Chapter 8

Conclusions and Recommendations for Future Scope of Work

8.1	Overview	*137*
8.2	Conclusions	*137*
8.3	Future scope of work	*139*

8.1 Overview

The primary objective of this study is forest health monitoring and its risk prediction in mining affected forest area. In this chapter, conclusion of the thesis is presented along with the future scope of work.

8.2 Conclusions

The hyperspectral remote sensing-based forest health monitoring and its risk prediction is today's need so that the forest department, local self-government, and mining companies must adopt an adequate policy for reclamation and restoration of the forest ecosystem affected by mining activities. This research work could be utilized for geo-environmental planning and management of the Saranda forest. This work is a significant step put forward for the protection of forest health, biodiversity conservation as well as effective management of Saranda forest.

Objective 1 carried out the forest health assessment at Kiriburu and Meghahataburu iron ore mines surrounded by forest area. This work demonstrated the use of hyperspectral data to get the result with greater accuracy and proved that it has more capability than multispectral data. The hyperspectral instrument is over upper signal multiplication, high spectral resolution, and high accuracy and has comprehensive coverage of spectral characteristics for forest health assessment. The study focuses on 21 wave-bands obtained from Wilki's Lambda test on hyperspectral remote sensing data, and classification is done by VIs model, SVM, and SAM algorithms to obtain better forest health assessment results. The forest health by VIs model classification (overall accuracy 81.52 %) offered the best result than that educed from SAM (overall accuracy 79.55 %) and SVM (overall accuracy 76.53 %). Hyperion bands achieved significant growth in forest health classification over Landsat-OLI image (overall accuracy 67.21%). Also, a good negative correlation was observed between forest health and distance from mines with leaf dust. It means that, as the mining area increases, forest as well as the surrounding environment will also get affected. This methodology would be capable of monitoring various categories of forest regions routinely irrespective of the different climate conditions, forest structure, and soil conditions.

Objective 2 described the development of methods for tree species mapping and its diversity estimation using hyperspectral and field tree spectral data. The species classification was carried out by comparing three different supervised classification algorithms (SAM, SVM, and MD) of the hilly terrain mining-affected forest region. Hyperion based SVM produced better accuracy (85.16% overall accuracy) followed by SAM (79.55% overall accuracy) and MD (76.58% overall accuracy). The classification accuracy obtained by Hyperspectral (Hyperion) data has better accuracy over Multispectral (Landsat OLI) data (68.71% overall accuracy). The tree species diversity carried out by hyperspectral narrow banded vegetation indices (VIs) are also correlated with field measured Shannon Index. The NDVI705 shown a better fit for species diversity estimation. Also, a good correlation result (R^2=0.72) was observed between fields measured Shannon Index, and Hyperion derived Shannon Index. The output maps and statistics had shown that hyperspectral data has the capability to monitor tree species and its diversity. The study reveals that due to increased mining activities, the tree species and its diversity are diminishing. The tree diversity results showed a reduction in species number and their ecosystem. So, the monitoring of tree species and its diversity are important for forest and its management. Our work mainly focused on the tree species classification, comparison between different classification algorithms, identification of best classifier, species diversity mapping, and correlation between mining and species diversity in hill-top forest region.

Objective 3 deals with the VIs differentiating approach, foliar dust estimation in and around the open-cast mines of Kiruburu and Meghahatuburu iron ore mining sites and its mapping, based on field and laboratory spectral measurements. However, having used both Landsat and Hyperion data, based on the validation of the result by field observations and relevant ancillary data like Google Earth and toposheets, we found that the Hyperion (Hyperspectral) data gave more reliable and accurate results than the Landsat (Multispectral) data. The conclusions of this study are as follows: New methodology might be established to estimate the foliar dust by vegetation indices (VIs) based on laboratory spectral measurements. Due to its higher accuracy and smaller error in dust estimation (i.e., R=0.90 and RMSE=0.06), NDVI was selected to estimate foliar dust volume based on the Hyperion image. According to the result of the spatial analysis, the vegetation dust cover was identified, and its locations were observed near the mining sites, transportation roads, dumps, and tailing ponds. Near the open cast mining area of

Kiriburu and Meghahatuburu, a huge amount of iron ore is extracted and transported, which leads to the generation of enormous amount of dust resulting in the degradation of vegetation health in and around the mining sites. It is suggested that frequent sprinkling of water during dry season could reduce the amount of dust. It is also recommended that if metal roads are constructed, then they might help in decreasing the amount of dust generation. Covers can be used for loaded trucks during the transportation of minerals. Moreover, this methodology could be employed in other mining regions, considering the dust sample variance.

Objective 4, describes about the forest health risk (FHR) assessment, and prediction for forest planning and management. In this study, a total of twenty-eight (twenty-two past and six future) parameters (climate, geomorphology, forestry, topography, environmental, and anthropogenic) are coupled with multi-criteria based AHP model for FHR assessment and prediction at Kiriburu, and Meghataburu mining-affected forest region. The twenty-two past parameters were generated from different data sources and models (of the year 2016). Six future parameters were generated using various models, namely, MOLUSCE, AHP, and MIROC5 (of years 2030, & 2050). Finally, all forest health-related parameters were integrated into a GIS framework using the AHP model for FHR assessment and prediction. The sensitivity analysis had shown that some parameters (mines to distance, temperature, LST, foliar dust, wind speed, deforestation, drought, tree diversity, NDVI, altitude, future maximum temperature, and deforestation susceptibility) are more sensitive to FHR for this region. The results of the FHR assessment were validated with sixty field spectra of forest health. This study showed that the forest health risk (FHR) will increase in the future due to the mining and allied activities. The results also portrayed that most of the very-high FHR classes are close to mining sites. Very high FHR zones are situated at the Kiriburu and Meghataburu mining surrounding forest compartments. Future FHR (for the year 2050) results also showed that these forest compartments are at high risk. Therefore, we have requested the local forest administration to take remedial action for these compartments as soon as possible. We believe that this work could be applied to other mining-affected forest regions also with suitable modifications of parameters.

8.3 Future scope of works

The future scope of this research work can be highlighted as follows:

1. Though Hyperspectral remote sensing is a hopeful tool for effective forest health assessment, the result could be exceptionally good by ultra-hyperspectral images coupled with large scale field survey data.
2. High-resolution satellite data could be used for better results with greater accuracy in tree species and its diversity estimation.
3. The methodology adopted in this study for foliar dust estimation could be modified, considering the dust samples variance and apply in other mining areas.
4. The methodology for FHR assessment and its prediction could be applied not only in the mining-affected forest area, but to other regions also with suitable modifications to parameters.
5. Continuous Drone survey coupled with ultra-hyperspectral imagery for forest health monitoring could serve as the base for future work in forest management and geo-environmental planning.