

Evaluation of Development and Changes in Land Use using Different Satellite Image Processing and Remote Sensing Techniques (Case Study: Kermanshah, Iran)

¹Mohammad Maleky and ²Behzad Saeedi Razavi

¹Department of Civil Engineering, Faculty of Engineering, Ilam University, 69315-51 Ilam, Iran

²Department of Construction and Mineral Materials, Standard Research Institute (Sri)-Iran

Abstract: Currently the largest city in the western Iran, Kermanshah enjoys fast growing trend because of its strategic location. Remote sensing and satellite imagery are well suited for assessing the changes in land use over different time periods. In this study, satellite images from Landsat TM sensor and ETM sensor have been prepared during 1987 and 2007 as geometric and radiometric corrections have been made to them. The process was followed by selecting the best combination of false color by using Optimal Index Factor (OIF) in ILWIS software. Greenness, brightness and wetness indexes along with NDVI index of land cover were then derived in each period using Fuzzy Art map Supervised Classification, Principal Components Analysis and Tasseled-cap Transformation. The results indicated that Pca2 index can properly demonstrate increasing and decreasing changes among the main components as greenness index can display decreasing and no changes in land uses among tasseled-cap components, while the wetness index would reflect increasing changes in land use with high accuracy. Moreover, the precision and results of NDVI index is so close to that of greenness index. The overall results of the study suggest that the urban surface area is annually increased at a rate of 109.6 ha, which was a major decline in agricultural and range land use.

Keywords: Kermanshah, monitoring changes, principal components analysis, tasseled-cap transformation, urban land use

INTRODUCTION

In recent decades, urban sprawling is one of the most crucial issues with which developing countries including Iran are faced. In these countries, there is a growing tendency toward urbanization. Uncontrolled population growth is one of the factors which contribute to the physical development of cities. Unplanned expansion of cities causes destructive issues and many social ailments. In general, about 3% of world total population consisted of urban residents in 1800, which rose to 14% in 1900 as the world urban population stands at about 47% in 2000 (Ministry of Agriculture of Iran, 1998). As a developing country, Iran has been faced with a rapid growth in its cities both in terms of its location and population. The proportion of urban population to total population in Iran was approximately 47% in 1976, which climbed to 68% in 2007. Understanding various land use coverage in urban areas and assessing their changing trend have been proved pivotal as basic information for different planning purposes (Zobairi, 1997). Meanwhile, the application of satellite data with respect to the characteristics namely broad, integrated view, use of different sections of the electromagnetic energy spectrum for recording the characteristics of the

phenomena, duplicate coverage and possible deployment of hardware and software, has come to receive warm welcome in recent years. On the contrary, land surveying methods often proved to be impossible to carry out due to their huge cost and time-consuming feature for examining the growing trend of urbanization (Mohammad Esmaeel, 2011).

Preparing maps of land use and detecting their change trends are incorporated to the application of satellite images and data (Falihatkar *et al.*, 2010). Satellite image is viewed as effective means of monitoring changes due to being obtained at different times from one location. There have been a lot of researches on land use changes at urban levels. Anderson (2002) utilized four categorizing methods, namely post classification comparison, red band image distinction, Principal Component Analysis (PCA), Change Vector Analysis (CVA), to monitor land use changes in Las Vegas, an area with semi-arid climate and little vegetation coverage as well as Atlanta region. He concluded that the image distinction and post classification comparison could be used with higher accuracy than other methods for the former region, while principal component analysis and change vector analysis can accurately displays the changes in land use (Anderson, 2002). Having compared image distinction

and tasseled-cap transformation techniques to detect changes and urban vegetation coverage using the images prepared by Land sat TM sensor. Mohammed Esmail studied land use changes of Karaj, Iran from 1987 to 2002 by using images provided by Landsat ETM⁺ sensor, utilizing supervised classification and brightness and greenness indexes to that effect. Zeaiean Firouzabadi and Ghanavati (2007) studied the land use changes in a metropolitan area, Tehran, Iran using Principal Component Analysis (PCA) technique on Land sat images within a 10-years period, concluding that the most changes occurred in vegetation coverage (Zeaiean Firouzabadi and Ghanavati, 2007). Falahatkar *et al.* (2010) studied the changes in the land coverage of Isfahan, Iran from 1972 to 2001 using Land sat images. They concluded that the biggest increase in urban land use was relevant with an average of 571 ha/year.

