Abstract

This study focuses on two major environmental aspects, i.e., assessment of impacts of mining on forest health and intrusion of modern hyperspectral remote sensing technology to monitor forest health for effective geo-environmental planning and management. This work emphasizes on four objectives: (i) Forest health assessment for geo-environmental planning and management (ii) Assessment of impact of mining activities on tree species and its diversity (iii) Foliar dust estimation and mapping for environmental monitoring of forest surrounding mines and (iv) Assessment and prediction of forest health risk (FHR) for effective planning and management of mining-affected forest area. In this work, we had used narrow-banded vegetation indices (VIs) for forest health assessment based on the VIs model. Also, we had classified forest health status (healthy, moderated healthy, and unhealthy) based on tree spectral data analysis. Hyperspectral data (Hyperion) used with VIs model shown better accuracy for forest health assessment (overall accuracy 81.52%, kappa statistic 0.79) than spectral angle mapper (overall accuracy 79.99 %, kappa statistic 0.75) as well as support vector machine (overall accuracy 76.53 %, kappa statistic 0.71).It was observed that the health assessment accuracy (SVM) achieved with hyperspectral bands was significantly higher than multispectral Landsat-OLI data (overall accuracy 67.27 %, kappa statistic 0.62). The result showed that healthy forest parts are found in the upper as well as the lower hilly side of Kiriburu and Meghahatuburu mines. Furthermore, it also exhibits a negative relation amongst different forest health class, distance from mines, and foliar dust concentration. In the present study, we have classified the local tree species, and its diversity was estimated based on hyperspectral remote sensing data at a fine-scale level as well as correlated with foliar dust concentration and distance to mines. A total of 21 spectral wavebands were selected by discrimination analysis (Wilk's Lambda test). The SVM, SAM, and MD algorithms were applied for tree species classification based on field trees spectra data. The hyperspectral VIs were used to estimate species diversity based on field measured Shannon diversity index. The result shows that NDVI705 (Red edge normalized difference vegetation index) is having the best R^2 (0.76) and lowest RMSE (0.04) for species diversity estimation. The results portrayed a good negative correlation between foliar dust concentrations; Shannon Index based species diversity, and the distance from mines. The scope of this work is to estimate foliar dust concentration using Hyperion and Landsat images, with the aid of eight different VIs and field-based laboratory spectra. The healthy and dust contaminated areas were detected by vegetation combination analysis using narrow banded VIs. Vegetation different (VI_{diff}) based dust model used for this estimation and mapping. The NDVI (Normalized difference vegetation index) showed an excellent negative correlation (R^2=0.89 for Hyperion and R^2= 0.81 for Landsat). Amongst the eight VIs, NDVI was selected as an optimal VI (RMSE = 0.06 g/m^2 for Hyperion and 0.11 g/m^2 for Landsat) based on both, the field measurement and satellite data for estimation of foliar dust concentration. The result showed that maximum foliar dust was concentrated near the ore transportation network, surrounding mining locations, tailing ponds, and mining dumps areas. It also exhibits a negative correlation between foliar dust classes and average distances from mines. This work focuses on forest health risk (FHR) assessment and prediction in mining-affected forest regions using an AHP (Analytic hierarchy process) model based on the multi-criteria analysis. We considered twenty-eight parameters, including climate, natural or geomorphology, forest, topography, environment, and anthropogenic variables. Six parameters were also evaluated from the predicted time frame (2030 and 2050). According to the predicted FHR maps, the very high-risk class was found at and around Kiriburu and Meghataburu mines surrounding forest compartments. The sensitivity analysis indicated that some parameters were more sensitive to FHR. The correlation results between FHR and sensitive parameters have shown positive results. The correlation results showed a good negative relationship between FHR and distance from mines and foliar dust concentration. This work will provide a basis for effective geo-environmental planning and management in the mining-affected forest region.

Keywords: Hyperspectral remote sensing, Forest health assessment, Tree species mapping, Plant diversity estimation, Assessment of foliar dust, Forest health risk assessment & prediction