THE CLASSIFICATION OF FOREST TREE SPECIES USING SATELLITE IMAGERY IN MONGOLIA

Dolgorsuren Sanjjav[1]*, Chi-Farn Chen[2] Shou-Hao Chiang[3].

[1] Master Student, International Environment Sustainable Development (IESD), National Central University, 300, Jhongda Rd., Jhongli 32001, Taiwan.
[2,3] Professor and assistant professor in the Center for Space and Remote Sensing, Center for Space and Remote Sensing Research National Central University, 300, Jhongda Rd., Jhongli 32001, Taiwan.

*Corresponding author: dogoo_1011@yahoo.com

KEY WORDS: Landsat image, Terrain variables, Forest inventory, Tree species classification.

ABSTRACT

Forest is a very important ecosystem and natural resource for living things. Based on forest inventories, government is able to make decisions to converse, improve and manage forests in a sustainable way. Field work for forestry investigation is difficult and time consuming, because it needs intensive physical labor and costs, especially surveying in a widely and remotely mountainous area. A reliable forest inventory can give us more accurate and timely information to develop new and efficient approaches of solving problems in a forest area. The remote sensing technology have been recently used for forest investigation for large scale. To produce an informative forest inventory, forest attributes, including tree species and ages, are necessarily investigated. This research focuses on the classification of forest tree species in Erdenebulgan sum, Huwsgul province, Mongolia, using satellite imagery. The study area covers a forest area of 4230.1km^2 and located in a high mountain region in northern Mongolia. Landsat 7 satellite imagery in July, 2011 were used in this study. Supervised classification, support vector machine (SVM), and 30x30 m digital elevation model (DEM), are applied to tree species classification. Result shows that main six different tree species were classified using Landsat imagery. Result of classification map compared with ground truth forest tree species map and overall accuracy was 66.2%.

1. Introduction

Image classification is a useful technique to perform image analysis and pattern recognition. Species classification is an upcoming field with broad applications in the fields of forest management, conservation of biodiversity, tree demographic analysis and forest inventory. (Elvidge, 1990; Vogelmann *et al*., 1993). With the advent of technology in remote sensing, imageries with high spatial and spectral resolutions became commercially available, facilitating researchers in classifying and categorizing forests species on the basis of their unique spectral signatures (Westmoreland and Stow, 1992; Gahegan and Flack, 1996).

This research focuses on the application of Geographic Information System (GIS) and Remote Sensing (RS) technologies for forest management. The main purpose of this research is to use RS and GIS as tools for preparing forest inventory. The traditional methods still prevailing in Mongolia are labor intensive and time consuming. Thus, this research significantly provides a better and improved method for identifying, categorizing and classifying forest tree species.

The main objective of this study is to provide the information of tree species and their spatial distribution in species in Erdenebulgan sum, Huwsgul province, based on the analysis of Landsat 7 satellite imagery and digital elevation model (DEM). The support vector machine (SVM) was used in this study for classification. This algorithm has been widely applied for land-use/land cover classification, pattern recognition, handwritten digit recognition, and text categorization (Vapnik, 1995, Joachims, 1998). This study also attempts to integrate topographical information into conventional supervised classification to improve the classification accuracy. Therefore, this study performed classification of tress species under two experiments: (1) 5 image bands were uses to perform the classification. (2) 5 image bands and 7 terrain variables were both uses to perform the classification. Six classes were identified in the classification results, including larch, birch, cedar, brushwood, fired tree and empty space.

2. Materials

2.1 Study area

The study site is located in the Northern part of Mongolia in the province of Khuwsgul, sum Erdenebulgan , between 50º40’00” S, 101º35’00” E - 108º48” E as shown in Figure 1. The site with the area of 469,400 ha, and forested area is 423,016 ha, falling in the elevation range of 1200 m -1800 m above sea level. The study area is bounded by Russian and Tsagaan-ur sum in the north, Teshig sum, Bulgan province in the east, Tarialan sum in the south and Tunel sum in the west. The topography is relatively mountainous, except some flat plains in the central part of study area. The climate is continental with the average temperature between -12°C~ -30°C in winter, +10°C~+20 °C in summer, and annual total precipitation is about 301 mm. The site is generally covered by snow from late October to April and the maximum snow depth is about 18 cm.

