FOREST RESOURCES MAPPING IN MONGOLIA USING MULTISOURCE IMAGES

D.Amarsaikhan[*1], V.Battsengel[2], E.Egshiglen[1] and D.Enkhjargal[1]

[1]Institute of Informatics and RS, Mongolian Academy of Sciences
Ave.Enkhtaivan-54B, Ulaanbaatar-51, Mongolia; Tel: 976-11-453660, Fax: 976-11-458090

[2]Department of Geography, National University of Mongolia
Ikh Surguuliin gudamj-6, Ulaanbaatar-46, Mongolia; Tel/Fax: 976-11-322822

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ABSTRACT: The aim of this study is to conduct forest resources mapping using multisource images. As data sources, Landsat ETM+ image and Envisat C-band synthetic aperture radar (SAR) VV polarisation data are used. As a method for the land cover information extraction, a Mahalanobis distance classifier is applied. Overall, the study demonstrates that the combined use of the optical and microwave data sets can improve a forest mapping and produce an improved map used for different decision-making processes.

1. INTRODUCTION

Forests cover approximately 30 percent of the land area of the planet, however, estimates suggest that deforestation is occurring at a rate of between 15-17 million ha per year, predominantly because of human-induced land-use changes. Over 45 per cent of the Earth's original forests have been cleared during the past century. These human-induced changes in forest extent and condition impact biodiversity, climate, biochemical cycles and economic development. Therefore, it is very important to protect forests, as they contain the majority of the planet's land-based species. Nature's products support such diverse industries as agriculture, cosmetics, pharmaceuticals, pulp and paper, horticulture, construction and waste treatment. In addition, forests regulate the global atmospheric cycles that make biological life possible on earth (Amarsaikhan *et al.* 2011).

In recent years, deforestation and forest land degradation have become the main concern for forest specialists and ecologists as well as policy and decision-makers dealing with the environment. It has been found that much of the existing forests have been destroyed, mainly by shifting cultivation, timber preparation, legal and illegal logging, forest fires and increased number of people involved in agricultural activities. To protect and conserve the deteriorating forest, there are needs to conduct thorough planning and management. For rapid planning and management, one needs very accurate and real-time spatial information (Amarsaikhan *et al.* 2009). Although, such information can be collected from many different sources, the most reliable source that could provide data for the real-time analysis might be remote sensing (RS).

The aim of this research is to conduct forest resources mapping using optical and microwave RS images. For this purpose, a test site located in northern Mongolia has been selected. As RS data sources, visible and infrared bands of Landsat ETM+ data with a spatial resolution of 28m and Envisat C-band image with a spatial resolution of 25m were used. To produce a land cover map from the multisensor images, a Mahalanobis distance classifier has been applied. For the accuracy assessment an overall accuracy was used selecting more randomly distributed pure pixels. Overall, the study demonstrated that the combined use of optical and radar images could be successfully used for forest resources mapping.

2. STUDY AREA AND DATA SOURCES

As a test site, a coniferous forest-dominated area around the Lake Khuvsgul located in northern Mongolia has been selected. The lake is considered as the second largest fresh water lake in Asia after the Lake Baikal with 100 km in length, 35 km in width, and over 265 m in depth. The area in this region represents a forest ecosystem and is characterized by such main classes as coniferous forest, deciduous forest, grassland, light soil, dark soil and water. The annual precipitation in the region is about 350-400 mm and it makes the area as the most humid region in the country. As data sources, Landsat ETM+ data of August 2010 with a spatial resolution of 28m, Envisat C-band VV polarization image with a spatial resolution of 25m of September 2010 with a spatial resolution of 25m, a topographic map of scale 1:100,000 and a forest taxonomy map have been used. The selected test site in the Landsat ETM+ image frame is shown in figure 1.

Figure 1. Landsat ETM+ image of the test area.