Qharagozlo *et al.* (2010) have dealt with land use change in the 5th District of Tehran, Iran using images of Land sat ETM sensor and those of IKONOS satellite. The results of their study showed an increase in the residential area. Ahadnejad (2002) has studied the land cover changes in somewhere in the Eastern Azerbaijan, Iran using satellite images. He classified land uses into ten classes, indicating that the spread of urban land use has had the greatest impact on reducing garden land use. Using satellite images of Land sat MSS, TM and ETM, Sarvestani (2009) studied land use changes in

Shiraz, Iran from 1976 to 2005 based on supervised probabilistic classification method. He classified the land uses into three classes, range, built and vegetated areas as the results showed the built area had been triplicated. In general land use change detection techniques can be divided into two sets:

- Those that only represent the binary information on any or no changes such as image differencing, image ratio, Vegetation index differencing and principal component analysis methods.
- Those that show changes from one type to another one, e.g., post-classification comparison and hybrid methods (Liu and Weng, 2006).

The methods of change detection as a considerable debate were raised from the last three decades, which is why various methods have been developed. In this study, the attempt was made to detect the changes in land use in Kermanshah, Iran during the period from 1987 to 2007. With a growth in Kermanshah urbanization after end of War between Iran and Iraq, the picture in 1987 has been selected to that effect.

RESEARCH MATERIALS

In this study, satellite images of Land sat TM sensor obtained in May 1987 and those of Land sat

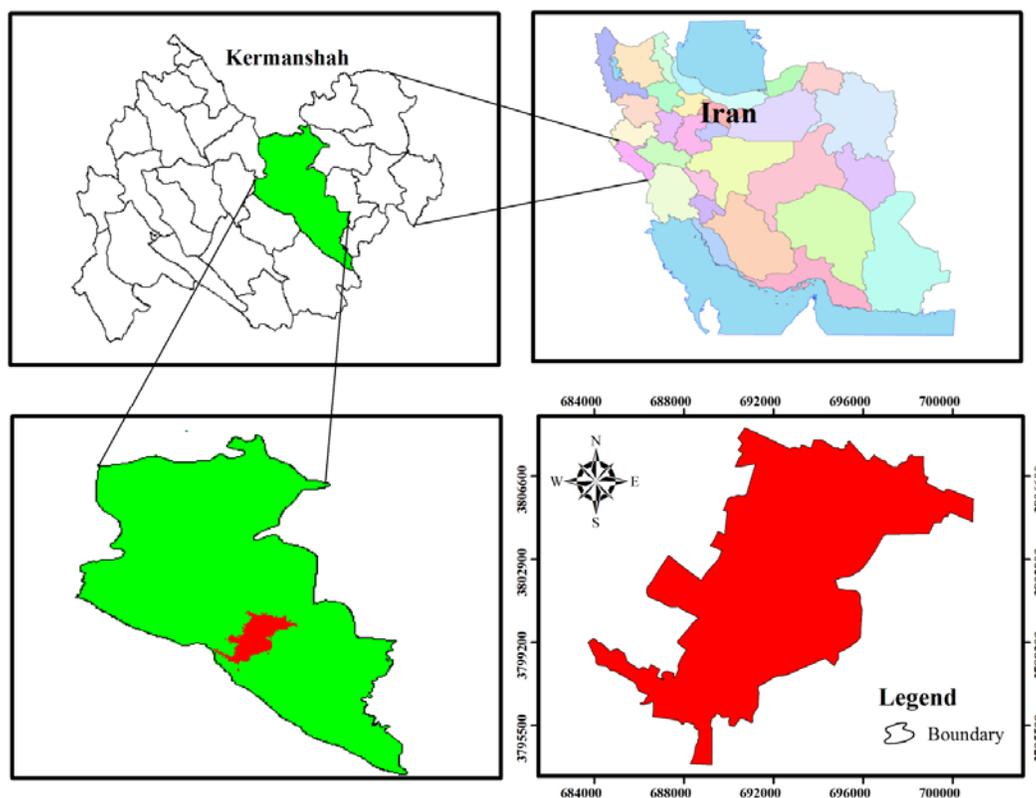


Fig. 1: The study area

ETM sensor obtained in June 2007 have been used. Moreover, the data collected from field visits as well as images of Google Earth and those of master plan (1:2500) of Kermanshah have been utilized. In addition to this, some software programs such as ILwis 3.3, ENvi4.5, Idrisi 3.2 and Arcgis 9.3 have been used for processing the data and various outputs.

Area of the study: Laid out on the Silk Road, Kermanshah is of considerable importance as linking Iran to Iraq. The area of the research is laid out in the Kermanshah's master plan with an area 9,638 ha. The area is located within the latitude and longitude of 26.2691° to 34.42024° N, 46.9971° to 47.1847°E (Fig. 1). In this study, the changes of the area have been studied from 1987 to 2007.

METHODOLOGY

To examine land use changes, initially geometric and radiometric corrections were carried out to the images. This was proceed with tasseled-cap transformation, NDVI and PCA analysis for the images. Determining appropriate thresholds and differentiating

the above methods for two time periods namely 1987 and 2007, the map of the area was prepared for each period along with increasing and decreasing or no change. In order to determine the type and extent of the changes in land uses ranging from a land use to the other, image classification was carried out using fuzzy method as the map of changes was created; which will be further elaborated and their results will be addressed. The conceptual model of the research is shown in Fig. 2.

