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Applicability of ETM Satellite Images for Surveying Land Cover Condition (Case study: Kashan-Iran)

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ABSTRACT

Remote sensing is a major source of data to prepare land cover map. The present study has been conducted to investigate the ability of Landsat ETM satellite in order to prepare land cover map. The images were taken on July 10, 2014 and has been geo referenced by using digital coordinate map with scale of 1:25000.The amount of RMSE that obtained from geo-referenced images was o.348. In order to prepare for processing digital data, such as contrast enhancement, optimum index factor OIF), principal component analysis(PCA), producing false color composite and vegetation indices improving operations and enhancing images were carried out on the data. Based on studies and field visits with help of control points and global positioning system, ground real map was prepared. To classify data Supervised classification methods were used. After classification, land cover maps with different classes were prepared. Overall accuracy and Kappa coefficient to classify maximum likelihood are 86.31% and 83.93% respectively. For a minimum distance 70.83% and 68.49%, for Minimum Mahalanobis Distance 85.95% and 81.53% and parallelepiped are 82.31% and 79.84% were obtained.

Introduction

Identifying natural resources phenomena and their constituents are the first and important step to their management. Being aware of land cover types and human activities in various parts and knowing how to utilize the land as basic data is of great importance. Maps that display these activities at different levels of the earth known as land cover map (Ehsani, 2001). Nowadays, remote sensing is considered as a prominent technology in land cover status. This technique is recognized as primary data sources to exhibiting land cover and resource management. Moreover, it has significant impact on land management and urban planning (Matinfar et al., 2007; Rogan and Chen, 2004; Rezvani, 2010) and provided updated information for management purposes (Abdollah et al., 2013). Darvishsefat et al. (1997) analyzed Landsat-7 Satellite data in semi-steppe area (Hana-Semirom) in Isfahan province, in order to study the capability of ETM+ in estimating canopy cover and plant production . Mokhtari (1997) evaluated plant cover by using Landsat TM satellite data in three areas in Isfahan.

NDVI indices showed the highest correlation with canopy cover among utilized criteria and the correlation coefficient was estimated more than 90%. Zahedifard (2002) prepared land use map of Bazoft' watershed in Chaharmahal and Bakhtiari province using Landsat TM data. In Pen method, the highest overall accuracy and kappa coefficient related to maximum likelihood classification, were respectively 89.15% & 87%. In order increasing the accuracy of the map, Zahedifard (2002) used hybrid method and GIS and then combined different layers for producing the final map. Kartris(1990) analyzed Landsat TM sensor data date back to October 1982 from Central Michigan in the United States and evaluated the ability of different classes such as types of pine, other softwoods, hardwoods, prairies and water. Auhja et al. (1993) interpreted the multi-temporal and multi-spectral sensor on 1986 at 1:50000 scale and Indian remote sensing satellite images (IRS) with at 1:50000 scale and aerial photography of 1: 250,000 scale and identified the problems of natural resources of Howie in India. Then they produced land use map based on the capability of land, vegetation and climate. Hurcom et al (2003) investigated Amazon jungle by using AVHRR, NOAA, TM and MSS data in Rondoma in the southwestern of Brazil. Philip et al. (2005) in a study in northwest of Jordan, used ETM+ images to provide land cover map.

The images were classified as supervised and unsupervised and then they could be divided into land cover maps of urban areas, shrub land and rangelands by accuracy of 83%. Luciana et al. (2007) studied changes in jungles area at 1778 square kilometers. In this area, TM and ETM+ landsat from 1987 to 2001 were studied. The aim of present study was to showing Kashan desert plains status. Also, the capability of ETM of Landsat satellite which was placed into orbit on July 10, 2013 to provide land cover map.

Materials and Methods

The study area

The study area with an area about 249434 ha is located in 240 km of South of Tehran and is in desert margin in 19́ 98" 51̊ to 51̊ 56́ 41"East longitude and 34̊ 00́ 86" to 12" 34̊ 23́ North latitude. The study area is limited to Salt Lake, Salt marsh and Rigboland-Kashan from east and northeast and to mountains from west and its south is limited to Kashan. The highest elevation in the study area is 1500 m above sea level in the northwestern and the lowest one is 810 m in Ab-Shirin area.

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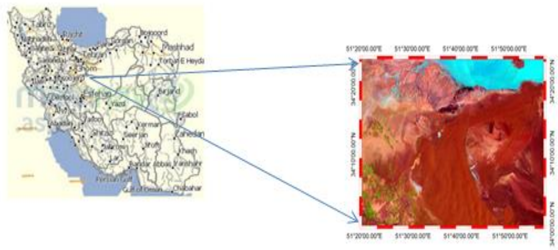

Fig 1. False color composite about B=1 ‹G=4 and R=7 in study area.