3. GEOMETRIC CORRECTION OF THE MULTISENSOR IMAGES

At the begining, the Landsat ETM+ image was geometrically corrected to a UTM map projection using a topographic map of the study area, scale 1:100,000. The ground control point (GCPs) have been selected on clearly delineated crossings of rivers, mountain peaks and other clearly defined sites. In total 16 points were selected. For the transformation, a second order transformation and nearest neighbour resampling approach have been applied and the related root mean square (RMS) error was 0.95 pixel. In order to geometrically correct the SAR image, 16 more regularly distributed GCPs were selected comparing the locations of the selected points with other information such as Landsat ETM+ image and the topographic map. Then, the image was georeferenced to a UTM map projection using the topographic map of the study area. For the actual transformation, a second order transformation and nearest neighbour resampling approach were applied and the related RMS error was 1.23 pixel.

As the microwave images have a granular appearance due to the speckle formed as a result of the coherent radiation used for radar systems; the reduction of the speckle is a very important step in further analysis. The analysis of the radar images must be based on the techniques that remove the speckle effects while considering the intrinsic texture of the image frame (Serkan *et al.* 2008). In this study, four different speckle suppression techniques such as local region, lee-sigma, frost and gammamap filters (Amarsaikhan *et al.* 2010) of 3x3 and 5x5 sizes were applied to the SAR image and compared in terms of delineation of forest and other texture information. After visual inspection of each image, it was found that the 5x5 gammamap filter created the best image in terms of delineation of different features as well as preserving content of texture information. After the speckle suppression, the microwave image was added to the optical bands, thus forming multisource images.

4. FOREST LAND COVER MAPPING USING OPTICAL IMAGE

Initially, from the Landsat ETM+ image, several areas of interest (AOIs) representing the selected classes (ie, coniferous forest, decideous forest, grassland, light soil, dark soil and water) have been selected using a polygon-based approach. Then, training samples were selected on the basis of these AOIs. The separability of the training signatures was firstly checked on the feature space images and then evaluated using transformed divergence (ERDAS 1999). After this, the samples demonstrating the greatest separability were chosen to form the final signatures. For the classification, bands 3,4,5 and 7 of Landsat ETM+ data have been used.

For the actual classification, a Mahalanobis distance classifier has been used. The Mahalanobis distance classification a parametric method, in which the criterion to determine the class membership of a pixel is the minimum Mahalanobis distance between the pixel and the class centre. The sample mean vectors and variance-covariance matrices for each class are estimated from the selected training signatures. Then, every pixel in the dataset is evaluated using the minimum Mahalanobis distance and the class label of the closest centroid is assigned to the pixel (Richards and Jia, 1999). The classified image is shown in figure 2. As seen from the figure 2, although the optical image performed well, still, there are different overlaps on the decision boundaries, especially among the statistically similar classes.

