Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 4, No. 1, p. 149-156, 2014
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Investigation of land use change detection using satellite imagery (case study in Behbahan Province hills in Iran)

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Article published on January 16, 2014

Key words: Land use, change detection, forest extent, satellite imagery, TM and ETM+.

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 Land used 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%. After classification maps of TM and ETM+ overlaid to detect changed and measure changed and changing position. The results showed that amount of forest land decreased from 40.61% to 14.95% of the total area, while agriculture, pasture and surface water respectively from 2.11% to 5.44%, 56.75% to 75.13% and 0.53% to 2.44%, increased in this period, and land forest to pasture and then pasture to agriculture have been the more changes. The results showed that the TM and ETM+ satellite imagery able to produce Land use map in Mountain regions.

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Introduction

The growing population, increased pressure on nature, unsuitable harvesting and land use changes caused the destruction of ecosystems (Liu *et al*, 2004). Degradation and land use changes may be caused by factors such as drought, fire, floods, volcanic activity and human activities such as grazing, urban sprawl, agricultural and natural resources management (Ojigi , 2006). High ecosystems changes rate in recent years have caused difficult adaptations of organisms to environmental changes which is a result of ignoring land use changes and natural resources uses (Mass *et al*, 2004). Therefore, a balance could be obtained by considering the trend of land use changes in conducting ecosystems. Having the necessary data and information is required for proper natural management. One of the principles of natural resource management is the data of land use changes maps. Due to the high cost and untimed preparation of these maps in filed, the use of satellite images has been proposed as a way for this regard in recent years (Shataee , 2003). Satellite data according to their superior characteristics such as vast coverage, reproducible and continuous updates could be considered as a first option in recognition of land use (Shataee and Abdi , 2007). A lot of studies have been accomplished about determining land use and land cover around the world and using satellite data such as Landsat, SPOT and IRS in preparation of these maps have been confirmed by many experts (Alavi Panah , 2009).

Akbari *et al* (2007) studied the change and desertification of land in the north of Esfahan by comparison of TM and ETM+ satellite images and that 65% of the area is covered by human destruction and due to the conversion of rangeland and agricultural land the main reasons for this were overgrazing, improper economic conditions and overuse of underground water.

Moradi *et al.* (2008) studied the land use changes by desertification using aerial photographs and IRS images in Ardakan, Yazd between years of 1334- 1381 and concluded that the desert area had reduced to 2160 ha which was a result of increasing in urban and agricultural uses.

Saleh Yousefi *et al* (2011) used TM and ETM+ images and detection technique and classification method in detecting and studying the land use and cover changes in Marivan over a 16 year period from 1989 to 2005 and stated that during this period 24.11% of the land had been changed and the most changes were related to the agricultural land and forest.

Yuan *et al* (2005) by studying the changes of land use around urban areas using TM and ETM+ data and the accuracy of the resulting map and aerial photographs found that study the land cover changes using remote sensing data is possible.

Wakeel *et al* (2005) studied the determination of changes using Landsat satellite data in Himalayan region in India. The study period was 30 years. During this period from 1967 to 1997 the forest cover has changed due to increased population and agricultural activities.

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

Since the information of the uses and its changes over time is one of the main items in planning and policy therefore, the future changes could be predicted by knowing the land use changes scale.
There have been a few researches in studying the ability of satellite images to identify and distinguish the lands in the west Zagros and determine the

extent and location of damages to these areas. The result of this research can be effective in using satellite images to prepare land use maps in west of Iran. According to the results of the conducted survey and necessity of more research in Zagros, this study aims to estimate the land use changes using satellite images in highlands of Behbahan, Khuzestan over a 24 year period.

Material and methods

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 (Fig. 1.).

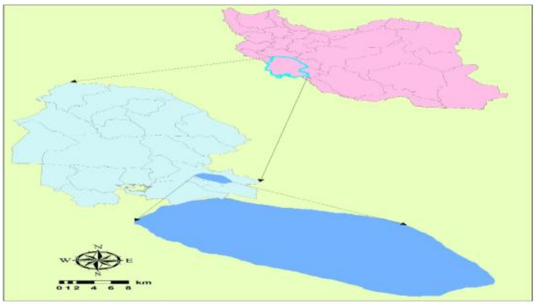

Fig. 1.the study area.

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.

Qualification of geometric and radiometric of satellite images

In order to evaluate the presence or absence of radiometric and geometric errors the qualification study has 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 fill.

Geometric correction of images

In order to dereference 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 re-sampling procedure was carried out using the nearest neighbor to ignore possible to changes in spectral value of images.