Geometric correction: In the present study, the TM image obtained in 1987 was geo referenced based on image-to-image method with the aim of ETM image of 2007. To do so, fifteen ground control points were selected in relation to the fixed and unchangeable points such as crossroads. The first degree polynomial functions were used for converting the coordinates as the TM image of 1987 was eventually geo referenced with RMSE error of 35%.

Radiometric correction: To reduce the atmospheric effects over different time periods (1987 and 2007),

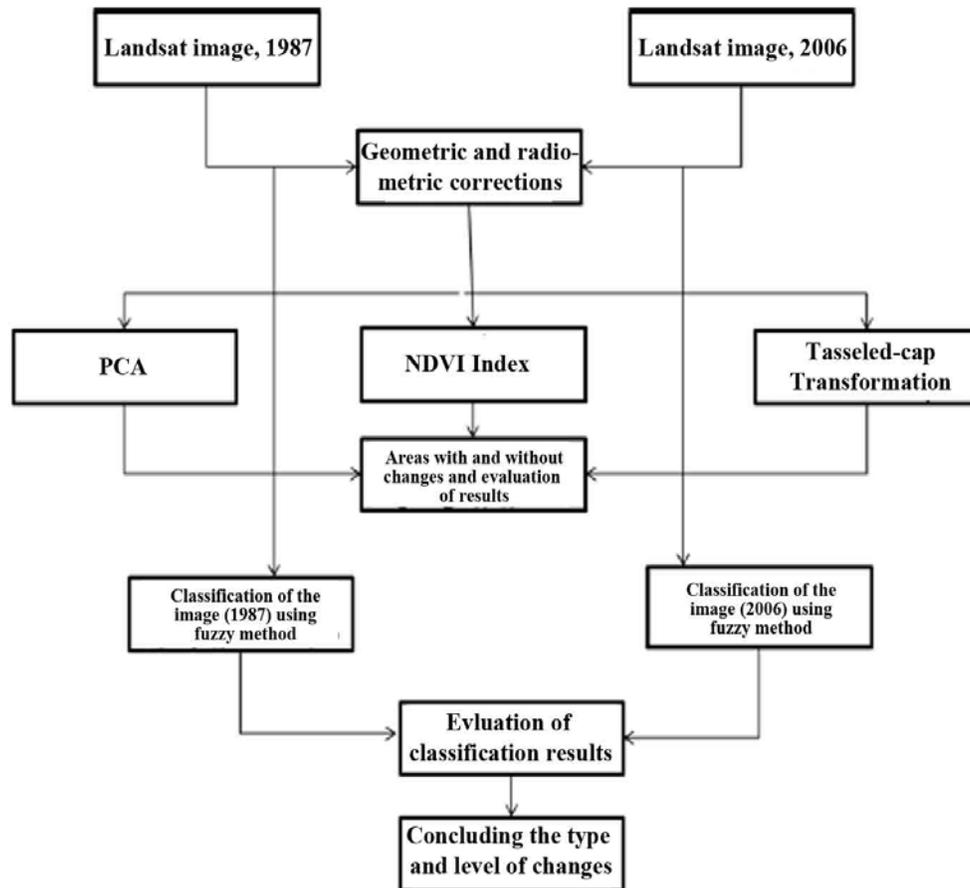


Fig. 2: Conceptual model of deriving land use changes in Kermanshah

radiometric correction should be made to the images. Dark object subtraction method has been applied in this respect. Normally, dark phenomena like water include pixel value of zero or near this. However, a fixed value will be added to each pixel of every band due to the atmospheric effects of radiation emission (Ahadnejad, 2002). The method of dark object subtraction reduces the value from the total values of pixel in each band so that the atmospheric effect will be eliminated. Such application was performed on the TM and ETM satellite images on ENVI 4.5 software. Following the image correction process, a variety of techniques were used to detect land use changes, which are explained as follows:

Principal Component Analysis (PCA): Different bands of multi- spectral images like Land sat are often considered to be highly correlated. Principal component transformation is a linear combination of the original bands of which no spectral correlation can be found. To put differently, PC transformation has a number of components equal to that of the initial bands wherein the spectral variance reach their maximum. Indeed, the first principal component enjoys data with the biggest variance as the second component has the biggest number of variances following the principal component and the last component has invariably the least number of variances (Richard, 1999).

