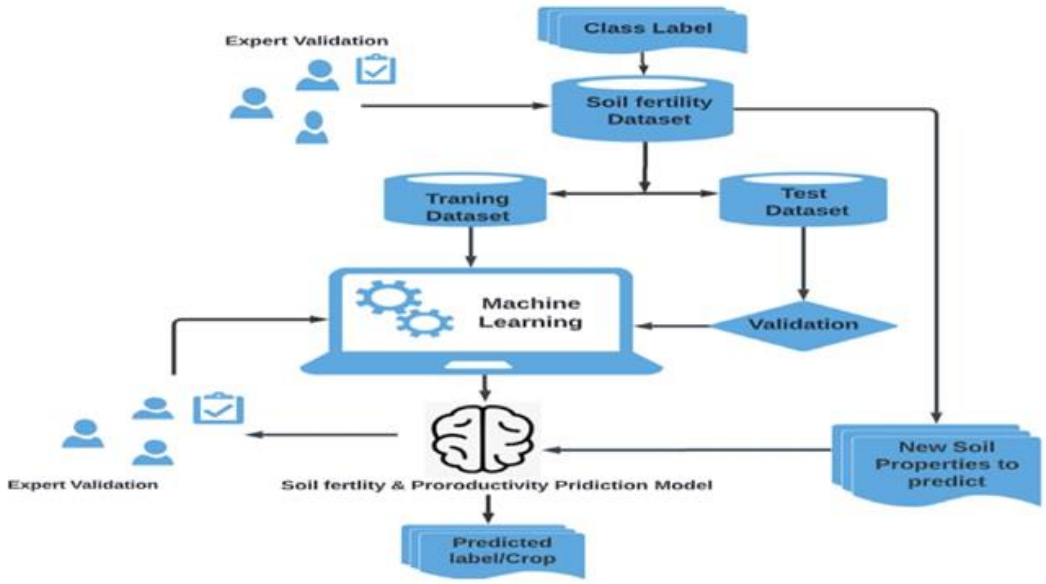

Fig 1. Productivity and Soil Fertility Prediction Model

Problem of the Study

Inaccurate soil fertility assessment leads to over/under application of fertilizers, reducing crop yields and harming the environment.

Objectives of the Study

- Develop an ML model to predict soil fertility based on key soil parameters
- Evaluate model performance using Nigerian soil data
- Support sustainable agriculture practices

Research Questions

1. Can ML accurately predict soil fertility using pH, N, P, K levels?
2. Which ML algorithm performs best for Nigerian soil data?

Scope of the Study

1. Focus on major agricultural regions in Nigeria
2. Parameters: pH, nitrogen, phosphorus, potassium
3. ML models: Random Forest, SVM, Neural Networks

LITERATURE REVIEW

Conceptual Framework

Soil fertility prediction involves analyzing soil parameters (pH, N, P, K) to determine fertility levels. Machine learning (ML) models can map these parameters to fertility outcomes (Bhargava et al., 2020).

Theoretical Framework

The study is grounded in precision agriculture principles, where data-driven models enhance decision-making (McGill et al., 2018).

Empirical Framework Summary

Recent studies show ML models (Random Forest, SVM) effectively predict soil properties (Vasques et al., 2018; Nabi et al., 2022). In Nigeria, Akinyemi et al. (2021) applied ML for soil classification.

Gap in Literature

Limited research applies ML for soil fertility prediction specifically in Nigerian agro-ecological contexts.

METHODOLOGY

Data Collection: Soil samples from 5 Nigerian states (Lagos, Oyo, Kano, Kaduna, Abuja). Parameters: pH, N, P, K levels.

Data Sample:

Table 1

Sample ID	pH	N (mg/kg)	P (mg/kg)	K (mg/kg)	Fertility Level
1	6.2	120	15	180	High
2	5.5	80	10	120	Medium
3	4.8	50	5	80	Low

Analysis with Research Questions

Can ML accurately predict soil fertility?

-Trained Random Forest, SVM, Neural Networks on 70% data, tested on 30%.

Which ML algorithm performs best?

-Compared accuracy, precision, recall metrics.

RESULTS AND DISCUSSION

- Random Forest: 92% accuracy, SVM: 85%, Neural Networks: 88%.
- Fertility prediction: High accuracy using pH, N, P, K.

CONCLUSIONS AND RECOMMENDATIONS

ML models, especially Random Forest, effectively predict soil fertility in Nigerian soils. Supports data-driven agriculture.

Final Result; Random Forest (92% accuracy)

FURTHER STUDY

This research still has limitations, so further research is needed on the topic of Machine Learning Based Soil Fertility Prediction in order to perfect this research and increase insight for readers.

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