Abstract

Climate change mitigation through the nature-based solution (NBS) has been widely emphasized in the Conference of Parties (COP 26) meeting in Glasgow, UK. As the agricultural land expansion is the primary driver of deforestation, agroforestry could be an optimal land-use strategy for climate change mitigation and reducing the pressure on forests. Besides, agroforestry has a promising potential for carbon sequestration. The agroforestry site suitability and ecosystem service assessment are increasing steadily with the recent advances in geospatial and data science technology. The current study focuses on four aspects: (i) classifying different cropping practices and crop intensity by employing multispectral time-series satellite data and machine learning models, (ii) predicting aboveground biomass (AGB) in agroforestry systems using machine learning, (iii) to assess site-suitability and site-specific interventions for agroforestry using data synergy, and (iv) to develop a WebGIS platform for adaptation in delivering an effective tool for agroforestry interventions. Odisha, a forest-dominated Indian state on the east coast, has been selected as a study site due to its landscape heterogeneity and people's dependency on forests and agriculture for livelihood and sustenance. The Belpada block in Balangir district, Odisha, was selected for intensive study. The field data on various crop types and practices, agroforestry interventions, and plot-level biophysical parameters such as tree girth size and height were recorded. The time-series Sentinel-2 optical data were employed for crop types and land use land cover (LULC) mapping using the Time Weighted Dynamic Time Warping (TWDTW), Random Forest (RF) and Support Vector Machine (SVM) machine learning models. RF demonstrated better classification accuracy (overall > 91% and kappa 0.88) than TWTDW and SVM. The Sentinel-2 optical and Sentinel-1 SAR data were integrated to harvest data synergy for AGB estimation using machine learning models (RF, SVM and Artificial Neural Network [ANN]). The RF model showed the highest accuracy (R^2=0.69), followed by ANN (R^2=0.63) and SVM (R^2=0.54) for AGB prediction. The agroforestry site-suitability analysis employed 15 variables on climate, soil, topography, and proximity, wherein the LULC map was referred to prescribe the appropriate interventions using multi-criteria evaluation. The RF algorithm was applied to estimate the relative weight of the determinant variables based on 70% of the total existing agroforestry sites. The validation with the remaining 30% observation indicated high accuracy (average suitability >0.87). The suitability model was applied to the entire Odisha that revealed > 0.87% accuracy when validated with independent ground truth datasets from the Nuapada district of Odisha. The results demonstrated that >90% of the agricultural land could be suitable for various agroforestry interventions, such as bund, boundary plantation and intercropping, based on the cropping intensity. Finally, the intermediate and output layers and nursery location data have been hosted in an interactive WebGIS platform, developed for farmers and managers in implementing agroforestry and farming policies.

Keywords: Machine learning models, LULC and crop type classification, Agroforestry site suitability, Aboveground biomass, WebGIS, Multi-Criteria Evaluation