Tasseled-cap transformation: This transformation was first introduced in 1976 by Kauth and Thomas (1976) for Land sat MSS sensor data. It is a linear transformation in which new components are derived from basic ones. The four components presented by Kauth and Thomas for MSS sensor involved brightness, greenness, yellowness and nonesuch (Kauth and Thomas, 1976). Later in 1986, Crist and Kauth (1986) introduced new coefficients for Land sat TM sensor data (Crist and Kauth, 1986). The maximum information on variances is represented by the first three components, while noise and atmospheric effects are incorporated to the fourth components onward. The first three components of the TM sensor involve brightness, greenness and wetness.

NDVI (Normalized Difference Vegetation Index) Index: The index was developed by Rouse *et al.* (1973) to separate vegetation from soil background for MSS sensor which its equation is as follows:

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (1)$$

where, NIR is near infrared band of image and RED is red band NDVI values range between -1 and 1, where

zero indicate the lack of vegetation as negative values reflect the absolute lack of vegetation.

Calculation of the normalized differences: The above methods mentioned earlier are among the techniques that can be used to monitor land use changes. To analyze the changes, the normalized differences of all the methods should be calculated in the first place:

$$S = \frac{X_i - \bar{X}}{\sigma} \quad (2)$$

where,

S = Normalized value of the variable

X_i = The numerical value of each pixel

\bar{X} = Mean of the pixels

Noting that the results of these techniques included three areas with increasing, no and decreasing changes, the next step is then to determine a threshold to distinguish these changes from one another. There are commonly two methods for determining thresholds, that is, trial and error process and statistical methods (Yool *et al.*, 1997). In this study, a statistical method based on the selection of a suitable standard deviation of a mean has been used. Various standard deviations were examined for each of above methods, e.g., ± 0.5 , ± 0.75 , ± 1 , ± 1.5 and ± 2 . Calculating the overall accuracy and Kappa coefficient of each method, the best threshold was finally selected for each method.

RESULTS

Four methods, i.e., principal component analysis, image differencing, tasseled-cap transformation and difference vegetation index, were used for monitoring land use changes in the present study. The normalized differences assessed in 1987 and 2007, which were relevant to the methods, were obtained in the first place. This was followed by setting thresholds as the best ones for each method were calculated so that decreasing, increasing and no changes were determined.

The results of principal component analysis difference method: In as much as the maximum information is more relevant to the first two components than other principal components, these two components have been used for monitoring land use changes as the results of Table 1 suggests that the second component, $Pc_{2\pm}$, with a threshold of ± 1.5 shows decreasing and no changes with the accuracy of 52 and 94%, respectively, while the increasing changes with low accuracy of 24 is shown thereto. Among the three methods used in this study, the overall accuracy of this method is lower than the other two as in Table 1 it is noticeable. Figure 3 shows map of PCA differencing.

Table 1: Confusion matrix of change monitoring methods

	Decreasing changes	No change	Increasing changes	Total	Commission error	User accuracy (%)
NDVI Difference						
Decreasing changes	351	0	1	352	0.0028	99.6
No change	0	585	57	642	0.088	100
Increasing changes	0	0	196	196	0	100
Total	351	585	254	1190		
Commission error	0	0	0.2283			
Kappa coefficient	0.92					
Overall accuracy (%)	95.1					
Tasseled-cap (moist)						
Decreasing changes	187	55	0	242	0.2273	67
No change	164	508	36	708	0.2825	45
Increasing changes	0	22	218	240	0.0917	88
Total	351	585	254	1190		
Commission error	0.4672	0.1316	0.1417			
Kappa coefficient	0.62					
Overall accuracy (%)	76.72					
Tasseled-cap (greenness)						
Decreasing changes	345	29	0	374	0.0775	89
No change	6	555	50	611	0.0917	82
Increasing changes	0	1	204	205	0.0049	99.3
Total	351	585	254	1190		
Commission error	0.0171	0.0513	0.1969			
Kappa coefficient	0.8831					
Overall accuracy (%)	92.77					
PCA2						
Decreasing changes	219	6	30	255	0.14	79
No change	132	576	149	857	0.33	35
Increasing changes	0	3	75	78	0.038	95
Total	351	585	254	1190		
Commission error	0.3761	0.0154	0.7047			
Kappa coefficient	0.53					
Overall accuracy (%)	73.2					