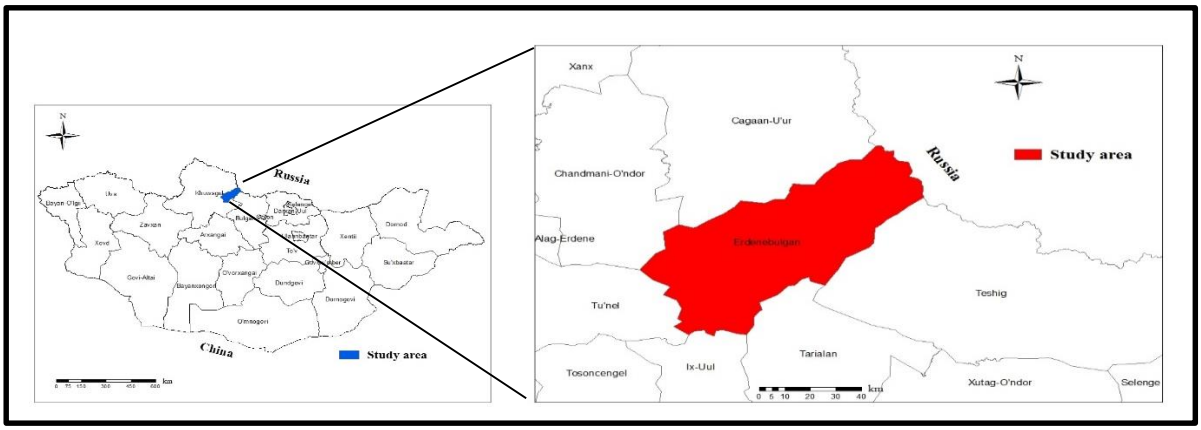

Figure 1. Location of the study area with administrative boundaries of provinces.

2.2 Data

Approximately over 85 % of study area covered by forest. According to results of field work of 2012, we obtained the forest inventory that includes more than seven tree species in this study area (Fig. 2). The area is dominated by Larch (Larix Sibirica), occupying almost 80% of the total forested area. Secondary tree species are Birch (Betula platy-phylla), Cedar and Brushwood, with the coverage of 10% of the forest area. The forest inventory also includes fired tree and empty space where the surveying is not practicable. To perform the tree species classification, Landsat 7 (30m resolution) of September, 2011 and a digital elevation model (DEM) were used (Fig. 3).

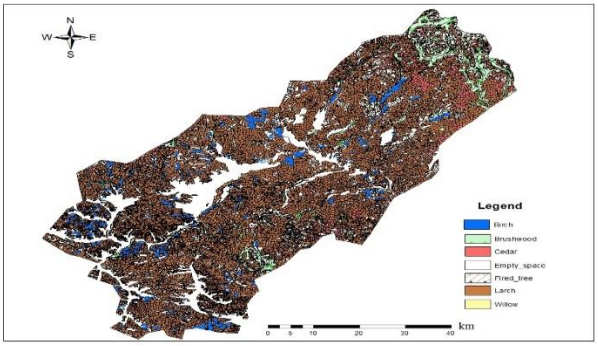

Figure 2. Tree species map of Erdene-bulgan sum (Ground truth)