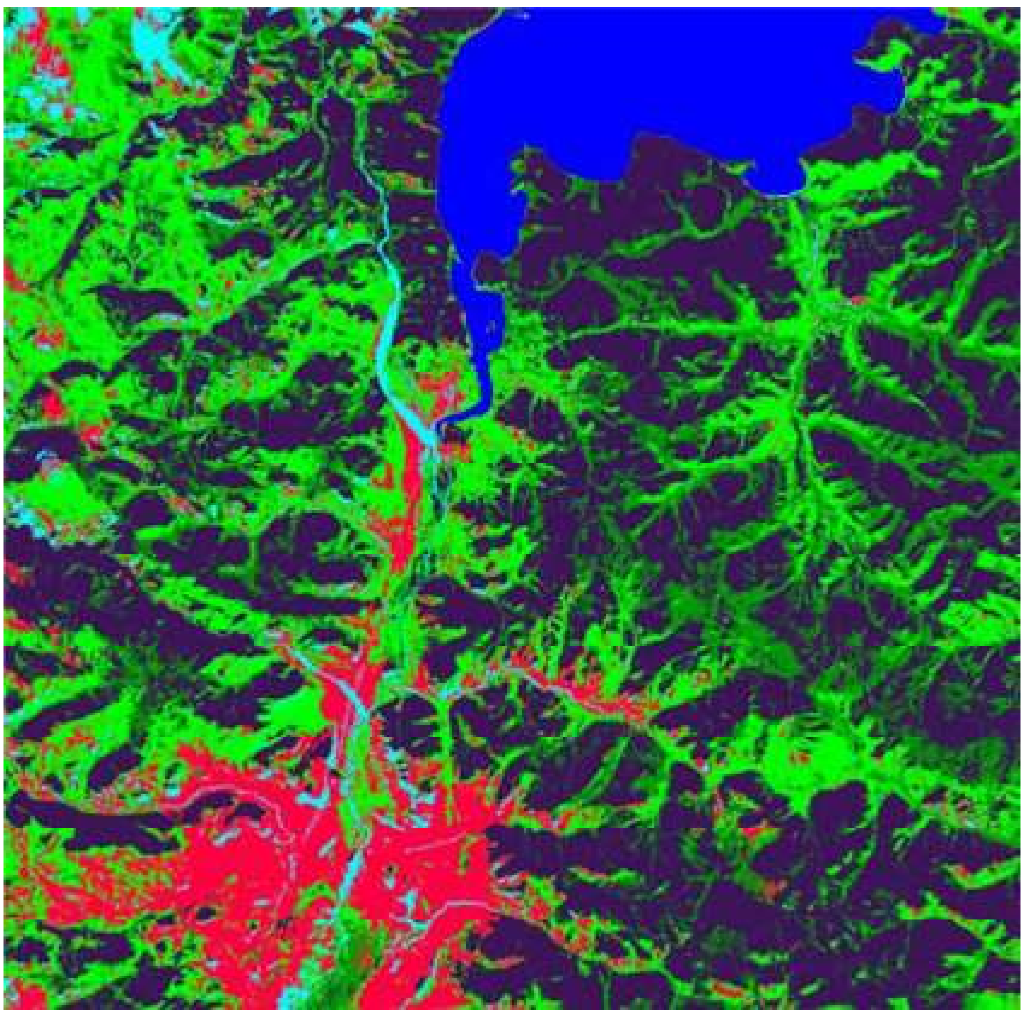

Figure 2. The classification result of the Landsat ETM+ image.

For the accuracy assessment of the classification result, the overall performance has been used. This approach creates a confusion matrix in which reference pixels are compared with the classified pixels and as a result an accuracy report is generated indicating the percentages of the overall accuracy (Mather, 1999). As ground truth information, different AOIs containing 10708 purest pixels have been selected. AOIs were selected on a principle that more pixels to be selected for the evaluation of the larger classes such as conferous forest and grassland than the smaller classes such as decideuos forest and dark soil. The confusion matrix produced for the Landsat ETM+ image classification showed overall accuracy of 86.93%.

5. FOREST LAND COVER MAPPING USING MULTISOURCE IMAGES

For several decades, multispectral data sets have been effectively used for a land cover mapping. Unlike single-source multichannel data, multisource data sets have proved to offer better potential for discriminating between different land cover types, because of the complementary information provided by these sources (Amarsaikhan *et al.* 2012). For the classification of optical and SAR data sets, the same set of training samples and bands 3,4 and 5 of Landsat ETM+ data as well as Envisat VV polarisation image have been used. As the classification method, again the Mahalanobis distance classifier was applied.