Authors and output of software programs

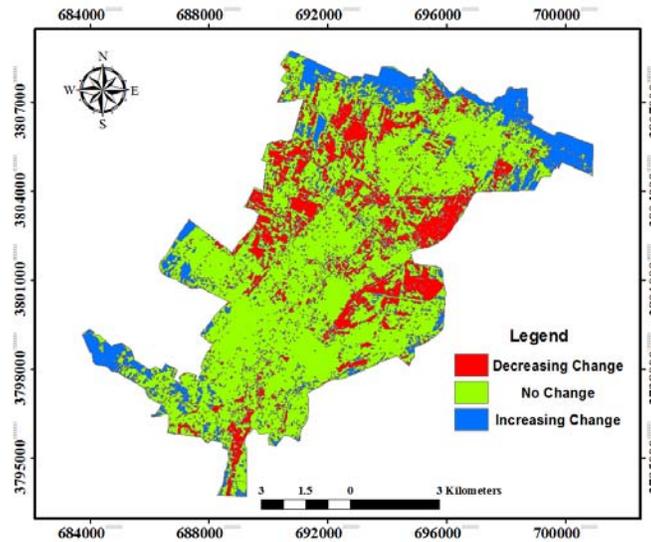


Fig. 3: PCA2 difference

The results of Tasseled-cap method: As for this transformation, the first three components, i.e., brightness, greenness and wetness have the maximum information. The results of the analyses indicate that the brightness component does not properly display any of the changes. This was as opposed to Table 1 where the

greenness component with a threshold of ± 1.5 showed decreasing and no changes with the accuracy of above 97.5 and 89.4%, respectively. Furthermore, the component shows the increasing change with the accuracy of 76.2% which was really close to the accuracy value of wetness component (Table 1).

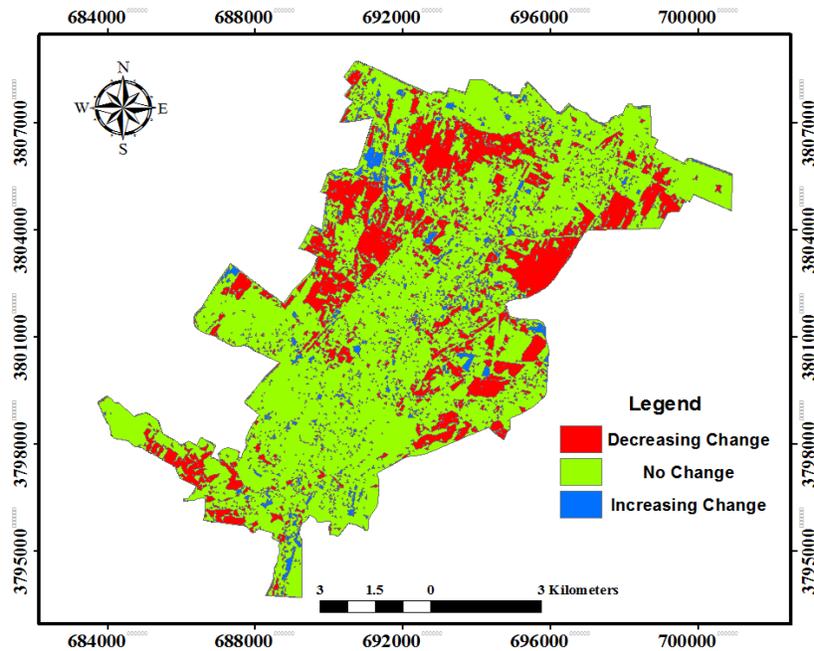


Fig. 4: Tasseled-cap-greenness difference

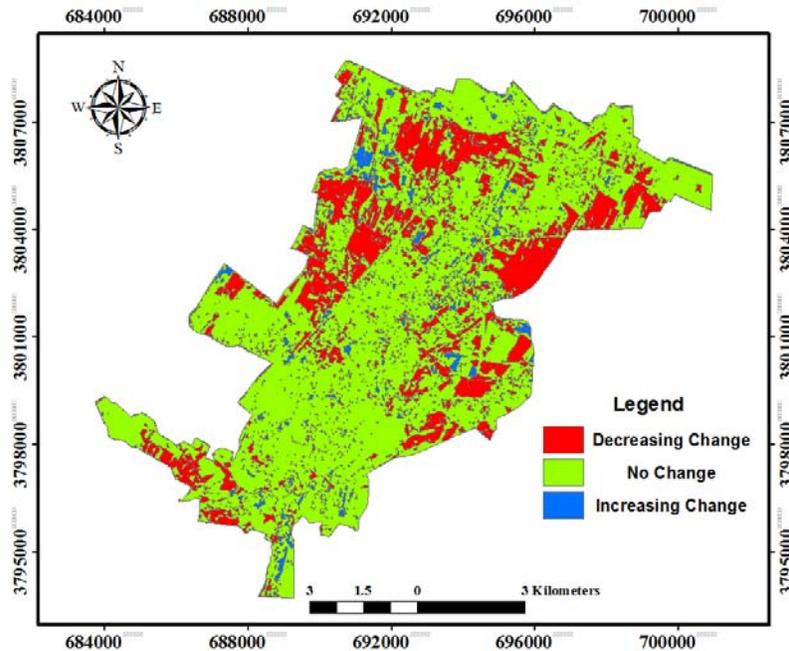


Fig. 5: Tasseled-cap-moist difference

Wetness component also show increasing change with the accuracy of above 82% (Table 1). Indeed, the wetness component demonstrated increasing change with higher degree of accuracy rather than all other methods used in this study. According to Table 1, we can conclude that the overall accuracy of greenness component proved practical with respect to wetness component in terms of displaying changes in the

present study. Figure 4 and 5 show map of Tasseled cap greenness and moist.