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. In this study the choosing of required didactic samples to classify the different uses by direct ground method were performed by recognition the area and using secondary data. For this purpose, suitable number of didactic samples was taken according to the portion of each class in the study area. Since the classification by controlled method and maximum likelihood algorithm are the most common methods among other classification methods using didactic samples (Darvishsefat and Shataee, 1997) these two methods have been used. To remove single pixels in the classified image and also to obtain a desired image with more resolution a 3×3 filter were 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 4 mentioned categories (forest, pasture, water and agriculture) 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 (Table 2-3-4).

Preparation and determination of changes map accuracy

After images classification and accuracy evaluation of results, the changes map was obtained by contrasting the first and second land use map (land use changes maps and determination of changed area location) during the 24 year study period (1986 to 2010). To assess the accuracy of the changes maps that related to contraction of two images, the mean overall accuracy (mean overall accuracy of the first and second uses map) and mean kappa coefficient (mean kappa coefficient of the first and second uses map) were used (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 (Fig. 2. and3).

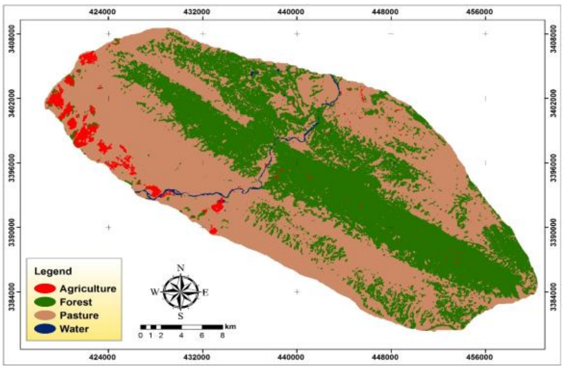

Fig. 2. Map of land use in 1986.

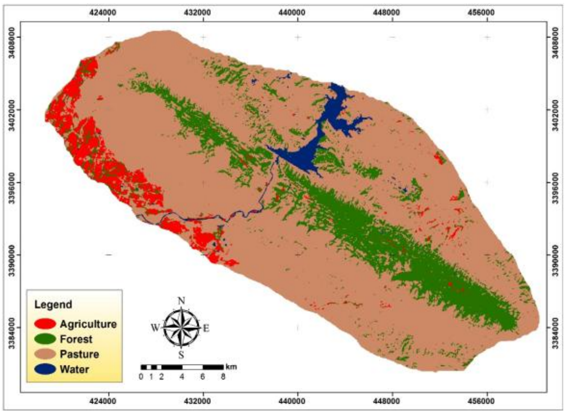

Fig. 3. Map of land use in 2010.

Based on obtained results different land uses have been increased except forest which has been decreased. Forest land use has had the largest percentage of changes which 23.66% of the area had declined and pasture use with 18.38% has had the highest increase among the land uses and agricultural and water uses with 3.33 and 91.91% increase were the next (Table 1.)

Table 1. Land use Area at the beginning and end of the period.

Land cover class	1986		2010		Change Amount		Change type
	Area (ha)	%	Area (ha)	%	Area (ha)	%	
Forest	25840	40/61	10790	16/95	15050	23/66	Decrease
Agriculture	1347	2/11	3462	5/44	2115	3/33	Increase
Water	338	0/53	1564	2/44	1226	1/91	Increase
Pasture	36110	56/75	47810	75/13	11700	18/38	Increase

Evaluation the accuracy of results

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 2.).

Table 2. Results of overall accuracy and Kappa coefficient for TM and ETM+ images.

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

Table 3. Results of accuracy assessment for TM sensor images in different classes.

Land use	User accuracy	Producer accuracy
Forest	91/46	93/98
Agriculture	76/62	76/29
Water	100	97/56
Pasture	93/98	98/11

Water and pasture uses due to their different spectra are easily separable and also have higher user and producer accuracy in classification but, the similarity of the spectrum of agricultural and forest land caused a lower user and producer accuracy than the other (Table 2. and 3.).

Table 4. Results of accuracy assessment for +ETM sensor images in different classes.

Land use	User accuracy	Producer accuracy
Forest	90/82	92/34
Agriculture	89/85	90/05
Water	95/12	100
Pasture	98/02	98/02

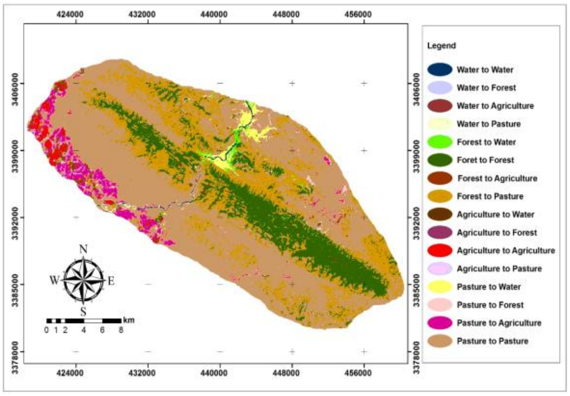

Fig. 4. Map of land use changes from 1986 to 2010.

