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Investigation of forest extends change detection using satellite imagery in Zagros forests (case study in Behbahan Province Hills in Iran)

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Abstract

Change detection using remote sensing data has been intentioned much expansive with researchers in recent years. This study aimed to investigate changes in the area of Zagros forests using satellite imagery using TM and ETM+ Landsat data to achieve the forest changes from 1986 to 2010. We used post classification method to determination of change detection. The radiometric, geometric and atmospheric errors of satellite images is corrected, training samples selected from forests and non-forests area then images classified using maximum likelihood algorithm of supervised classification. The results showed that the overall accuracy and kappa coefficient of TM classification is respectively 90.86% and 85%, and ETM+ 95.31% and 93%. The classification maps of TM and ETM+ overlaid to detect changed and non-changed areas and changing rate. The results showed that 16231.23 hectares of forest areas reduced in this period. The changing rate is 676.3 hectares and 1.06 percent per year. The results showed that the TM and ETM+ satellite imagery able to produce forest map in Zagros forests.

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Introduction

Forest in west of Iran as the most extensive forest have an important role in economic development and ensure the survival and stability of soil and water in country. These forests with a fifth of the total area of the country and about a third of the population were a living place for residents and nomads and consequently suffer several damages. These damages are caused disappearance and regression in some parts of forest (Fattahi, 1996). Therefore, the forest management and planning is associated with difficulties which lack of necessary studies in this area adds to the problem. Hence, managers, experts and sponsors knowledge about the quantity and quality of occurred changes will be necessary for policy and alternative thinking to solve the problems.

The importance of accurate and updated information on the status of the area's natural resources and its temporal changes especially with the rapid growth of the urban area is increasing (Sivirikaya *et al*, 2006). Due to time consuming and costly mapping of forest and its constituent types through aerial photo interpretation especially in large scale caused researchers to seek new ways. In recent years the use of satellite data has been proposed as an appropriate method for this purpose (Alrababah and Alhamd, 2006). Satellite data has various advantages such as high coverage, less need for mapping, less cost as well as up to date information which its use seems inevitable for studying and evaluating the land use changes and geology, agriculture and forestry usages (Itten *et al*, 1993). A variety of research have been done in the field of forest mapping and studying forest changes using different satellite images and its ability around the world.

Rafieian (2003) studied the forest changes in Babol, Iran in the area of 15000 hectares, during 1994 and 2001 using Landsat ETM+ images and stated that a total of 2.8 percent of the original forest has been lost since 1994 to 2001. Finally, a map with overall accuracy of 96.39 and kappa coefficient of 0.92 has been obtained. Karami (2004) studied the forest destruction of Zagros using TM and ETM+ data on a area of 629 ha in two time periods of 1990 and 2000 and expressed that average of 6.8 ha equal to 0.1% of the forest area of this region was destroyed.

Najjarlou (2005) studied the changes in forest area of southern Kordkoy as a review study using aerial photograph, topographic maps and satellite images of IRS-1C and ETM+ from 1966 to 2001 and achieved the value and position of changes after preparing and comparing the map of each period. The result of this study showed that the satellite data had a good capability for mapping forest area in the Northern forests of Iran and can be used to evaluate the changes in forest.

Ranjbarnejad (2010) studied the rate of forest change and preparing map of changes using satellite images of TM in 1987 and ETM+ in 2001 on an area of 6332 ha in Golidaghi forest, Golestan by comparison after classification method and maximum likelihood algorithm and reported 14.5% loss of forest area in the region during 1987-2001.

(Satapathy *et al.,* 2007) by studying the changes in mangrove forests of India in an area of 62,000 ha and a 12-year period stated that 1250 ha of it were destroyed.

(Gunlu *et al*, 2008) studied the ETM+ images to determine the type and forest coverage and prepare the required maps in forests of Turkey and eastern Black Sea region. The supervised classification method was used in this study and the result showed the overall accuracy of 72.2% for land cover and 32.8% for the stand type.

Torahi and Chand rai (2010) studied the forest changes and land classification in high lands of Dehdez, Khuzestan during 1998-1990 and 2006 by the supervised method and maximum likelihood algorithm using data of Landsat TM and ASTER and stated that the forest area had declined to 37.5% from 67% between 1990 and 2006 while other uses area (water, residential, pasture and agriculture) has increased dramatically.

Zagros forests which a major part of it is located in west of Iran, have a great importance. Compared to northern forests, these forests have several features. Canopy cover of trees and forest is often sparse and semi- sparse and in limited areas is semi-continuous. Due to the destruction of these forests in the past, preparing update maps and information about conditions in past and now could be very useful in planning. Many studies have been done to determine the ability of satellite images in identification and separation of Zagros forest area and there is no study about the value and position of these destructions. Results of this research can be used in application of satellite images in providing forest area map in west forests of the country.