The results of vegetation index difference method: As is seen in Table 1, the accuracy of this method involves higher degrees than other methods as to revealing decreasing and no changes; the method enjoys the accuracy of 100% for the both changes. The

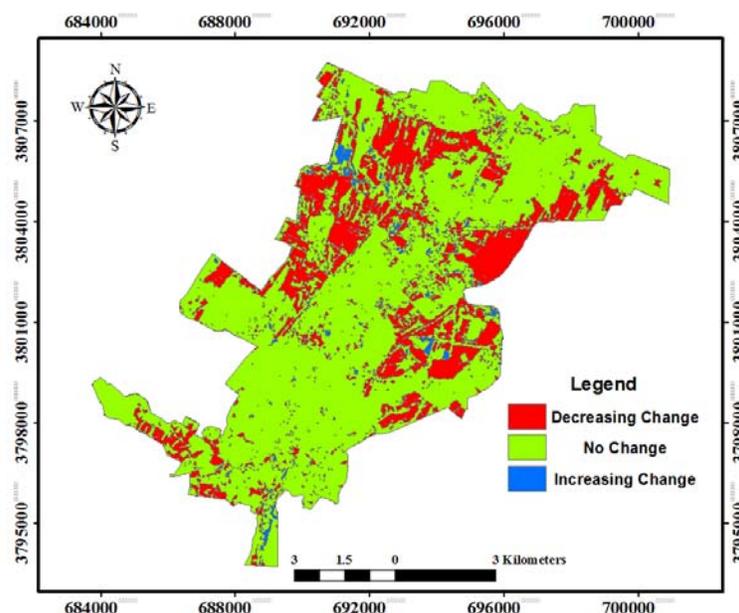


Fig. 6: NDVI difference

best threshold for this method stands at ± 1.5 . The accuracy of this method is 72.66 for showing increasing changes. Among the three methods, i.e., tasseled-cap NDVI and PC, the overall accuracy of NDVI is surmounted (Table 1). Table 1 represents the statistical parameters of the error matrix, the accuracy of the producer and the user as well as the overall accuracy and kappa coefficient for different methods of classification and monitoring changes. Figure 6 shows map of NDVI differencing.

POST-CLASSIFICATION COMPARISON METHOD

The images, in this method, taken in 1987 and 2007 were classified using supervised classification technique. The fuzzy Artmap approach, in the present study, has been used for the supervised classification. The entire area was classified based on seven land uses, that is, built up area (including residential, commercial, administrative, military areas, etc.), agricultural, water, green space, garden, forest, and range lands.

The multi-temporal images separately classified into thematic maps, so some techniques such as classification comparison, difference of maps and statistics of detecting changes were used to monitor changes. The main reason why this method has been taken was to minimize the environmental and climatic effects existed between multi-temporal images.

The results of post-classification comparison method: As for the classification of satellite images, land use classes were divided into seven categories. It

was followed by collecting training data from the area using Google Earth satellite images, the map of master plan for Kermanshah (1:2500) and field visits. After this, the supervised classification stage was conducted using fuzzy Art map approach and land cover maps of 1987 and 2007 were created (Fig. 7 and 8). In the end, the confusion matrix was formed according to Table 2 and 3 by using random sampling from the region and Google Earth satellite images. As it is seen in Table 2, the overall accuracy of the classifications for 1987 was 94%, 0.88 with Kappa coefficient. According to Table 2, the overall accuracy of the classification of 2007 is 96.44% with kappa coefficient of 0.92. The results were quite satisfactory for both years.

The area of the land uses were extracted from the classification in Table 3. The analysis of the results indicates that the maximum changes are believed to be increasing with respect to the built area use, which shows the annual increase of almost 109.6 ha. According to Table 3, the maximum decreasing changes was relevant to the range land and agricultural land use, which was annually 54.13 and 45.3 ha, respectively. Unifying the results of Table 3 with those of Table 4, it is obvious that the maximum quantities of use changes related to agricultural and range land use were 845.63 and 1118.06 ha, respectively, which were both transformed to the residential area uses. In Fig. 8, it is evident that some parts of residential areas advanced toward Ghareh Sou River. This was happened at the northwest side of the river.

