GrowSmart Algorithm: A Machine Learning Approach to Predict Appropriate Fertilizer for Resilient Agriculture

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Abstract

With the challenges of climate change, food insecurity, and environmental degradation facing agriculture, innovative solutions are needed to optimize crop production while being sustainable. In this work, a crop recommendation system, powered by machine learning, is designed to help in rising to these new challenges. The system uses three algorithms, namely Random Forest, Naive Bayes, and XGBoost, to predict the most eligible crops based on comprehensive data sets encompassing soil characteristics, nutrient availability, rainfall, and temperature. With so much experimentation, it emerges that XGBoost is the model that thumps all others, reaching an impressive accuracy of 93%, followed by Random Forest at 92%. Naive Bayes, though computationally efficient, works less effectively with an accuracy of 65% and illustrates the general complexity of more precise models in predicting reality. The system considers users with different access to soil information from general information on the type of soil to detailed nutrient profiles, thus making it serviceable for smallholder and large-scale farmers. The research emphasizes prioritizing key soil parameters; that is, nitrogen, phosphorus, and potassium, as critical elements that determine crop viability and yield. The integration of climatic factors in the study makes the system adaptable to different agricultural environments by aligning the recommendations with regional weather patterns. Beyond its technological advances, the research suggests real potential in machine learning toward precision agriculture. The proposed system, on one hand, empowers farmers with data-driven insight and reduces resource wastage on the other, benefiting the environment as well. Its dual focus on scalability and sustainability integrates it as a transformative device in the agricultural sector to address both immediate and long-term challenges. This work forms the bridge that links traditional farming practices with modern technological solutions to pave the way to a more resilient and productive agricultural landscape.

1. Introduction

The agriculture sector is threatened by various and complex challenges of the 21st century, which are mainly fuelled by increasing climate change effects, widespread soil degradation, and increasing food production to meet soaring demand prompted by a burgeoning world population. This combination has emphasized an urgent need for new and sustainable agricultural practices that would satisfy the growing demand for food while simultaneously reducing environmental impacts. This has dramatically changed the development of intelligent crop and fertilizer recommendation systems within the last couple of years through the advancement of machinery learning and deep learning. Such advanced systems will probably optimize agricultural productivity as well as promote eco-friendlier farming methodologies by