Preparation of changes map and assessment of changes rate

Among the land use changes the most changes were in conversion of forest to pasture and secondly pasture to agriculture and also, the least changes were in conversion of water to forest and agriculture to water. Nearly 67% of the previous land uses area in 1986 has also been found without any change to previous in 2010. In addition to above factors, various items (below one percent) including conversion of forest to water, agriculture to pasture or other land use change were also obtained. These low values could be a sign of slight changes in these types of land use and on the other hand could be the errors of each land use classification (Table 5.).

Table 5. Type and extent of land use changes which have taken place from 1986 to 2010.

Change type	Change Amount(hectar)	Change Amount(persent)
Foret to Forest	9622/71	15/2
Forest to Agriculture	341/1	0/53
Forest to Water	392/58	0/61
Forest to Pasture	15497/55	24/35
Agriculture to Agriculture	908/55	1/42
Agriculture to Forest	169/92	0/26
Agriculture to Water	21/51	0/03
Agriculture to Pasture	246/78	0/38
Water to Water	190/89	0/3
Water to Forest	5/94	0/01
Water to Agriculture	20/25	0/03
Water to Pasture	121/05	0/19
Pasture to Pasture	31960/53	50/22
Pasture to Forest	991/08	1/55
Pasture to Water	959/58	1/5
Pasture to Agriculture	2178/45	3/42

ccuracy of changes map

Results showed that the classified image obtained from contraction of two periods by comparison after classification method had a relatively high producer and user accuracy. Overall accuracy and kappa coefficient which is shown in the table was 93.08 and 0.89, respectively that means 0.89 of the map obtained from images classification was accordant to georeference map which indicated the high accuracy (Table 6.).

Table 6. Results of accuracy assessment of the changes map.

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

Discussion and conclusion

Changes of land use are an important factor of hydrological changes, erosion and destruction of biodiversity. So by knowing the trend of changes in land use we could reach a balance in ecosystems. Having up to date data and information are required for natural resources management. One of the principles of natural resource management is information of land use changes maps. In the process of land cover and land use mapping, the remote sensing technology has unique capabilities and privileges which allow preparing the information of agricultural with less cost and time in comparison to traditional methods. Results of this study showed that the data of remote sensing and digital interpretation with didactic samples and acceptable accuracy are able to extract land use map (up to a high accuracy rate of 85 %). Above subject was presented by previous researchers such as Alavi Panah (2009) and Lilsend *et al.* (2008). Our result was in agreement with Torahi and Chand Rai (2010) regarding the loss of forest area and enhancement of other land uses (agriculture, water and pasture).

Most of the occurred land use changes were in conversion of forest to pasture and pasture to agriculture (24.35 and 3.42%, respectively). This shows that the land use changes in the highlands of Behbahan are progressive. In fact, the trend of land use conversion was toward pasture expansion in 1981 and 1991 but, the tendency was to agriculture in 2001. The reason of significant difference in the increase of water use in 1366 was the Maroon Dam which had increased from 338 to 1564 ha. In fact, due to Maroon Dam, proximity of Behbahan to the study area, public awareness of land value and providing livelihood needs were the major reasons for changing in pasture to agricultural land. In a conducted study in Mexico the construction of the dam and the need for agricultural products had caused increasing in pasture and agricultural land area during 25 years, in other words, forest lands had converted to agricultural lands and pasture (Lopez *et al.*, 2005).

Regarding to the transformations during the study period (24 years) the applied cycle has been moving towards forest land degradation such that within 24 years more than 16,231 has equivalent to 25% of forest area has declined and turned into other land uses. Overall, the results indicate that due to changes made in the study area the trend of land use change was towards forest conversion to pasture and pasture to agricultural land.

In this research the land use changes were studied using comparison of land use maps by controlled method from 1986 to 2010 and comparison after classification method and maximum likelihood algorithm for two time periods. Since the classified images obtained from methods like comparison after classification which shows the nature, type and extent of these changes (Jensen, 2004) and given that the maximum likelihood algorithm is the most common method in classifying using didactic samples (Darvishsefat and Shataee, 1997) therefore the comparison after classification and maximum likelihood algorithm were used in classification. 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 used in detecting changes in land use.

In this study, the use of GPS in preparing a georeference map had enhanced the speed and accuracy of this map and taking more points in spacious area were allowed. Taking point sample and providing georeference map in raster are more accurate than usual methods such as black and white aerial photos which is still faced with various questions. In this study similar to Alavi Panah and Masoudi (2001) the necessity of using GIS in preparing land use map was observed. 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 new processing methods such as object-oriented monitoring of satellite images as well as other common multi-spectrum satellites which has fairly good spectrum potency and proper ground size separation like IKONOS, SPOT-5, and IRS with multi-spectrum data in preparing land use maps.

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