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Assessment of Land Cover Changes Using RS and GIS (Case Study: Zagros forests, Iran)

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Abstract
The aim of this study was to monitoring land-use changes of Zagros forest in Iran, using four methods; namely, Green Tasseled Cap (GTS), Image Ratio (IR), Normalized Difference Vegetation Index (NDVI), and PCA_2 Difference (PCA). This study was done on satellite images of TM sensor (1988) and ETM+ sensor for 2013. The overall accuracy and Kappa coefficient were used to determine the accuracy of the produced maps. The results of the accuracy evaluation showed that PCA_2 differencing method with overall accuracy and Kappa coefficient of 97 and 0.95 respectively is the most accurate method and IR method with overall accuracy and Kappa coefficient of 75 and 0.61 respectively, is the least accurate method. Results showed that extensive changes have happened in these areas which are generally descending in a way that 60.51% of natural lands have changed over the past 25 years. In other words, in this area 2.41 percent of natural lands are being converted every year.

Key words: Green Tasseled Cap, NDVI, PCA_2, Difference, Ilam.

1. Introduction
Sustainable management of natural resources requires constant studying and monitoring land-use and land-cover along with their changes at different spatial and temporal scales [11]. Changes in land-use and land-cover in most cases have significant harmful impacts on the environment. Nowadays changes in land-use vegetation which have become a major problem due to improper planning and lack of appropriate management, such that most changes are done without considering their environmental impact. In recent decades changes in land-use happened very rapidly in Iran which has accelerated the process of land degradation. Given the fact that land degradation occurs at a wide range, remote sensing technology is a useful tool in assessing changes in Earth's vegetation cover [10]. Remote Sensing (RS) has been used to classify and map land cover and land use changes with different techniques and data sets [3]. The main basis for using remote sensing data in order to monitor changes, is measuring modifications in the amount of radiation and its variations. Changes in vegetation cover lead to changes in radiation level. Variations in radiation level which are related to changes of land-use should be higher than changes related to natural factors such as atmospheric conditions, differences in solar radiation angle, and differences in soil moisture [9]. The impact of these changes can be significantly reduced by selecting appropriate data, radiometric correction of multi-temporal data, and choosing an appropriate method [6]. So far numerous researches have been conducted regarding changes in land-use, using remote sensing images all of which are indicative of changes in land-use. Ridd and Liou compared Image Differencing Method and Tasseled Cap Conversion to monitor changes in vegetation cover using Land sat TM sensor images and concluded that subtracting the Red Band TM lead to a better outcome [14]. Liu has referred to comparison after the classification method for the change detection in land-use, as one of the methods of investigating variations [9]. Mohammad Esmaeil, investigated land-use changes in Karaj city in the period between 1986 and 2003

using ETM^{+} image sensor. The results showed that each year, about 300.6 hectares were added to urban areas of Karaj city in this timeframe [11]. Such studies however are very limited in Zagros forests of Iran. In other words, monitoring of natural lands and their changes during different time periods have not been investigated. Therefore, the present study has been conducted with the purpose of monitoring changes in land-use between 1988 and 2013. Moreover, the most suitable method for monitoring changes has been introduced.

2. Materials and Methods

2.1. Study Area

This study was done at Sarableh city of Chardavol region in forest of Zagros in the west of Iran (46° 32́ longitude and 33° 46́ latitude). It has relatively semi-arid climate and average annual precipitation is less than 500 mm and is 1050 meters above sea level (Figure 1) [12]. Chardavol region is surrounded by Kermanshah, Islam Abad and Gilan Gharb from north, Ivan from west, Ilam from south, and Kouhdasht from east.