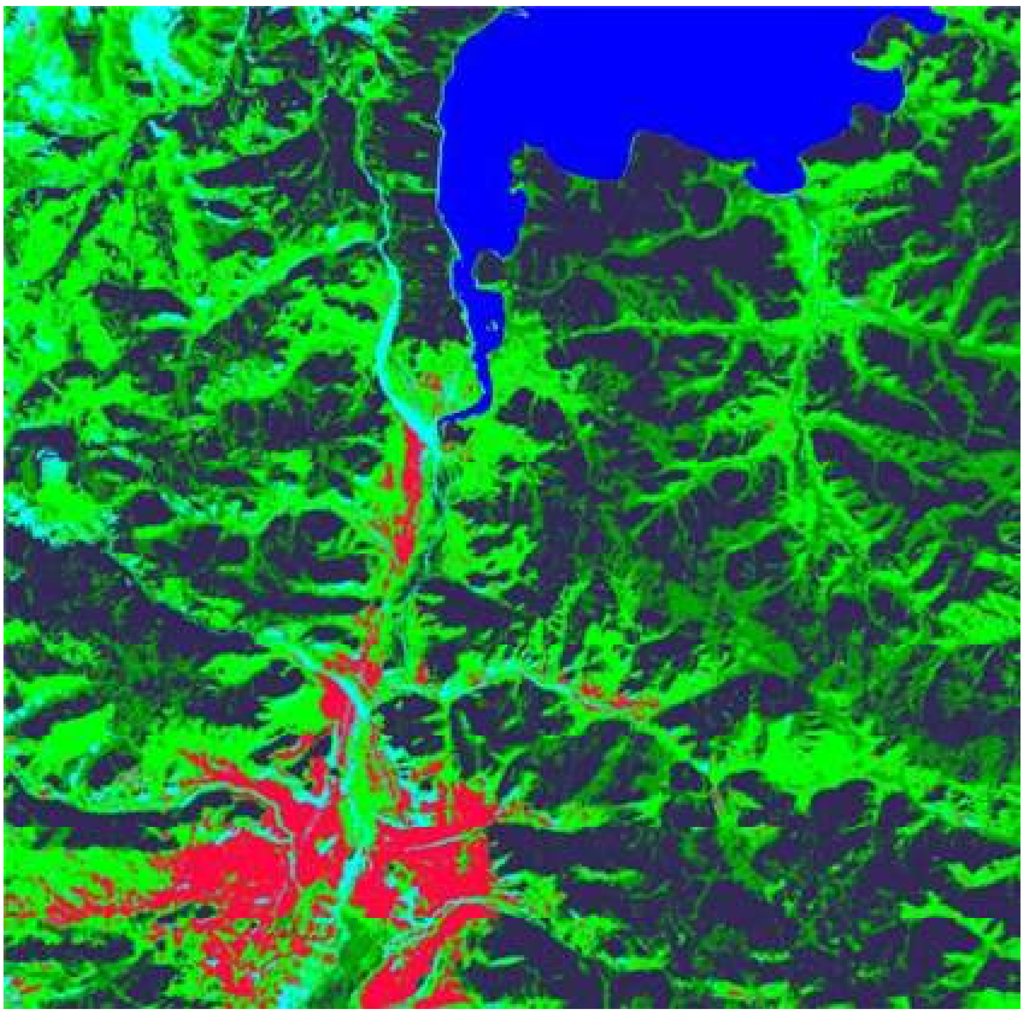

Figure 3. The classification result of the multisource images.

The result of the classification is shown in figure 3. As seen from the figure 3, unlike in the result of the optical image, in the result of the multisource images, there are less overlaps on the decision boundaries among the statistically mixed classes. For the accuracy assessment of the classification result of the multisensor images, the overall performance has been used, taking the same number of sample points as in the previous classification. The confusion matrix produced for the multisource image classification indicated overall accuracy of 90.68%. As could be seen from figure 3, the result of the multisource data classification is better than the result of the standard method and can be used for further forest related decision-making processes.

6. CONCLUSIONS

The overall idea of the study was to produce a reliable forest land cover map used for forest related decision-making processes by applying a standard classification method. For this aim, multispectral Landsat ETM+ image and Envisat C-band VV polarization data were used and as the method for the classification, the Mahalanobis distance classification was selected. At first, the Landsat ETM+ image was independently classified, and then it was classified along with the microwave image. As seen from the results of the classification, the original optical image could not reduce the overlaps on the decision boundaries and separate well the statistically similar classes. However, it was seen that the multisource data sets could solve this problem and produced an improved forest land cover map.

7. REFERENCES

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