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# Application of Landsat ETM+ satellite images in forest cover mapping; case study: Arasbaran protected area

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**Abstract**

Current research was carried out in Arasbaran protected area in order to investigate the capability of landsat ETM+ satellite images in forest cover mapping. For this perpose the ETM+ image of the study area acquired on june 16th, 2001 was used. Radiometric and geometric correction were done for the images. The best spectral bands were selected using Optimum Index Factor (OIF) method. False color composite map was created using bands 4, 3, 2 as the best combination of spectral bands. Sufficient number of training samples of each land cover class were collected for image classification. Supervised classification was accomplished using maximum likelihood classifier and forest cover map of the study area was created. According to the results the area of forest and non-forest classes are 20777.7 ha and 59813.9 ha respectively. Ground truth data was collected using Systematic-cluster sampling method In order to assess the accuracy of classification. The results showed that overal accuracy and kappa statistic are %95 and %88 respectively.

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## Introduction

Up-to-date information on forest and monitoring ongoing spatial processes in forested landscape are great importance to successful and sustainable management of forest resources (Mohammadi *et al.*, 2010). Satellite remote sensing has been used for forest inventories and landuse inventories mainly at a regional level (Varjo, 1995). Due to lower costs and improved technology, attention has recently focused on the benefits of remote sensing to supplement and improve resource information (Watt and watt, 2011). Satellite-based remotely sensed data in combination with semi-automated digital processing could reduce the time required to generate forest and nonforest estimates (Lannom *et al.*, 1995; Cooke, 1999; Czaplewski, 1999; Wayman *et al.*, 2001). In addition to forest and non-forest estimates, information about forests could also be produced from satellite data in a variety of formats including maps (Dymond *et al.*, 2002). Among other applications, these maps could be produced at regular time intervals and would improve the spatial accuracy and precision of forest cover estimates, provide spatially explicit estimates of changes in forest cover and condition, fuel availability and wildlife habitat among others (Beaubien, 1994; Wayman *et al.*, 2001).

The most efficient way to update forests condition is by taking satellite images. Satellite information and services are cost-effective, environmentally friendly and suitable tools to create the knowledge necessary for informed, integrated management and the protection of forests, taking into account their multifunctional role related to biodiversity, natural resources, economical value, CO2 storage and protective functions. Independent and frequent monitoring of large areas from space allows faster and more comprehensive reactions (EURISY, 2011). The fast changing nature of the forest areas requires repeated assessments at short time intervals (Mohammadi *et al.*, 2010). Remotely sensed data have been widely used as a cost effective tool in the mapping and monitoring of large areas (e.g. Danaher *et al.* 1998; Gould 2000; Mayaux *et al.* 2000; Freeman *et al.* 2002). Of the many satellites that provide information useful for terrain analysis, the Landsat series has provided the longest period of coverage, spanning from the present time back to 1972 when Landsat-1 (originally known as ERTS-1) was launched (Bruce and Hilbert, 2004).

Satellite image processing and classification of forest resources involves assigning the pixels in the image to predefined forest types. Methods such as unsupervised or supervised classification or a combination of these two are available for grouping pixels into forest or non-forest classes (Lillesand and Kiefer 2000).

In this research supervised classification was done for creation of forest cover map of the study area.

## Material and methods

*Study area*

Study area is Arasbaran Protected Area, the 9th Biosphere Reserve in Iran. It is situated Northwest of East Azarbaijan province in the Northwest of Iran (Fig. 1). The area is located between longitude of 46 39 23.40 to 47 02 37.31 E and latitude of 38 45 35.5 to 39 07 55.9 N. Due to the importance of the area in having a rich flora (about 1000 taxa) and fauna specially presence of rare species such as Lyurus mlokosiewiczi in 1971 was conserved and UNESCO was listed it as a wildlife refuge since 1976. In addition of rich flora, presence of some endemic plant species and fauna, there are long leaved trees such as Juniperus foetidissima and endangered species such as Taxus baccata in the area. The area is a part of Arasbaran forest site. This site is chracterized by special climatic characteristics, high biodiversity, presence of rare fauna and flora and vegetation elements associated with various climates. Despite the limited area, 1080 plant species and 97 woody species have been identified in the region. Soil depth is generally low to average due to the existing conditions and the parent rocks are often exposed. Soil pH is acidic and becomes more acidic in denser forest areas. The average annual rainfall is estimated to be around 300-500 mm, high number of fogy days and hidden precipitations are particularly effective in supply water to the soil especially at altitudes between 1000 m to 2000 m. Annual mean temperature at highlands, midlands and lowlands in Arasbaran forests are 5, 8 and 14°C respectively. The most important woody plants in this site are as follows:

Quercus macranthera, Q. petraea, Carpinus betulus, Acer campestre, Acer hyrcanum, Juniperus foetidissima, Taxus bacata, Pistacia mutica, Paliurus spina- Christi, Sorbus torminalis, Ulmus glabra, Cotinus coggygria, Viburnum lantana, and Cornus mass. Some of the above mentioned species such as Cotinus coggygria, Viburnum lantana, Juniperus foetidissima, Q. petraea and Cornus mass are indegenous to Arasbaran region (Sagheb-Talebi *et al.*, 2004).

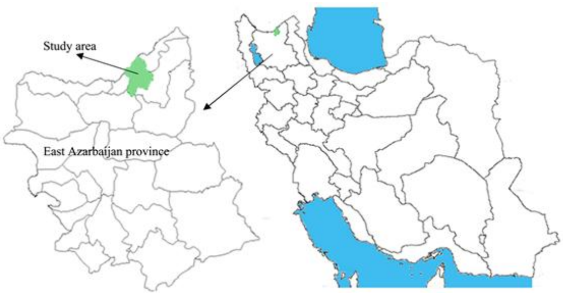


**Fig. 1.** Location of the study area in East Azarbaijan province of Iran.

*Materials*

The following materials were used in this study:

- Landsat Enhanced Thematic Mapper Plus (ETM+) image of 15/06/2001 with a spatial resolution of 28.5 by 28.5 m
- Topographical map at scale 1:50000, series numbers
- ILWIS, ArcGis and GPS Utility softwares
- GPS equipment

*Methods*

*Image Processing*

Radiometric and geometric corrections were performed for satellite images of the study area using ILWIS software. For the radiometric correction, the Darkest Pixel (DP) atmospheric correction method, also known as the histogram minimum method (Hadjimitsis *et al.*, 2004), was used. As haze has an additional effect on digital numbers, this correction value was subtracted from the digital numbers in the image. This method was applied to each individual band. The geometric correction was done for systematic and non-systematic geometric distortions of satellite image data. The correction process employs geographic features on the image called Ground Control Points (GCPs), whose position are known. Forty control points were found using topographic maps of the study area. Afine transformation using the nearest neighbour method as a resampling procedure was applied. A sub-scene of the study area was extracted using the map of the Arasbaran Protected Area obtained from East Azarbaijan Department of Environmental Protection.

*Image classification*

Supervized classification approach was used for image classification. Study area consists of several features having different reflectance. Therefore four classes including forest, range, agriculture and water were considered by carrying out fieldwork and using topographical maps. Optimum Index Factor (OIF) method was used for selection of the best combination of ETM bands. As a result False Color Composite (FCC) image using bands 4, 3, 2 was used for classification. Sufficient number of training samples of each class by carrying out field work and using GPS were selected. The number of selected pixels of forest, range, agriculture and water classes were 1818, 1064, 373 and 218 respectively. The image was classified using maximum likelihood classifier. Range, agriculture and water classes were merged as none-forest and final map (forest cover map) indicating forest and none-forest areas was obtained. The area of forest and non-forest classes were calculated using ILWIS software.

*Sample ground truth map and accuracy assessment*

In order to assess the accuracy of classification, sample ground truth data of the study area was collected. Systematic-cluster sampling method was used for ground truth data collection. Clusters were placed in 5*5 kilometers distances and samples were designed in 500*500 meters distances. Twenty-five samples were considered in each cluster. The land cover (forest or non-forest) of each sample point was recorded using field visits and GPS equipment. Sample ground truth map was created using GPS Utility and ILWIS softwares. Error matrix as cross-tabulation of the mapped class vs. the reference class were used to assess classification accuracy (Congalton & Green, 1999). Therefore Error matrix was constructed by crossing of Ground Truth and forest cover maps. Overall accuracy, user's and producer's accuracies, and the Kappa statistic were then derived from the error matrix. The Kappa statistic incorporates the off diagonal elements of the error matrix (i.e., classification errors) and represents agreement obtained after removing the proportion of agreement that could be expected to occur by chance.