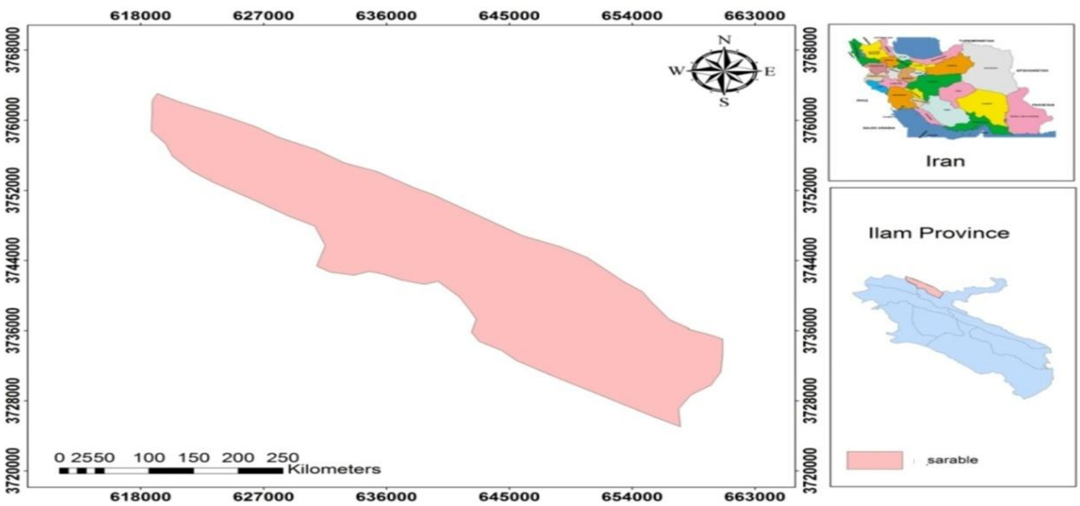

Figure 1. The geographical position of the study area in Iran and Ilam province.

2.2. The data collection

In this study, the TM multi-spectral satellite data for 1988 and ETM+ multi-spectral satellite data of 2013 have been used. Also, field data and 1:50,000 topographic maps from Topography Organization of Iran have been used for preliminary identification. ENVI 4.7 and Taiga Idrisi 16.03, and Arc GIS 9.3 software applications have been used for processing information and various outputs.

2.3. Processing satellite data

Processing satellite data involves Geometric and Radiometric correction of images. The correction of geometric errors was performed using ground control points in the ETM + and TM images. Firstly, images were registered as image to the map, and then as image to image. Radiation Measurement Error Correction which is one of the radiometric corrections was performed through regression analysis between the mentioned bands with band 2 due to the high correlation, due to lack of data strips inside bands 1 and 3 of TM data sensor. Other processes included: Separation of area on satellite images, image enhancements, principal component analysis, tasseled cap transformation into vegetation indices, integration of different bands with panchromatic band (Fusion) and determining the best band combination for using in image classification.

2.4. Principal Component Analysis (PCA)

Principal component analysis is a linear combination of the initial bands which have no spectral correlation. In other words, PCA conversion has components equal to the number of those initial bands which have the maximum spectral variance. In fact, the first principal component possesses the information with the highest variance. The main advantage of this method is collecting and aggregating phenomena information contained in various bands, inside a few components or images.

2.5. Image Ratio (IR)

In this method, the value of 1 is assigned to the unchanged pixels and changed areas are assigned with values which are larger or smaller than one [15]

$$x = x(t_1)/x(t_2)$$

2.6. Normalized Difference Vegetation Index

This index was presented by Rouse *et al.* in order to separate the vegetation from the background soil for the MSS Landsat and its formula is presented below [16]. This method is used for determining the vegetation cover and is calculated using the severe difference between infrared and red band spectra.

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RER}}{\mathrm{NIR} + \mathrm{RED}}$$

Where NIR is the near infrared band and RED is the red band.