As mentioned earlier, the most of the transforming changes are related to the conversion of range and agricultural lands into residential areas. According to

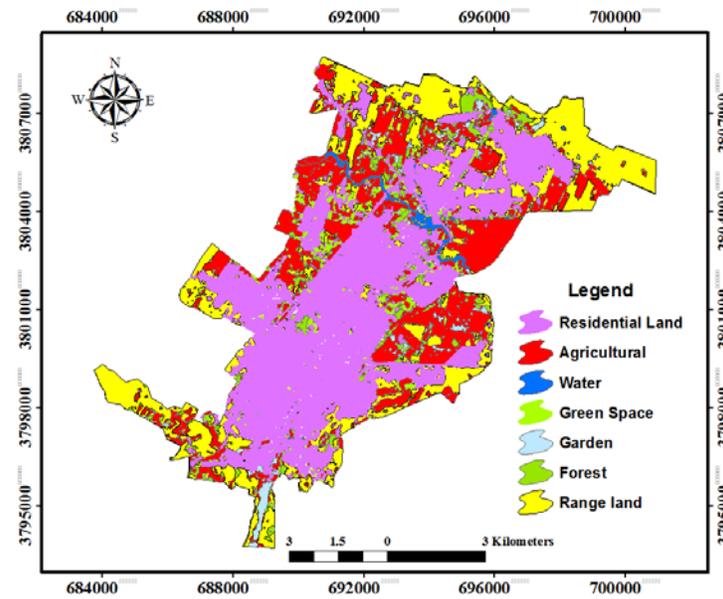


Fig. 7: Land use cover of Kermanshah in 1987

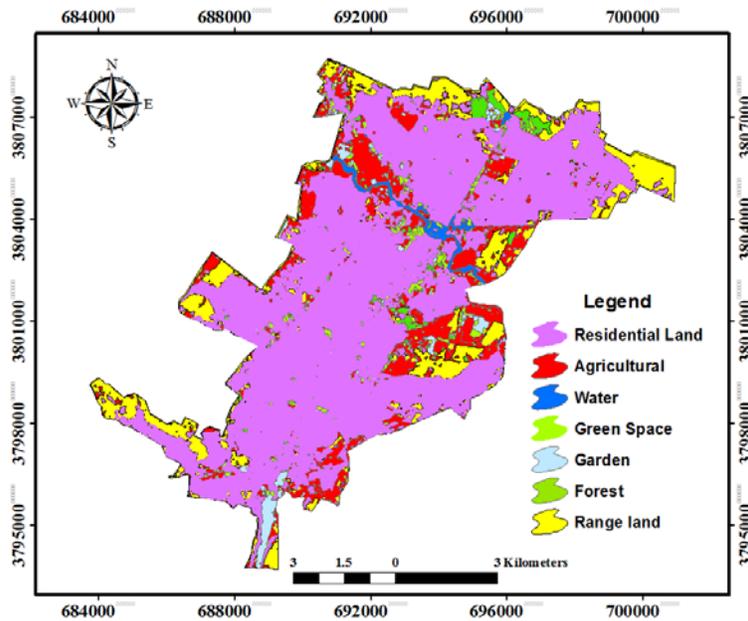


Fig. 8: Land use cover of Kermanshah in 2007

Table 2: Classification accuracy (%) in the images (1987 and 2007)

Cover class	TM-1987		ETM+/_ 2007	
	Productive accuracy	User accuracy	Productive accuracy	User accuracy
Residential land	98.04	96.07	100	99.13
Agricultural	98.88	70.58	92	87.71
Water	96.19	79.36	52.08	95.60
Green space	92.13	79.15	90.16	62.92
Garden	82.48	94.01	99.76	100
Forest	90.76	100	100	03.23
Renge land	99.54	99.31	100	99.62
Total accuracy%		94	96.44	
Kapa coefficient		0.88	0.92	

Table 3: Land use area in Kermanshah in 1987 and 2007

Land use	1987	Percent (%)	2007	%	Difference (%)
Residential	4330.93	44.936	6414.580	66.554	21.619
Agriculture	2102.83	21.818	1247.630	12.945	-8.873
Water	100.84	1.046	123.480	1.281	0.235
Green space	326.35	3.386	226.510	2.350	-1.036
Garden	202.19	2.098	188.630	1.957	-0.141
Forest	344.83	3.578	166.540	1.728	-1.850
Range land	2230.12	23.139	1270.720	13.184	-9.954
Total	9638.09	100.00	9638.09	100.00	0.000

Authors

Table 4: Changes in land use classes

	Area (ha)	Area (ha)	Area (ha)
2 1	845.63	1 4	71.31
3 1	64,	2 4	68.63
4 1	199.16	3 4	8.28
5 1	70.50	5 4	10.88
6 1	127.52	6 4	9.99
7 1	1118.06	7 4	21.6
1 2	122.65	1 5	8.28
3 2	25.42	2 5	76.83
4 2	97.06	3 5	4.79
5 2	3	4 5	8.04
6 2	77.24	6 5	11:53
7 2	256.02	7 5	27.86
1 3	151.89	1 6	14:13
2 3	77.89	2 6	35.08
4 3	36.31	3 6	8.83
5 3	36.31	4 6	9.09
6 3	30.95	5 6	9.09
7 3	47.03	7 6	10:48