Zagros forest resources are important and vital resources of Iran and sequence of these resources has been much important for prospective planning. For forest planning in future need to forest extends change detection by using Satellite Imagery.

According to the results of the conducted survey and the necessity of more researches in Zagros, this study was designed to investigate the extent of deforestation and changes in a 24-year period using satellite images and to study the deforestation of Maroon Dam area and high lands in Behbahan, Khuzestan using change comparison after classification method.

Material and methods

Study area

The study area is located at highlands of Behbahan around Maroon Dam with 30° 35' to 30° 47' 'east longitude and 50° 10' to 50° 35' north latitude and zone 39 in UTM system. This watershed is located in a mountainous region with warm and dry climate and the average annual rainfall is 370 mm with irregular and sparse distribution. Maximum and minimum altitude is 1680 and 280 m, respectively and according to Domarten classification the regional climate is semi-arid.

The forest construction is one story made of oak and shrubs in the area include: *Ficus, Amygdalus, Crataegus, Pistascia Khinhuk, and Piastacia Mutica*. (Fig. 1).

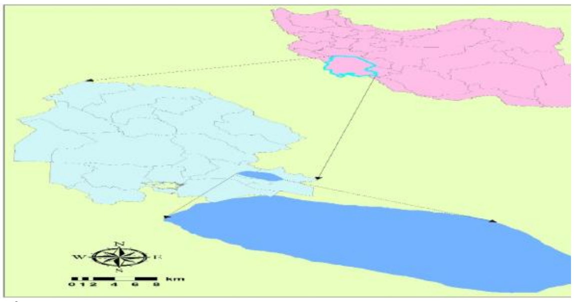

Fig. 1. The study area location.

The used data

in this study the data of TM sensor Landsat satellite with row of 164 and transit of 39 on 17/05/1986 and the second image of the ETM+ sensor on 05/14/2010 were used. To identify earth control points and geometry conform of images, also to prepare the required information layers in providing final land cover map the 1:25000 digital topographic maps has been used.

Study method

In this research, land use changes were studied using satellite images. Thus, images of the two time periods were prepared for the study area and land use maps of each time period were provided and then classified and compared by the method of comparison and maximum likelihood algorithm.

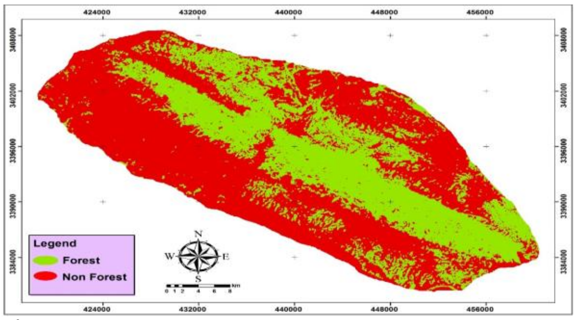

Fig. 2. Map of the forest area from satellite images in 1986.

Qualification of Geometric and radiometric of satellite images

In order to evaluate the presence or absence of radiometric and geometric errors the qualification study have done on satellite data. By studying the images in single band and different color combinations the radiometric error was observed in stripes type. The fixation of this error was done in ENVI software using Landsat Gap fills.

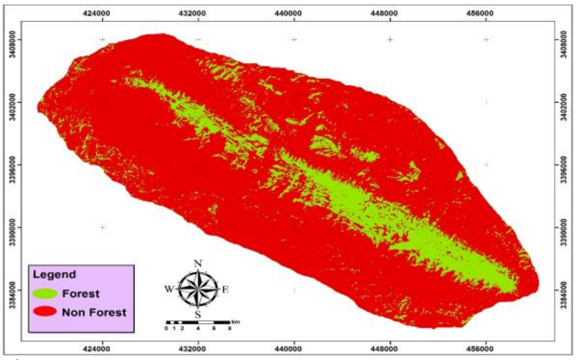

Fig. 3. Map of the forest area from satellite images in 2010.

Geometric correction of images

In order to georeference the satellite images, the geometric matching of images were done by nonparametric methods and using map and ground control points. For this purpose first 50 ground control points were selected from 1:25000 topographic digital maps and finally, by removing some points due to the large error 40 points with a good distribution on vector layers of streams and extracted roads from topographical maps were selected and used for geometric correction. Image geometric correction of first period (TM) by the image to map method with root mean square error of 0.29 for X and 0.37 for Y were corrected and image geometric correction of second period (ETM+) by the image to image method with root mean square error of 0.47 for X and 0.39 for Y toward image of 1986 were corrected. The resampling procedure was carried out using the nearest neighbor to ignore possible to changes in spectral value of images.