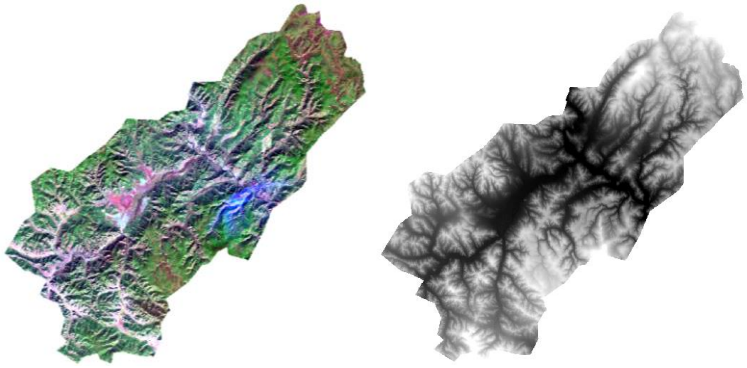

Figure 3. Landsat satellite image and DEM

3. Methodology

Image classification for this study aims to convert spectral data into several forest tree species. A conventional supervised classification algorithm, Support Vector Machine, is selected. This study attempts to integrate topographical information into conventional supervised classification to try to increase classification accuracy. Following methodological framework was applied for this study (Fig. 4).

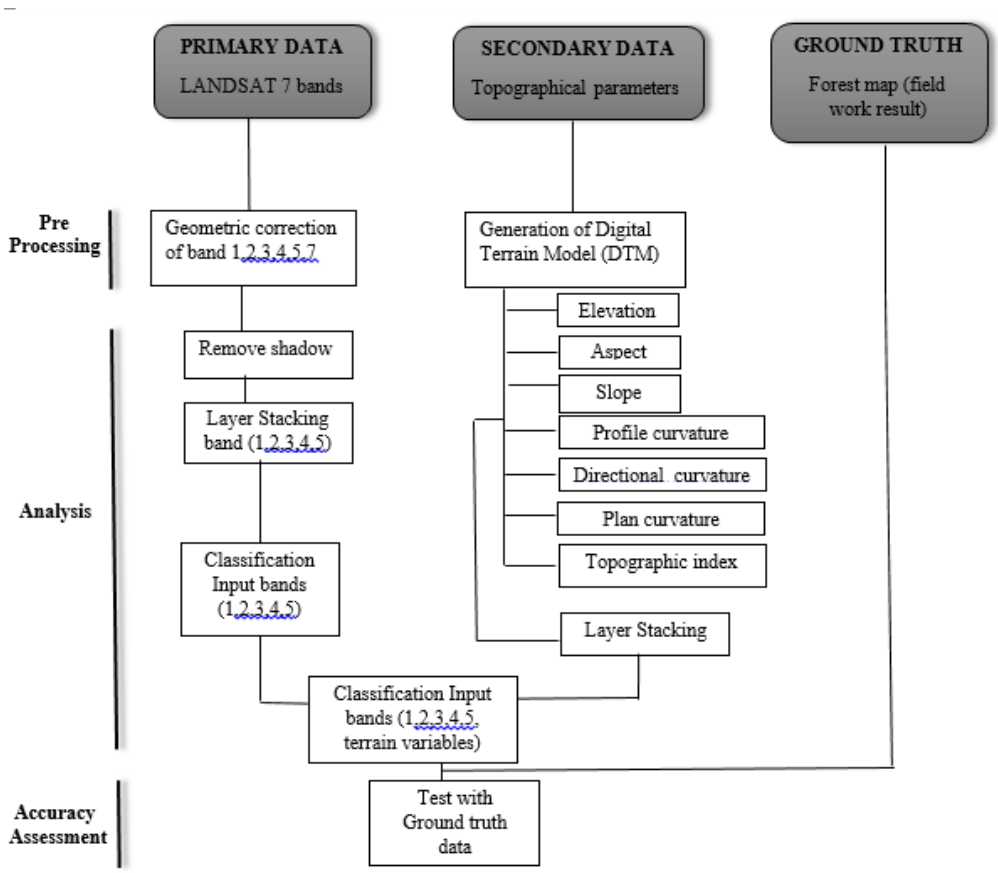

Figure 4. General framework of the study

3.1 Image preprocessing

Geometric correction of the imagery was undertaken using ENVI 4.8 software. Because of topographic condition in this study area is mountainous, the satellite imagery has many shadow areas. To remove all shadow areas, we use Band Math Tools with ENVI 4.8 software. Because band 7 is used to compare with other bands for removing shadow areas, band 7 is not used for classification procedure.