Authors

Map 6, the biggest increase in built areas is attributed to the southern and western of Kermanshah. Such expansion is as a result of the west of Kermanshah and its towns (e.g., Elahieh) where there are a lot of facilities and better infrastructures compared with the east of Kermanshah. Given the major traffic of the suburbs to this city flows from the west; this can be viewed as another reason to expand the city. Moreover, in the southern Kermanshah, the range lands available on the one hand, the height of this region of the city, which in turn exerts positive effect on its climate, on the other and the vicinity to Kasra district, a residential place for upper class, people are more inclined to reside nearby this are more than ever. This has led to the establishment of Motekhasasin and Zhandarmeri Towns in the South and Pardis and Sadra in the south west.

CONCLUSION AND SUGGESTIONS

Noting that the tasseled-cap (greenness, brightness and wetness components) as well as NDVI index have been used in this study, it seems that these methods can properly display increasing and decreasing changes of vegetation in spite of wetness component which can reveal other land use changes, in particular range land. It seems that neither of these methods is well suited to detect changes by themselves as it calls for the application of coordinated methods. Therefore, it is

quite advisable that other methods be investigated for displaying variety of land uses like CTVi. Since there are a lot of land uses in urban area and indeed changes of land uses can be found at a specific level, the images with relatively local differentiating power like Land sat, which has been used in the present study, have problems like compound pixels. Because of this, it is suggested that satellite images with higher local differentiating power be used. In this respect, many land use classes can be held and analyzed within urban district. For example, road uses for images with high differentiating power can be best analyzed. By Land sat images, we are unable to derive appropriate results of road uses. Given the growing trend of Kermanshah due to its strategic status, it is quite envisaged that these changes can be achieved for coming years, a plan that requires satellite images of at least three time periods.

REFERENCES

- Ahadnejad, M., 2002. Environmental Land use Change Detection and Assessment using with Multitemporal Satellite Imagery. Case Study Maraghe Region. Map Asia 2002-Bangkok, Thailand. Retrieved from: <http://www.gisdevelopment.net/application/environment/overview/frpf0004.htm>.
- Anderson, J., 2002. A comparison of four change detection techniques for two areas in in the United States. M.A. Thesis, Department of Art Geography, West Virginia University.
- Crist, E.P. and R.J. Kauth, 1986. The tasseled cap demystified. Photogramm. Eng. Rem. S., 52: 81-86.
- Falahatkar *et al.*, 2010. Evaluation of land use changing in Isfahan over last 4 decades city, Iran using remote sensing. Sci. Agric. Nat. Res. J., Vol. 47, Iran.
- Kauth, R.J. and G.S. Thomas, 1976. The tasseled cap-a graphic description of the spectral-temporal development of agricultural corps as seen by landsat. Proceeding of Symposium on Machine Processing of Remotely Sensed Data. Purdue University, West la Fayette, Indiana, pp: 47-51.
- Liu, D. and Q. Weng, 2006. Use of impervious surface in urban land use classification. Remote Sens. Environ., 102(1-2): 146-160.

- Ministry of Agriculture of Iran, 1998. Methods of spectral and spatial in land use mapping. Iran, 26: 36-48.
- Mohammad Esmaeel, Z., 2011. Monitoring of land use changing in Karaj city, Iran using remote sensing techniques. *Soil Res. J.*, Vol. 24.
- Qharagozlo *et al.*, 2010. Evaluation of urban analysis and land use change using high spatial resolution images (Case study, Tehran District No. 5, Iran). *Sci. Environ. Technol.*, Vol. 11.
- Richard, D.J.A., 1999. *Remote Sensing Digital Image Analysis: An Introduction*. Springer-Verlog-Berlin, Germany, pp: 240.
- Rouse, J.W., R.H. Haas, J.A. Schell and D.W. Deering, 1973. Monitoring vegetation systems in the Great Plains with ERTS. *Proceeding of the 3rd ERTS Symposium, NASA SP-351 I*, pp: 309.
- Sarvestani and *et al.* 2009. Three decades of urban growth in the city of Shiraz, Iran: A remote sensing and geographic information systems application. *Journal of cities* vol.28:pp 320-329.
- Yool, S.R., M.J. Makaio and J.M. Watts, 1997. Techniques for computer-assisted mapping of range land change. *J. Range Meas.*, 50(3): 314-317.
- Zeaiean Firouzabadi, P. and E. Ghanavati, 2007. Digital Approaches for change detection in urban environmental. *Geogr. Res.*, 22(1(84)): 133-146.
- Zobairi, 1997. *Remote Sensing and its Application on Natural Resource*. 6th Edn., Tehran University Press, Iran.