In the present study, ETM Landsat data around study area were collected on July 10, 2013. The data were corrected and converted into GEOTIFF format. Then preliminary analysis was conducted for images. For this purpose, geometric, radiometric and atmospheric errors of images were evaluated. Results showed that images require geometric correction. Therefore, georefrencing carried out by ILWIS. Prior to using satellite data for numeral analyzing, their quality in terms of geometric errors, actinometrical such as corrugated beam shrinkage, failure of scan lines, pixel duplication, geometric error like cloud spots were assessed. Following this procedure, geometric correction conducted by using Global Positioning System and image processing. After selecting points by using linear polynomial equation and sampling of the nearest neighbor method, values and DN of each pixel from the original image transferred to the created image and geometric correction was conducted. Obtained RMSE from georeferenced images which were less than 0.5 pixel on the figure and 12 m on the ground were considered as acceptable. (Darvishsefat, 2006). So, two approaches include using all bands and all bands without thermal bonding for classification were selected. Then, supervised classification was performed using maximum likelihood method and finally the accuracy of any approaches was investigated. Finally, land cover maps produced. Then the accuracy of maps realwas investigated to ensure the accuracy of the maps. Corrections via ground real map during this phase studied via field investigation.

The main purpose of the study was to preparing land cover map, therefore there is need to ground real in order to determination of the accuracy of the results which was obtained from analyzing satellite data. Ground real map could be prepared 100% or as a partial sample to verify the accuracy of obtained results of analyzing satellite data. The ground real map in executive tasks in 2-2.5% level as sampling could well estimate the accuracy of the subjective maps.

(Darvishsefat and Zare, 1997). A quick overview of terrains and different land uses obtained with the help of different maps and satellite images. Overall data for the study area derived using digital maps of geology, land use and vegetation cover of area.

Then field operations commenced. Firstly, filed surveying conducted for determination of land use types. A large area in the studied area consisted of sand dunes. Other land uses in the area include vegetation cover, mulching land, Alluvial fan, bloated saline land, salt crust, sandy desert, floodplain, clay plain, Flood spreading, mountain and flooded area. The best color combination selected based on correlation matrix bands (PCA), OIF, and creating multiple color images, which had the highest manifestation of the phenomenon (G, R, NIR). Table 1 shows the best combination of bands by using OIF indicats that the best bands combination is 4, 6 and 7. The criteria used to separate spectral-information classes are texture and pattern on the image and field survey.

These classes were introduced into the system for classifying images as educational samples. Getting information about vegetation cover using remote sensing is of great importance.

In the present study, in order to producing vegetation cover map, vegetation indices such as NDVI, TSAVI, RVI, DVI, SARVI, SAVI were used. (Table 2).

Table 1. Information on optimal band Combination Index

OIF	Band Combination	ROW
148/48	4 ,6 ,7	1
129/05	1, 4, 6	2
121/83	4, 5, 6	3
100/21	3, 4, 5	4
90/89	2, 4, 6	5
85/34	3 ,5 ,7	6

Table 2. Vegetation indices used.

Row	Name of inde	Formula
1	NDVI	$\frac{NIR - RED}{NIR + RED}$
2	DVI	$NIR - a \times RED$
3	RVI	$\frac{NIR}{RED}$
4	SAVI	$\frac{(1+L)\times(NIR - RED)}{NIR + RED + L}$
5	TSAVI	$\frac{a\times(NIR - a\times RED - b)}{RED + a\times NIR - a\times b}$
6	SARVI	$\frac{NIR}{RED + b/a}$

L=0.5 b=0.84726 a=0.96916

On the color image (FCC.123) in ILWIS, 11 classes recognized and at the same time two-dimensional graph pixels of education area were selected. After selecting homogeneous samples as well as having sufficient distribution, they were evaluated throughout the image. After selecting educational samples, their Spectral graph were drawn and evaluated in order to control the number of classes separating. Sampling was reformed by examining the mean standard deviation and two-dimensional graph. In figure 2, two-dimensional graph B3, B4 and educational samples were shown.

Two-dimensional graph between red band (3) and infrared (4) showed the common line of soil. In the mentioned graph vegetation cover separated from other classes and were located above the soil line and were separated from soil classes. Saline soils getting away from the coordination origin, according to the amount of salt which resulted in increasing reflections.

Those soil that had more salt and soil surface is whiter located at the end of the soil line because of maximum reflection. Considering two-dimensional graph, red band and infrared, it can be concluded that vegetation classes are well separated

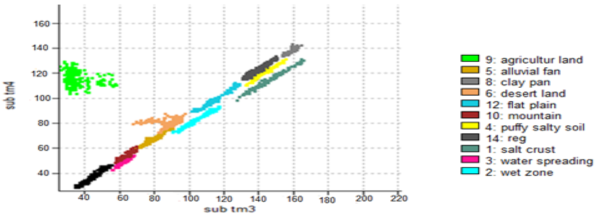

Fig2.Diagram of two-dimensional B3, B4 band and educational samples.