Satellite image processing

for detecting and extracting useful information from satellite images, composite color images were created. Color images due to higher eye's ability in visual interpretation and different phenomena separation are more appropriate than Gray tones images. In this study to indicate more clear some of particular phenomenon for the purposes of the research images with false color composite were produced.

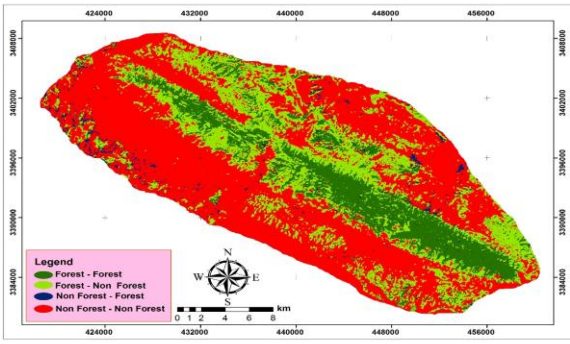

Fig. 4. Changes map obtained using contraction of 1986 and 2010 images.

To create this kind of images common compounds of false colors for TM and ETM+ images which band 4 (near infrared) with red, band 3 with green and band 2 with blue as RGB 2-3-4 mode were used (Rafieian, 2003). 2-3-4 mode based on clarity, visual separation ability and RGB standard in the world, provides the best combination for TM and ETM+ sensors.

Classification and mapping the land use

To evaluate the results of the images classification for preparing land use map, the satellite images were classified into 4 classes of forest, agriculture, water and pasture according to the area land cover and use. To examine the similarity and distinction of the classes, the distinction quantitative assessment method was used and the separation ability was investigated using Bhattacharya distance criterion. In this research required didactic samples for classification of different uses were randomly selected by earth direct method and recognition of the area and using secondary data.

For this purpose according to the portion of each category in the study area appropriate number of didactic samples were taken which these samples indicated all properties and classes conditions. To separate the main land uses on geometric satellite data, supervised classification and maximum likelihood algorithm were used. Also, to remove a single pixel on the classified image as well as to obtain the desired image resolution a 3×3 filter was used.

Preparation of georeference map

In this research due to the large area, time consuming and high cost in preparation of georeference map and a given that the main objective of this research was to prepare land use map therefore, using random sampling the georeference map was obtained.

Evaluation of the classification results accuracy

After classifying the satellite images into the 2 and 4 mentioned categories and merging 3 classes of pasture, water and agriculture as the class of non-forest the maps of two periods in the study area were prepared. All obtained maps were compared to the georeference map and after presenting the error tables, the accuracy of classification results were evaluated based on criteria of overall accuracy, Producer accuracy, user accuracy and Kappa coefficient.

Preparing changes map

After image classification and evaluation of result accuracy, the first and second land use map were prepared and were contrasted with each other to obtain changes map (land use change map and determination of spatial condition of altered levels) during the 24 year study period (1986 to 2010).

Accuracy of changes map

To assess the accuracy of changes maps that relate to contrasting two images, the mean overall accuracy (mean overall accuracy of the first and second land use maps) and the mean kappa coefficient (mean kappa coefficient of the first and second land use maps) (Yuan *et al.*, 2005).

Result

Images classification

After ensuring the absence of radiometric and geometric error on satellite images the land use map for the years of 1986 and 2010 were prepared. The results showed that the area of forest and non-forest in the study area were 25,840 and 37,795 ha in 1986, respectively and 10,790 and 52,836 ha in 2010, respectively (Figure 2 and 3). The results of quantitative evaluation of separated classes indicated that the separation value of forest and non-forest classes by Bhattacharya distance indicator was good and 1.68 and 1.83, respectively.

Evaluation the accuracy of results

The results of classification of forest and non-forest from selected bands by the maximum likelihood algorithm for classification were evaluated using georeference map. The result of classification mentioned images into 4 classes of forest, agriculture, water and pasture were evaluated using georeference map after merging non-forest classes and create images in forest and non-forest classes (Tables 1 and 2).

Table 1. Results of overall accuracy and Kappa coefficient for TM and ETM+ images.

Accuracy / Image	Overall accuracy	Kappa coefficent
TM 1986	90/86	0/85
ETM+ 2010	95/31	0/93

Table 2. Results of accuracy assessment of the obtained maps.