2.7. Tasseled Cap Conversion

This conversion was first introduced by Kauth and Thomas for Landsat MSS data [10]. This Conversion is a linear transformation during which four new components are formed from the initial components namely Brightness, Greenness, Yellowness and Non-such. Table 1 shows the coefficients related to the following formulas for the MMS sensor [4].

$$\begin{aligned} \mathrm{Brightness} &= \mathrm{a1.mss1} + \mathrm{b1.mss2} + \mathrm{c1.mss3} + \mathrm{d1.mss4} \\ \mathrm{Greenness} &= \mathrm{a2.mss2} + \mathrm{b2.mss2} + \mathrm{c2.mss3} + \mathrm{d2.mss4} \\ \mathrm{Yellowness} &= \mathrm{a3.mss3} + \mathrm{b3.mss2} + \mathrm{c3.mss3} + \mathrm{d3.mss4} \\ \mathrm{NonSuch} &= \mathrm{a4.mss4} + \mathrm{b4.mss2} + \mathrm{c4.mss3} + \mathrm{d4.mss4} \end{aligned} \qquad (1)$$

Table 1. Tasseled Cap Component Coefficients for Landsat MSS Images

Components	a	b	C	d
Brightness	0.433	0.632	0.586	0.264
Greenness	-0.290	-0.562	0.600	0.491
Yellowness	-0.829	0.522	-0.039	0.194
Non Such	0.223	0.012	-0.543	0.810

a, b, c and d; Coefficients of each component that multiplied in the bands.

The variance is greatest in the first three components whereas noise and atmospheric effects are visible in forth component onward [10]. The first three components of the TM sensor include Brightness, greenness, and humidity whose their coefficients are shown in Table 2.

$$\begin{aligned} \mathrm{Brightness} &= \mathrm{a1.TM1} + \mathrm{b1.TM2} + \mathrm{c1.TM3} + \mathrm{d1.TM4} + \mathrm{e1.TM5} + \mathrm{f1.TM7} \\ \mathrm{Greeness} &= \mathrm{a2.TM1} + \mathrm{b2.TM2} + \mathrm{c2.TM3} + \mathrm{d2.TM4} + \mathrm{e2.TM5} + \mathrm{f2.TM7} \\ \mathrm{Wetness} &= \mathrm{a3.TM1} + \mathrm{b3.TM2} + \mathrm{c3.TM3} + \mathrm{d3.TM4} + \mathrm{e3.TM5} + \mathrm{f3.TM7} \end{aligned} \qquad (2)$$

Table 2. Tasseled Cap Component Coefficients for Landsat TM Images [4].

Components	a	b	c	D	e	f
Brightness	0.3037	0.2793	0.4343	0.5585	0.5082	0.1863
Greenness	-0.2848	-0.2435	-0.5436	0.7243	0.0840	-0.1800
Wetness	0.1509	0.1793	0.3299	0.3406	-0.7112	-0.4572

a, b, c, d, e and f; Coefficients of each component that multiplied in the bands.

In 2002, Huang et al. presented conversion coefficients of ETM + sensor as shown in Table 3 [6].

$$\begin{aligned} \mathrm{Brightness} &= \mathrm{a1.ETM1} + \mathrm{b1.ETM2} + \mathrm{c1.ETM3} + \mathrm{d1.ETM4} + \mathrm{e1.ETM5} + \mathrm{f1.ETM7} \\ \mathrm{Greeness} &= \mathrm{a2.ETM2} + \mathrm{b2.ETM2} + \mathrm{c2.ETM3} + \mathrm{d2.ETM4} + \mathrm{e2.ETM5} + \mathrm{f2.ETM7} \\ \mathrm{Wetness} &= \mathrm{a3.ETM3} + \mathrm{b3.ETM2} + \mathrm{c3.ETM3} + \mathrm{d3.ETM4} + \mathrm{e3.ETM5} + \mathrm{f3.ETM7} \end{aligned} \qquad (3)$$

Table 3. Tasseled cap component coefficients for Landsat ETM + Images [6]

Components	a	b	C	D	e	f
Brightness	0.3561	0.3972	0.3904	0.6966	0.2286	0.1596
Greenness	-0.3344	-0.3544	-0.4556	0.6966	-0.0242	-0.2630
Wetness	0.2626	0.2141	0.0926	0.0656	-0.7629	-0.5388

a, b, c and d; Coefficients of each component that multiplied in the bands.

