APPLICATIONS OF OPTICAL AND MICROWAVE RS FOR FOREST MAPPING IN MONGOLIA

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ABSTRACT: The aim of this study is to produce a reliable forest land cover map using optical and microwave images. For this purpose, Landsat ETM+ image and PALSAR L-band HH polarisation data are used. As a method for the land cover mapping, a statistical maximum likelihood decision rule is applied. Overall, the study demonstrates that the combined use of the optical and synthetic aperture radar (SAR) data sets can improve a forest mapping and produce a reliable map for forest planning and management.

1. INTRODUCTION

Forest is a very important natural resource that plays a significant role in keeping an environmental stability, ecological balance, environmental conservation, food security and sustainable development in both developed and developing countries. 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. 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) (Amarsaikhan *et al.* 2011).

As it is known, optical RS data sets taken from different Earth observation satellites such as Landsat, SPOT and ASTER have been successfully for forest monitoring and management since the operation of the first Landsat launched in 1972. Meanwhile, SAR images taken from space platforms have been widely used for different forest applications since the launch of the ERS-1/2, JERS-1 and RADARSAT satellites. The combined application of data sets from both sources can provide unique information for different forest studies, because passive sensor images will represent spectral variations of the top layer of the forest classes, whereas microwave data with its penetrating capabilities can provide some additional information about forest canopy (Amarsaikhan *et al.* 2004). Moreover, it is clear that the integrated use of the optical and microwave data sets should improve the accuracy in a forest mapping, because as the images are acquired in different ranges of electro-magnetic spectrum, could inluence the decision-making in overlapping boundaries (Amarsaikhan *et al.* 2009).

The aim of this research is to conduct a forest mapping and produce a reliable forest land cover map using optical and microwave 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 ALOS PALSAR L-band HH polarization data with a spatial resolution of 25m were used. To produce a land cover map from the multisensor images, a statistical maximum likelihood classification has been applied and for the accuracy assessment an overall accuracy was used. The analysis was carried out using Erdas Imagine system installed in a PC environment.

2. STUDY AREA AND DATA SOURCES

As a test site, a forest-dominated area around the Khuvsgul Lake located in northern Mongolia has been selected. The area represents a forest ecosystem and is characterized by such main classes as coniferous forest, deciduous forest, grassland, light soil, dark soil and water. As data sources, Landsat ETM+ data of August 2007 with a spatial resolution of 28m, ALOS PALSAR L-band HH polarization image of 17 August 2007 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

Initially, the Landsat ETM+ image was geometrically corrected to a Gauss-Kruger 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 and other clear sites. In total 15 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 0.96 pixel.

In order to geometrically correct the PALSAR 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 Gauss-Kruger 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 1.18 pixel.

4. FOREST LAND COVER MAPPING USING LANDSAT ETM+ IMAGE

Initially, from the Landsat ETM+ image, 2-3 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 polygonbased 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 Jeffries–Matusita distance (Richards and Jia 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 statistical maximum likelihood classification has been used. The maximum likelihood classification is the most widely used supervised classification technique, because a pixel classified by this method has the maximum probability of correct assignment (Amarsaikhan *et al.* 2010). 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.