Land use	User accuracy		Producer accuracy	
	TM	ETM+	TM	ETM+
Forest	91/64	96/82	93/98	98/34
Non Forest	90/2	95/33	90/65	96/02

The result of accuracy assessment of classified images using georeference map indicated that the images obtained by maximum likelihood algorithm had higher accuracy. Results showed that the overall accuracy (95.31) and Kappa coefficient (0.93) of 2010 ETM+ classified image was higher than the overall accuracy (90.86) and Kappa coefficient (0.85) of 1986 TM classified image (Table 1). Also, the accuracy of user and producer of forest class on both TM and ETM+ images were higher than non-forest class (Table 2).

Preparing changes map and determine the extent and position of changes

After classifying the images, the changes map was obtained using contrast of 1986 and 2010 images and the extent and position of forest and non-forest changes were achieved (Figure 4).

After preparing changes map the area of changed and unchanged region as well as average annual changes were obtained (Table 3).

Table 3. Area of changed and unchanged region and the rate of changes.

Essence changes	Area(hectar)
Region of non-Changes	33452/55
Forest to Non forest	16231/23
Non forest to Forest	998/021
Average annually changes forest	676/30
rate of changes	%25

The results of comparison of two maps showed that the annual average rate of changes was 676.30 in the study period. It means that about 1.06% equal to 676.30 ha of forest area has been annually reduced and has changed into other uses.

Evaluation the accuracy of changes map

after preparation of changes map, evaluation the accuracy of changes map using the parameters of overall accuracy and Kappa coefficient were compared (Table 4).

Table 4. Results of evaluation the accuracy of changes map.

Overall accuracy	Kappa coefficent	User accuracy	Producer accuracy
93/08	0/89	93/13	94/04

The result showed that the classified image obtained from contrast of two periods by comparison after classification method had high producer accuracy and average user accuracy. Overall accuracy and kappa coefficient of this map as is shown in the table were 98.08 and 0.89, respectively which means that 0.89 of map obtained from images classification was in accordance with georeference map that shows the high validity of the classification.

Discussion and conclusions

Due to the light-demand and destruction and regeneration problems, have sparse covering and is different from northern forest (Amini, 2006). Because of this reason the result of classification and TM and ETM+ images process to prepare forest area map is different to the result of these images classification for preparing forest area map in northern forest (Shataee, 1996; Najjarlou, 2005; Majani, 2001). Therefore, due to the large spectral overlap of soil forest cover in the area and similar areas the overall accuracy and kappa coefficient obtained from the classification of satellite images in this region is less than dense areas of northern forest. These results are in agreement with Naseri (2003). The evaluation result of didactic samples and class differentiation showed that to classify images for mapping forest area, providing didactic samples for forest and non-forest classes were enough and there was no need to separate non-forest class into sub-classes. This matter was confirmed after integration of agriculture, water and pasture classes into non-forest class and images classification such that the highest accuracy of classes was achieved for classified images of forest and non-forest classes. Given that classified images of methods like comparing after classification, in addition to the essence of changes, type and extent of these changes would be also shown (Jensen, 2004) and also maximum likelihood algorithm is the most common method of classification using didactic samples (Darvishsefat, 1998; Latifi *et al*, 2007). The classification was done by comparing after classification and maximum likelihood algorithm.

The result of accuracy assessment of obtained map by the maximum likelihood algorithm classification on TM and ETM+ images showed that the accuracy of each classified TM and ETM+ image in controlled classification method was high and acceptable. According to 90.86 overall accuracy and 0.93 Kappa coefficient on ETM+ image it could be said that these two sensors have the ability to prepare land use map and can be use in detecting changes in land use.

The results indicated that factors such as similar reflection of some non forest land and forest class would cause an improper class differentiation and or destroyed forests or with very low density which is identified as forest on field may categorize as non-forest due to their dissimilarity reflection that would make error and low accuracy. This study showed that the differentiation of forest and non-forest and then preparation of forest area map in west forest is possible using TM and ETM+ data. According to FAO the annual rate of forest destruction than its initial area is estimated 0.2% in the world during 1990-2000.

Regarding this case it could be said that the damage extent was more that global average in the study. Considering this it is expected that if the present trend continued, we would have poor forest as completely destroyed one in Zagros in near future. Thus, to preserve Zagros forest ecosystem more attention to activities which would reduce the high dependence on the forest area and agricultural activities on forest edge is required. Given the relatively good results in this study based on ability of images from these sensors in segregation of different land use in mountainous area of Zagros it could be concluded that the satellite images can be used as a source in mapping land use in different areas.

It is proposed to use other common multispectrum satellites which have fairly good spectrum potency and proper ground size separation like IKONOS, SPOT-5 and IRS with multispectrum data in preparing land use maps.

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