This Conversion is a linear transformation. This type of conversion is determined and prepared based on the type of the sensor. Monitoring is based on three components of brightness, greenness and wetness. The greenness component is used in the current study.

2.8. Calculation of Standardized Differences

For the analysis of land use changes, firstly we should calculate the standardized difference for each method (Equation 4).

$$S = \frac{X_i - \overline{X}}{\partial} \tag{4}$$

Where S is the standardized value of variable, X_i is the numerical value of each pixel, and $\overline{X}$ is the mean score of the pixels. Given that results obtained with this technique consist of three regions with increasing changes, no changes, and decreasing changes, the next step is to select a threshold which can distinguish these changes from each other. Usually, trial and error process and statistical method are used for selecting thresholds [17].

In this study, the statistical method based on selection of a suitable standard deviation from the mean was used. Different standard deviations were investigated for each of the above methods, including $2 \pm ،5/1 \pm ،1 \pm ،75/0 \pm ،5/0 \pm$.

2.9. Evaluation of Accuracy

Firstly, using satellite images and field sampling, samples were obtained for each increasing, decreasing, and constant areas and then images were evaluated using overall accuracy indices and Kappa coefficient. Overall accuracy indices were calculated using Equation 5 [1].

$$OA = \frac{1}{N} \sum P_{ii} \tag{5}$$

Where OA is the overall accuracy, N is the total number of training pixels, and $\sum P_{ii}$ is sum of the main diagonal elements of the error matrix. Due to the presence of errors in overall accuracy, Kappa coefficient index is often used in those operational works which are focused on comparing the classification accuracy, since it can target pixels that are classified incorrectly. The Kappa index is calculated using Equation 6 [2]:

$$\text{Kappa} = \frac{P_0 - P_c}{1 - P_c} \times 100 \tag{6}$$

Where P_0 is the observed correctness and P_c is the expected agreement.Ideally, the value of Kappa coefficient is one. If this value is equal to zero the classification is completely random and if a negative value is obtained, there is an error in the classification.

3. Results and Discussion:

After applying atmospheric and geometric corrections on the image, changes detection was performed using the four methods: Green Tasseled cap, image Rationing, difference in vegetation cover index, and difference in PCA_2. Based on these methods maps of vegetation cover changes were prepared (Figures 2, 3, 4 and 5).Also to evaluate the accuracy and correctness of the obtained maps, classified maps were compared with the ground truth maps derived from field visit and based on that the overall accuracy and Kappa coefficient were obtained. Tables 4 and 5 show the results of the evaluation of monitoring methods.

Furthermore, Table 6 shows land-use changes from 1988 to 2013 in the study area. Base on this result a significant shift from vegetation to agriculture was happened during 15 years. Our result is consistent with founding of Butt et al. [3] and Diallo et al. [5]. Despite, Rawat and Kumar (2015) showed that vegetation has been increased and agriculture decreased in the Hawalbagh block of Uttarakhand, India [13].