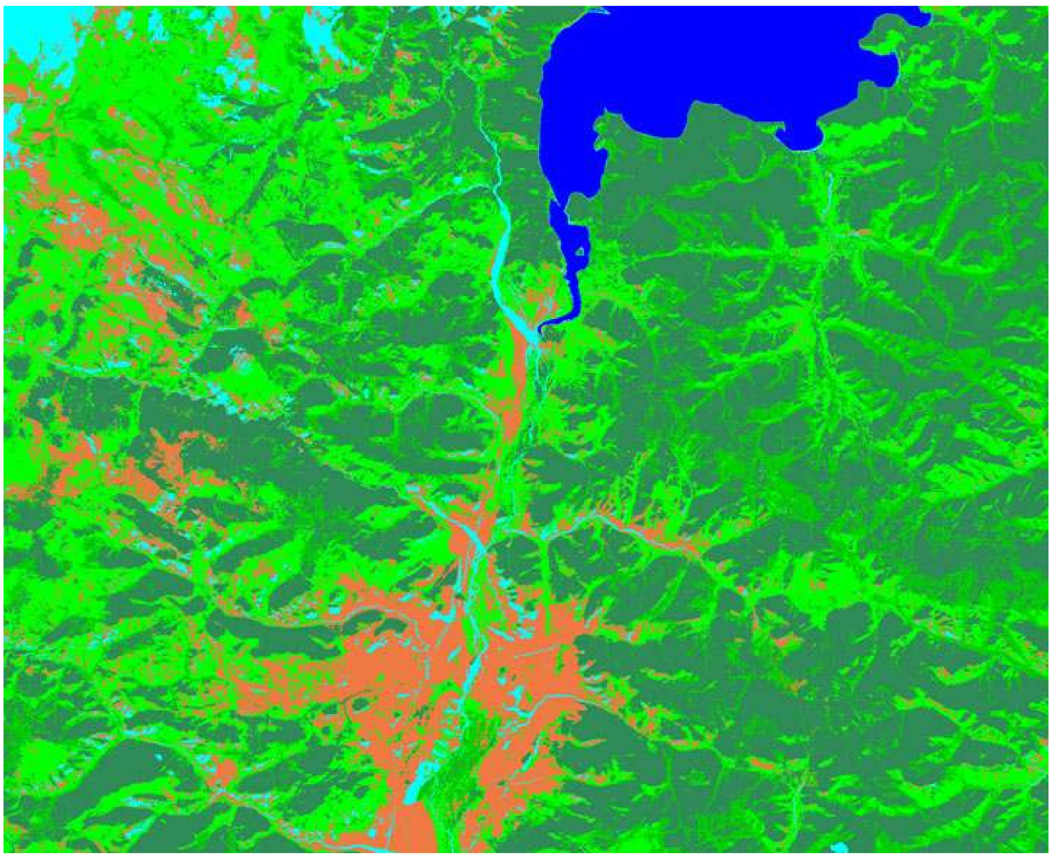

Figure 2. The classification result of the Landsat ETM+ image.

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 10895 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 86.65%.

To separate the statistically mixed classes, the class specific features can be applied. The class specific features can be determined through the feature extraction process or addition of bands originated from different sources. In the present study, the second approach has been used.

5. FOREST LAND COVER MAPPING USING LANDSAT ETM+ AND PALSAR IMAGES

In the current study, as the class specific feature, the PALSAR HH polarisation image has been used. As the image was acquired at L-band frequency, the wavelength will penetrate to the forest canopy and will cause volume scattering to be derived from multiple-path reflections among twigs, branches, trunks and ground. This interaction will determine the overall backscatter coming from the entire forest and due to this valuable information to be used for the classification improvement will be formed.

In general, before applying a classification decision rule, the speckle noise of the SAR images should be reduced. The reduction of the speckle increases the spatial homogeneity of the classes which in turn improves the classification accuracy. In this study, to reduce the speckle of the PALSAR HH polarisation image a 5x5 size gammamap filter has been applied (ERDAS 1999). After the speckle suppression, the SAR image was added to the optical bands, thus forming multisource images. For the classification, the same set of training samples and bands 3,4 and 5 of Landsat ETM+ data as well as PALSAR HH polarisation image have been used. As the classification method, again the maximum likelihood classification was applied.