3.2 Terrain variables derived from DEM

In this study, the Aster Digital Elevation Model (DEM 30x30 m) were used to generate seven topographic variables, including slope, elevation, aspect, profile curvature, direction curvature, plan curvature and topographic index. We assume that these ancillary topographic variables may contribute to the improvement of classification procedure.

3.3 Classification analysis and accuracy assessment

This study attempts to integrate topographical information into conventional supervised classification to improve the classification accuracy. Support Machine Vector classification was therefore performed under two experiments: (1) 5 image bands were uses to perform the classification. (2) 5 image bands and 7 terrain variables were both uses to perform the classification. Six classes were identified in the classification results, including larch, birch, cedar, brushwood, fired tree and empty space. To practice the SVM, 1000 training samples were selected and randomly distributed overall the image.

4. Result and Discussion

For accuracy assessment, the forest inventory was used to generate the confusion matrix to obtain the overall accuracies. Classification accuracy is tested by means of two classification results; one is derived from image spectral data (Table 1) and the other from both image spectral and topographic data (Table 2). The comparison between the classification map using satellite image and the ground reference forest map showed that the overall accuracy was 66.2%. Integration of topographical data and spectral data decreased by 22% for overall accuracy for the classification in this study area. Some of terrain variables removed (slope, aspect, elevation and topographic index), rest terrain variables (plan curvature, directional curvature, profile curvature) combined with spectral data. Overall accuracy was increased by 17% with all curvature data and spectral data to compare all topographic data and spectral data. But all topographic data can't increase overall accuracy for forest tree species classification.

Table 1. Confusion matrix for classification of satellite image.

	Ground truth						
Class	Birch1	Cedar1	Empty space1	Fired tree1	Larch1	Brushwood1	Total
Birch	67	1	44	87	259	10	468
Cedar	94	1517	87	452	5332	65	7547
Empty space	60	10	1411	215	2754	357	4807
Fired tree	24	24	161	576	444	133	1362
Larch	2076	504	2144	2272	37195	496	44687
Brushwood	83	53	741	453	2583	2421	6334
Total	2404	2109	4588	4055	48567	3482	65205
				Overall accuracy = 66.2 %			

Table 2. Confusion matrix for classification of satellite image and all terrain variables.`

	Ground truth						
Class	Birch1	Cedar1	Brushwood1	Empty space1	Fired tree1	Larch1	Total
Birch	1326	173	363	1605	1644	16055	21166
Cedar	167	1510	68	84	670	6663	9162
Brushwood	134	193	3322	581	1141	4115	9486
Empty space	147	17	216	1946	328	4276	6930
Fired tree	36	101	267	174	1174	885	2637
Larch	980	455	503	1083	1165	23631	27817
Total	2790	2449	4739	5473	6122	55625	77198
				Overall accuracy = 42.63 %			