After classifying satellite images and producing cover map and land use, it seems to be necessary to evaluating the accuracy of these maps for most of the users.

The final step in producing land cover map is estimating the maps accuracy. The most common way to assess the accuracy of produced maps from satellite images is analyzing error matrix that is also known as Confusion matrix or Contingency table. In order to producing the error matrix , obtained maps from classification, would cross with ground real map. Also, Kappa coefficients utilized for verifying the accuracy of classification. Therefore, wrong and right classified pixels were applied to calculate this criterion and accidentally agreement was deleted. The coefficients vary between zero to one. Kappa coefficient equal to 1 represents 100-percent agreement between classification and ground real, reflecting perfection of the classification. After classification, the most common practice is using Filter mode that eliminates single pixels and small areas within other classes. The performance of filter is based on the frequency of classes that is placed within the filter window.

Research findings

Figure 3 shows spectral reflectance for different classes. Salt crust had the highest reflection mulching and agricultural lands had the lowest one. This could be due to this fact that salt crystal can increase reflection. Vegetation cover absorbs visible light (especially green light) via chlorophyll and hence lower reflection. As plant cover increases on soil, more soil would be bare and consequently will result in less reflection. There was reverse trend in the infrared range. Apart from plain clay, saline lands bloated and sandy desert, the highest amount of reflection observed agricultural lands which is due to the impact of intracellular water. Increasing the amount of intracellular water will increase absorption. After supervised classification, different map classes were produced. Error matrix obtained to evaluate the accuracy of classification.
Table 3 shows the overall accuracy for each classification method.
The highest overall accuracy for classification method was the most probable method and the least for classification was the least minimum distance.

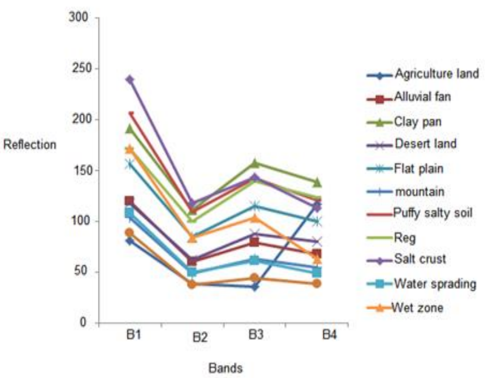

Figure 3. Spectral graph of data in study area

Table 3. Overall accuracy for each classification methods

Classification method	Overal accuracy	Kapa coefficient
Parallelepiped method	82.31	79.84
Least distance method	70.83	68.49
Mahalanobis distance method	85.95	81.53
Maximum likelihood method	86.31	93.83

The highest amount of Kappa coefficient for classification method is the most probable method and the lowest amount for classification is the least distance method. Kappa coefficient represents the number of correctly classified pixels. It means that in classification method with most probable method the possibility of correctly classified pixels is equal to 83.93%. While for the least distance method is 68.49%. Also, Commission and Omission error were evaluated. Commission error created due to heterogeneity and complexity of spectral reflection of area and mixed pixels that is located on the border between two floors.

In maximum possibility classification method, most of these errors are related to mountain areas and the highest spectral interferences related to mixing mountain areas with wet area and saline bloated land.

Commission error shows that how many pixels were put in other classes. In Maximum likelihood classification, highest number of errors relates to wet area and the maximum error is in saline bloated land and wet area. Figure 4 compares Commission and Omission error.

When comparing mixed graph of Commission and Omission error, it can be concluded that in those classes that the amount of Omission error is more than Commission, and the area of this land on the ground is more than what is shown on the map. Also in those classes that Commission error is more than Omission, the area of the

ground is less than what is shown on the map. Error matrix method of classification shows the most probable (Table 4).

Figure 4. Comparing commission and Omission error in Maximum Likelihood Classification

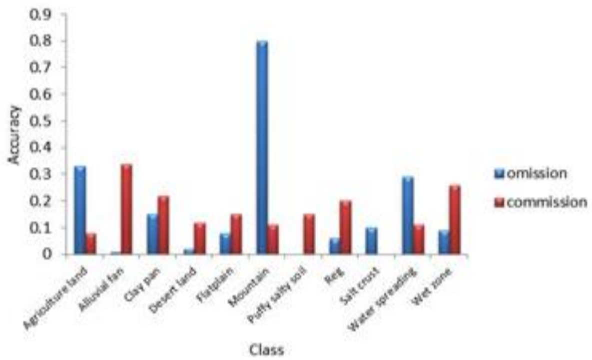

Figure 5 shows the map of the coverage area . According to the results, Alluvial Fan devoted the highest and Saline lands bloated had the lowest percentage of study area. Figure 6 shows the distribution of user classes in the region