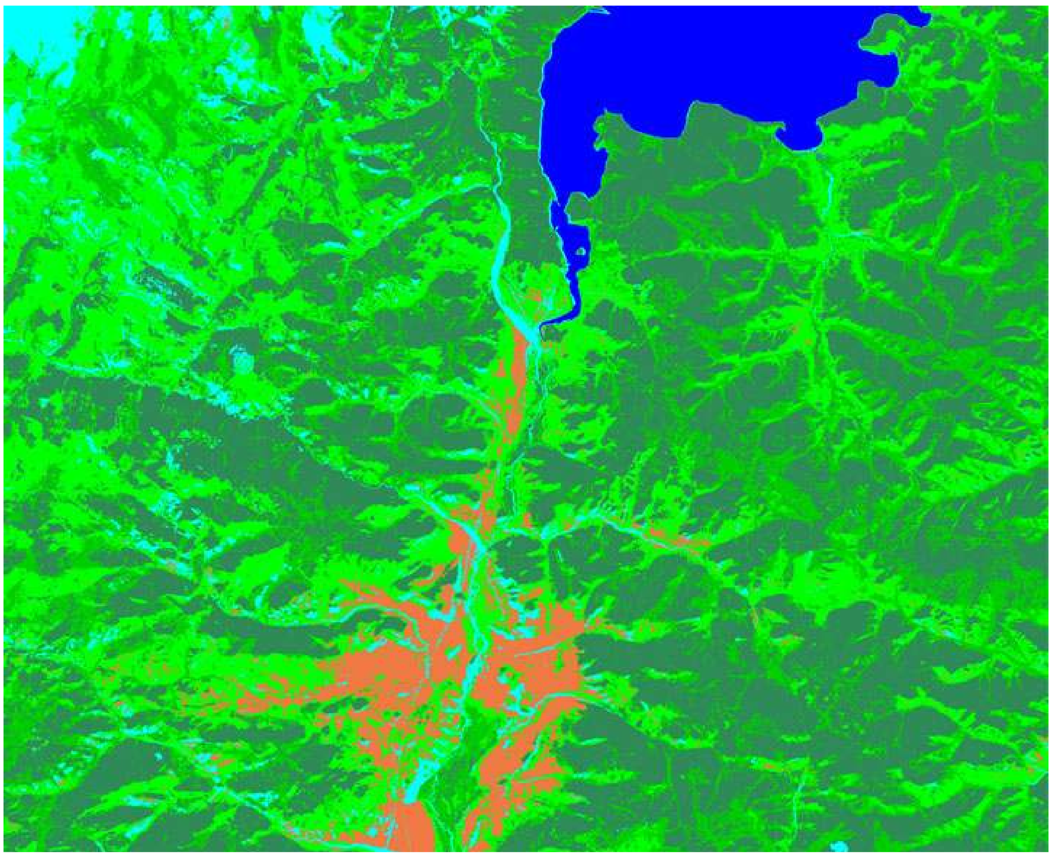

Figure 2. The classification result of the multisource images.

The result of the classification is shown in figure 3. As seen from the figure 3, unlike in the result of the Landsat ETM+ 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 multisource 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 showed overall accuracy of 90.06%. As the classification accuracy exceeds 90% threshold, the result can be used for forest planning and management.

6. CONCLUSIONS

The overall idea of the research was to produce a reliable forest land cover map used for planning and management by applying a standard classification method. For this aim, multispectral Landsat ETM+ image and PALSAR L-band HH polarization data were used and as the method for the classification, the statistical maximum likelihood decision rule was selected. Initially, the Landsat ETM+ image was independently classified, and then it was classified along with the SAR 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 combined use of the optical and microwave data sets could solve this problem and able to produce a reliable land cover map to be used for forest planning and management.

REFERENCES

Amarsaikhan, D., Ganzorig, M., Batbayar, G., Narangerel, D. and Tumentsetseg, Sh., 2004, An integrated approach of optical and SAR images for forest change study, Asian Journal of Geoinformatics, No.3, 2004, pp.27-33.

Amarsaikhan, D., Bolorchuluun, Ch., Narangerel, Z. and Gantuya, R., 2009, Integration of RS and GIS for forest monitoring in Mongolia, Full paper published in CD-ROM Proceedings of the Asian Conference on RS, Beijing, China.

Amarsaikhan, D., Blotevogel, H.H., van Genderen, J.L., Ganzorig, M., Gantuya, R. and Nergui, B., 2010, Fusing high resolution TerraSAR and Quickbird images for urban land cover study in Mongolia, International Journal of Image and Data Fusion, Vol.1, No.1, pp.83-97.

Amarsaikhan, D., Ganzorig, M. and Shiirev-Adya, S., 2011, Applications of advanced technology for combating land degradation and desertification in Mongolia, Proceedings of the Council Asia Conference, Ulaanbaatar, Mongolia.

ERDAS. 1999. Field guide. Fifth Edition, ERDAS, Inc. Atlanta, Georgia.

Mather, P.M., 1999, Computer Processing of Remotely-Sensed Images: An Introduction, Second Edition, (Wiley, John & Sons).

Richards, J.A., and Jia, X., 1999, Remote Sensing Digital Image Analysis-An Introduction, Third Edition, (Berlin: Springer-Verlag).