## Results

*Forest cover map*

Forest cover map of the study area resulting from supervised classification is presented in Fig. 2. The area of forest and non-forest classes are 20777.7 ha and 59813.9 ha respectively.

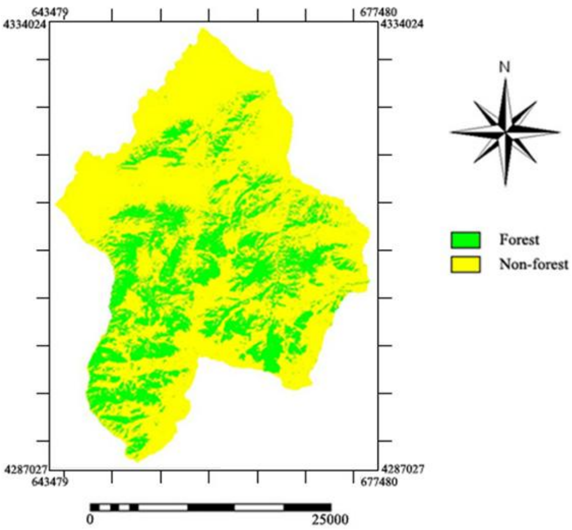


**Fig. 2.** Forest cover map of the study area.

*Sample ground truth map and accuracy of classification*

Fig 3. shows the sample ground truth map of the study area that was used to assess the classification accuracy. The error matrix derived from cross-tabulation of forest cover map vs. the Ground Trouth map is indicated in table 1. As can be seen the overal accuracy and kappa statistic are %95 and %88 respectively. User's accuracy for forest and non-forest classes were %99.4 and %94 respectively. Producer's accuracy for forest and non-forest classes were respectively %84 and %99.8.

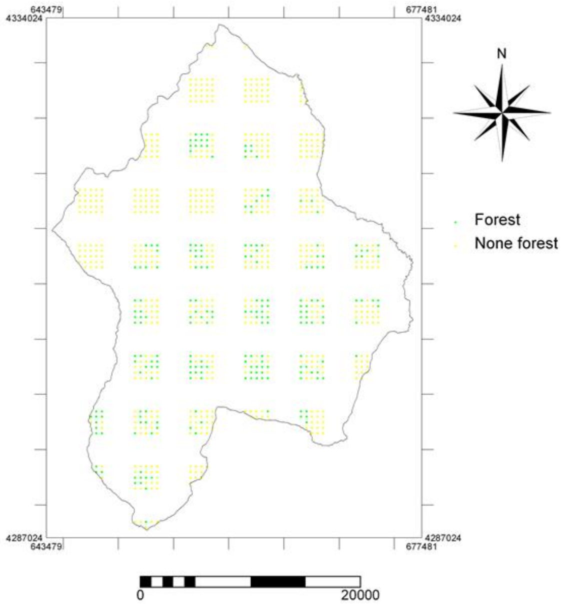


**Fig.3.** Sample ground truth map of the study area.

**Table 1.** Classification error matrix.

| Reference class | Classification | | Producer's accuracy (%) |
|---|---|---|---|
| | Forest | Non-forest | |
| Forest | 180 | 35 | 84 |
| Non-forest | 1 | 581 | 99.8 |
| User's accuracy (%) | 99.4 | 94 | |

Overall accuracy: 95% Kappa statistic: 88%

## Discussion

The results of this study demonstrate that Landsat ETM+ image classification can be used to produce accurate forest cover map. The overal accuracy of 95% and Kappa statistic of %88 indicate high accuracy of classification. Fleiss(1981) noted that kappa statistic more than %75 is indication of a very good agreement. The result is in agreement with the findings of Rafieian *et al.* (2006) who reported the capability of ETM+ imagery for forest mapping in mountainous areas. Bagheri and shataee (2010) also reported the capability of TM and LissIII images for forest mapping. They noted high overal accuracy of classification (more than %85). Yuan *et al.* (2005) and Torahi and Rai (2011) stated that Landsat classifications can be used to produce accurate landscape change maps. Shataee and Abdi (2007) reported that the maximum likelihood classifier exhibited the highest result amoung the other three classifiers with 91% overal accuracy and 87.56% kappa statistic. They also noted that forest lands were more severable from the other land cover classes.

The result of this study can be used in forest management and furthermore Periodically updated information through satellite remote sensing technology can help forest resource managers to devise suitable management plans.

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