Species - Level Mangrove Classification Using UAV Multispectral Imagery and Machine Learning: A Case Study from Rekawa Lagoon, Sri Lanka

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Accurate species-level mapping of mangrove forests remains a persistent challenge due to spectral similarity among taxa and the limited spatial resolution of conventional satellite imagery. Despite increasing recognition of Sri Lanka's mangrove biodiversity, no previous study has employed unmanned aerial vehicle (UAV)-derived multispectral imagery integrated with machine learning for automated species-level classification. This study aimed to discriminate four dominant mangrove species, namely *Lumnitzera racemosa, Avicennia officinalis, Excoecaria agallocha,* and *Rhizophora mucronata,* within an approximately 12-hectare mangrove area of Rekawa Lagoon, Sri Lanka. An integrated framework was developed, combining UAV derived multispectral imagery, object-based image analysis, and comparative machine learning classification. Five-band multispectral imagery was acquired using a DJI Phantom 4 Multispectral UAV equipped with a Real-Time Kinematic Global Navigation Satellite System, flown at an altitude of 70 m, achieving a ground sampling distance of 3.44 cm. Image objects were delineated using the mean shift segmentation algorithm. Twenty-eight features were extracted, encompassing raw spectral bands, six vegetation indices, sixteen Haralick texture metrics, and a canopy height model. Ground truth data were incorporated to train and validate the classification models. Three machine learning algorithms implemented in ArcGIS Pro 3.6-Support Vector Machine (SVM), Random Forest (RF), and K-Nearest Neighborhood (KNN) were evaluated across five incremental feature combinations. SVM achieved the highest overall accuracy of 82.18% when spectral bands were combined with canopy height data. McNemar's statistical test confirmed canopy height as the most significant contributor to classification performance ($p < 0.05$). Vegetation indices yielded no statistically significant improvement over baseline spectral features, while texture metrics provided a secondary but meaningful contribution. These findings underscore the importance of three-dimensional structural information for resolving spectral ambiguity among mangrove species. The proposed framework offers an operationally efficient and transferable approach for high-resolution mangrove species mapping, biodiversity assessment, and conservation planning in Sri Lankan coastal ecosystems.

Keywords: *Mangrove classification, Machine learning, Multispectral, UAV*