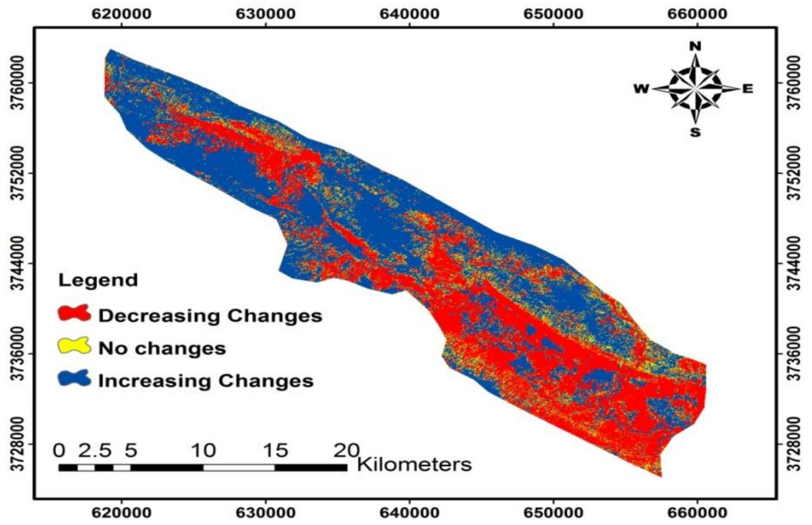

Figure 2: Monitoring map using Tasseled Cap Differencing method

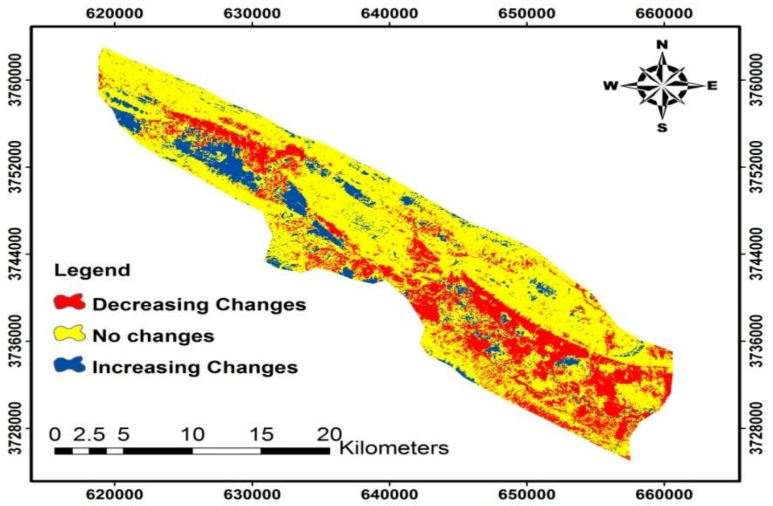

Figure 3: Monitoring map using NDVI Green Difference in vegetation cover index method