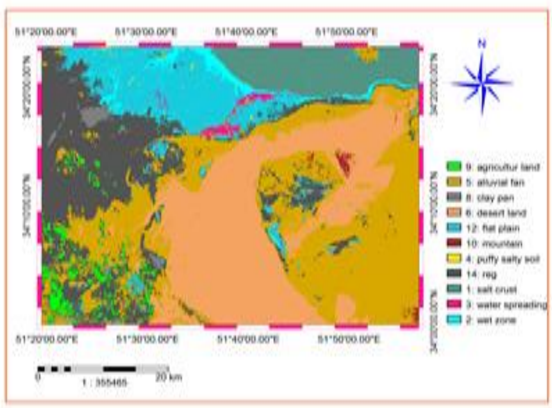

Fig 5.land cover map

Table 4. Matrix error of maximum likelihood classification method

	Agriculture land	Alluvial Fan	Clay pan	Desert land	Flat plain	Mountain	Puffy salty soil	Reg	Salt crust	Water spreading	Wet zone	Accuracy	Commission error	Total
Agriculture land	301	0	0	0	0	0	0	26	0	0	0	0.92	0.08	327
Alluvial Fan	0	758	0	188	0	0	0	0	0	0	0	0.8	0.2	946
Clay pan	0	0	211	0	0	0	58	0	0	0	0	0.78	0.22	269
Desert land	0	17	0	1243	0	206	0	0	0	0	0	0.85	0.15	1467
Flat plain	0	0	0	0	574	0	0	0	0	48	0	0.88	0.12	655
Mountain	0	0	0	0	13	137	0	0	0	0	0	0.91	0.09	150
Puffy salty soil	0	0	0	0	76	0	215	0	0	0	0	0.73	0.27	293
Reg	0	0	47	0	0	0	0	826	0	0	0	0.95	0.05	837
Salt crust	0	0	0	0	0	0	0	0	677	0	0	1	0	677
Water spreading	0	0	0	0	0	0	0	0	0	283	39	0.88	0.12	322
Wet zone	0	0	0	0	0	0	0	0	146	0	319	0.69	0.13	465
Omission error	0.07	0.02	0.18	0.13	0.13	0.6	0.21	0.03	0.18	0.15	0.11			
Total	223	775	258	1431	663	343	273	852	826	331	358			6749

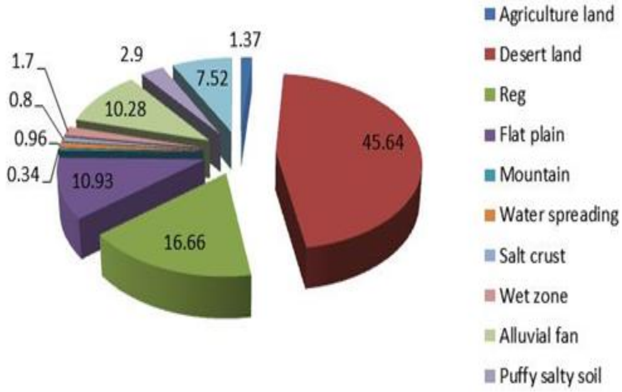

Fig6. Distribution of user classes in the region.

Discussion

According to Anderson (1976), acceptable accuracy in classified data, especially land uses by using satellite images must be more than 85%. In this area, the highest overall accuracy for ATM, was 86.34.

So, images of Landsat ETM has a high capacity of producing classification land cover map. The highest Overall accuracy (86.31%) for maximum likelihood classification and the lowest 70.83% is for Minimum distance classification method and this result is in agreement with other studies including Philip et al. (2005), Lillesand (1991), Alavipanah et al. (2001) that introduced Maximum likelihood classification as a best classification method. The study area is an arid area and has saline soil. Hence the variety of vegetation is low and most of them are poor. Given the ability of DVI, RVI, TSAVI indices, so they can be used on vegetation studies. All supervised classification algorithms correctly recognized all pixels in salt crust. High accuracy of classification of salt crust could be due to distinct spectral features or spectral resolution in comparison with other types of vegetation cover. Results showed that separating residential areas is not simply possible. Spectral reflectance of residential areas is largely similar to farmland due to this fact that trees could affects the spectral reflectance of residential areas. As a result, separating residential areas from agricultural land is not possible.

Alavipanah et al (2001) Fars province found that residential areas are not separable and had difficulties to separate them. The results indicated that satellite data can help determine the type and area of various applications with the minimum energy and cost on large scales and with high precision studying the effect of land application in a specific year in different years.

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