Yield Estimation of Potato Crop Using Uav Imageries and Machine Learning Algorithms

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SUMMARY

Agricultural yield estimation plays a pivotal role in enhancing food security, ensuring effective resource allocation, and supporting decision-making in precision agriculture. In countries like Nepal, where smallholder farming is predominant and traditional yield estimation techniques remain manual, labour intensive, and time-consuming, there is a critical need for modern, accurate, and scalable approaches. This study introduces a data-driven framework for estimating potato yield by integrating Unmanned Aerial Vehicle (UAV) remote sensing with machine learning algorithms.

The research was conducted in a 3.7-hectare agricultural field in Dhulikhel Municipality, Kavrepalanchok District, Nepal. High-resolution imagery was acquired using both RGB and multispectral sensors mounted on UAV platforms across five key phenological stages of the potato growth cycle. To ensure spatial accuracy and reliable data, nine Ground Control Points (GCPs) were established using Differential GPS, and 80 georeferenced sample plots were used for systematic ground truthing. Vegetation indices (VIs) derived from UAV imagery including NDVI, EVI, CIrededge, VARI, and others were computed and statistically analysed to assess their correlation with actual yield data.

A total of twenty vegetation indices were extracted, and both simple and multiple linear regression models were applied to determine their predictive capabilities. Seven advanced machine learning algorithms support Vector Machine (SVM), Random Forest, XGBoost, AdaBoost, Decision Tree, Gradient Boosting, and K Nearest Neighbors (KNN) were trained and tested for yield prediction performance. The multi-temporal multiple linear regression model, incorporating indices from various stages of crop development, achieved the highest performance with an R^2 value of 82.61% and a predicted R^2 of 77.54%. Among the machine learning models, Gradient Boosting

outperformed others with an R^2 of 76.62% and RMSE of 0.1526, indicating high prediction accuracy.

The study also revealed that multispectral-based vegetation indices had greater predictive power than those derived from RGB imagery, underlining the advantage of using multispectral UAV sensors in precision agriculture. For example, the Chlorophyll Index Red Edge (CI1) showed significantly higher correlation with yield than the RGB-based VARI index. These results confirm the relevance of spectral data in capturing the physiological characteristics of crops that are closely related to productivity.

Throughout the research, a comprehensive set of data was generated, including high-resolution orthomosaics for each growth stage, digital surface models (DSMs), digital terrain models (DTMs),, vegetation index maps, plant height models, and yield sample polygons linked with ground-truth yield measurements. These datasets enabled rigorous statistical analysis, model training, and yield mapping, forming a valuable resource for future research and decision-making in precision agriculture.

The overall findings suggest that combining UAV-acquired spectral data with advanced analytical techniques provides a reliable, non-destructive, and spatially explicit method for crop yield estimation and health monitoring. This integrated approach has the potential to transform traditional agricultural practices in Nepal by enabling timely interventions, optimizing resource use, and supporting smallholder farmers with actionable insights.