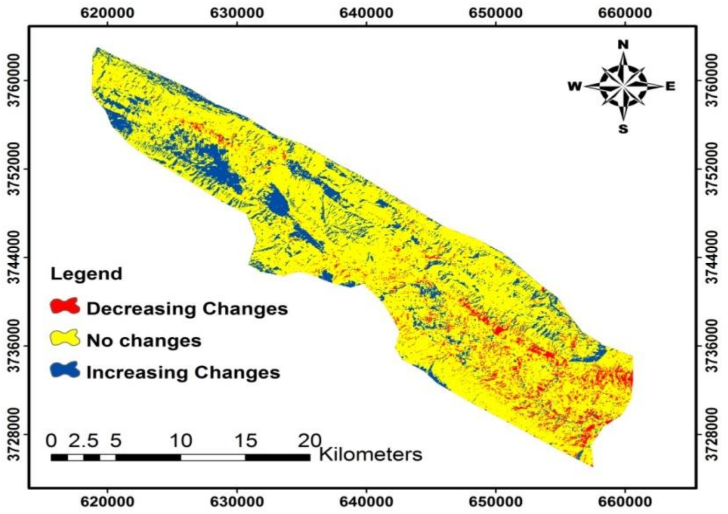

Figure 4: Monitoring map using IR method

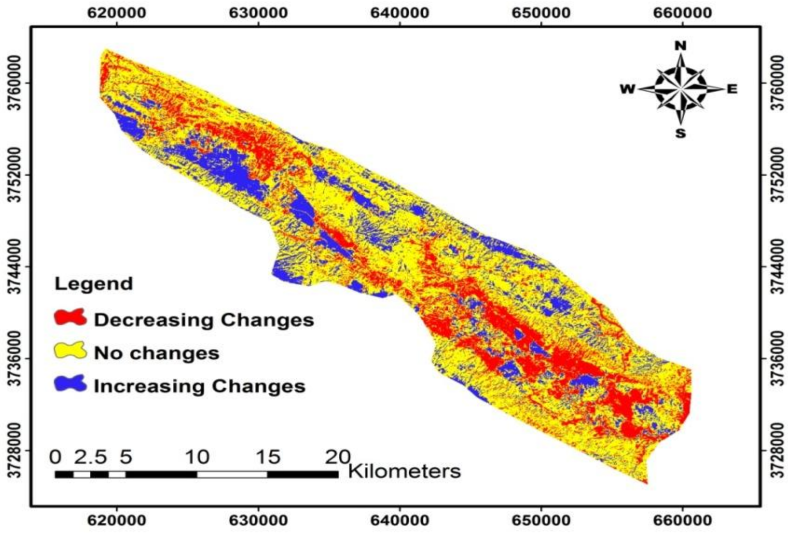

Figure 5: Monitoring map using difference in PCA_2method

Table 4: Error Matrix for changes monitoring methods

	User accuracy (percent)	Total	Increasing Changes	No changes	Decreasing Changes
NDVI differencing					
Decreasing Changes	71	470	0	13	457
No changes	96	627	5	489	133
Increasing Changes	99	1021	1021	0	0
Total		2118	1026	502	590
Producer Accuracy (Percent)			99	71	96
Kappa coefficient					0.88
Overall Accuracy (percent)					92.87
Image Rationing (IR)					
Decreasing Changes	11	93	0	0	93
No changes	92	970	1	482	487
Increasing Changes	99	1055	1025	20	10
Total		2118	1026	502	590
Producer Accuracy (Percent)			94	34	100
Kappa coefficient					0.61
Overall Accuracy (percent)					75.54
Tasseled Cap (greenness)					
Decreasing Changes	86	635	0	101	534
No changes	21	161	0	136	25
Increasing Changes	100	1322	1026	265	31
Total		2118	1026	502	590
Producer Accuracy (Percent)			56	79	77
Kappa coefficient					0.66
Overall Accuracy (percent)					80.08

PCA					
Decreasing Changes	90	561	0	13	457
No changes	95	531	5	489	133
Increasing Changes	99	1026	1021	0	0
Total		2118	1026	502	590
Producer Accuracy (Percent)			100	71	96
Kappa coefficient					0.95
Overall Accuracy (percent)					97.11

Table 5. The results of the evaluation of monitoring changes methods

Kappa coefficient	(%) Overall accuracy	Monitoring Method
0.66	80.08	Tasseled cap(greenness
0.61	75.54	Image Rationing
0.88	92.87	Difference in vegetation cover index
0.95	97.11	Difference in PCA_2

Table 6. Land-uses area of Srableh city between 1988 and 2013

land-use	Area (hectares) in 1988	Area (hectares) in 2013	Changes in land-use between year 1988-2013
Semi-dense forest	20117.65	9043.68	-11073.97
Sparse forest	1922.49	1678.22	-244.27
Fair rangeland	6159.18	3800.36	-2358.82
Poor rangeland	5206.98	15017.81	9810.83
Agriculture	11797.06	15663.29	3866.23

Conclusions

This study was done to determine the land cover changes for Zagros forest in Iran and select the most accurate and suitable method for forest monitoring. According to the obtained results, as far as accuracy is concerned PCA_2 difference is the best with the accuracy of 97.11% and image Rationing is least accurate method with accuracy of 75.54 percent. Hence, using difference in PCA_2 method is suggested in similar studies to assess changes in vegetation because of its high accuracy. Moreover, results showed a 30.2 percent decrease in rangelands and forests of the area and more than 30% land-use change to poor rangelands and agriculture in the time interval studied. Similar to our research, Butt et al., (2015) indicated a significant shift from vegetation cover to agriculture in Simly watershed of Islamabad [3].

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