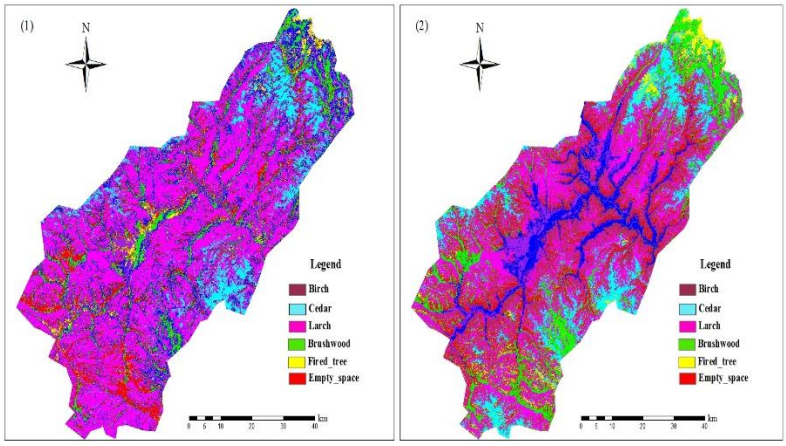

Figure 5. Spatial distribution of tree species estimation derived from SVM classifier using (1) Landsat imagery only, (2) Landsat imagery and all terrain variables in the study area.

5. Conclusion

The goal of this study is to classify forest tree species using Landsat 7 imagery. Classification map result of Landsat 7 image (5 bands) compared with 2012 ground reference forest tree species map and overall accuracy was 66.2%. The result of the classification with topographic data checked that method a reasonable amount of improvement in classification where conventional logical channel approach provided only slight amount of increase in total accuracy. Integration of topographic data and spectral data can't increase overall accuracy in this study area.

6. References

1) Anderson J. R., Hardy E. E., Roach J. T. and Witmer R. E. 1976. "A Land Use and Land Cover Classification System for the Use with Remote Sensor Data" Geological Survey Professional Paper, U.S. Government Printing Office, Washington D.C.
2) Buddenbaum, H., Schlerf, M. and Hill, J. (2005). Classification of coniferous tree species and age classes using hyperspectral data and geostatistical methods. International Journal of Remote Sensing 26 (24): 5453-5465
3) Carleer, A., E. Wolff (2004). Exploitation of Very High Resolution Satellite Data for Tree Species Identification. Photogrammetric Engineering and Remote Sensing 70(1): 135-140.

4) Chen, G., Hay, G. J., Castilla, G., St-Onge, B. and Powers, R., 2011. A multiscale geographic object-based image analysis to estimate lidar-measured forest canopy height using Quickbird imagery. International Journal of Geographical Information Science, 25(6):877-893.
5) Elvidge, C. D. (1990). Visible and near-infrared reflectance characteristics of dry plant materials. International Journal of Remote Sensing 11 (10): 1775-1795.
6) Gualtieri, J. A., and Cromp, R. F., 1998. Support vector machines for hyperspectral remote sensing classification. In Proceedings of the 27th AIPR Workshop: Advances in Computer Assisted Recognition, Washington, DC, Oct. 27, 1998 (Washington, DC: SPIE), 221-232.
7) Liu, X.H., Skidmore,A.K. and Oosten,V.H., 2002, Integration of classification methods for improvement of land-cover map accuracy, ISPRS Journal of Photogrammetry&Remote Sensing, 56, pp 257-268.
8) Markus Immitzer, Clement Atzberger and Tatjana Koukal. 2012. "Tree Species Classification with Random Forest Using Very High Spatial Resolution 8-Band WorldView-2 Satellite Data" Remote Sens. 2012, 4, 2661-2693;
9) Nemmour, H., Chibani, Y., 2006. Multiple support vector machines for land cover change detection: An application for mapping urban extensions. ISPRS Journal of Photogrammetry & Remote Sensing, (61) 125-133
10) Vapnik, V. N., 1995. The nature of statistical learning theory. Springer-Verlag, New York.
11) Westmoreland S. and Stow D. A. (1992) "Category Identification of Changed Land-Use Polygons in an Integrated Image Processing Geographic Information System" Photogrammetric Engineering and Remote Sensing Vol. 58, No. 11, pp. 1593-1599
12) Zhenyu Zhang1, Xiaoye Liu, and Wendy Wright. " Object- based image analysis for forest species classification using Woldview-2 satellite imagery and airborne Lidar D". Journal of Photogrammetry and Remote Sensing, 58:239-258.