پژوهش های جغرافیایی – شماره ۵۱، بهار ۱۳۸٤
ص ۱٤۳

تشخیص تغییرات و بیابانزایی با استفاده از سامانه های اطلاعات جغرافیایی داده های ماهواره ای چند طیفی *

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چکیده

داده های سنجش از راه دور چند طیفی منبع اطلاعات مهمی برای تشخیص تغییرات سطحی می باشد. تغییرات پوشش اراضی، بدلیل فعالیت های بشری، موضوع اصلی برنامه ریزی منطقه ای است. تشخیص تغییرات یکی از کاربردهای اصلی سنجش از راه دور است. در این مطالعه که بر اساس روشهای چشمی و رقومی انجام شده است، تغییرات ۲۳ ساله در دوره های مختلف شناسایی و مشخص شده است. تصاویر رقومی MSS (۲۰ژولی، ۱۹۷۷) TM ۷ سپتامبر، ۱۹۸۸ و +ETM ۲۰ ژولی، ۲۰۰۰ استفاده شد. برای بررسی تصاویر سه زمانه، تصحیحات رادیومتریک و هندسی انجام و سپس روشهای مختلف مانند رویهم قرار دادن تصاویر رقوی، تفریق تصاویر، مقایسه پس از طبقه بندی به کار گرفته شده نتایج حاصل نشان داد مه طی ۲۳ سال گذشته تغییرات فاحشی در رابطه با بیبان زایی روی داده است که ۶۸٪ این تغییرات در مدت زمان بین ۲۰۰۰–۱۹۸۵ روی داده است. براساس نتایج حاصل نتیجه گیری می شود که داده های MSS ، TM و +ETM برای تهیه نقشه های تشخیص و تغییرات مناسب هستند. ضمناً نتایج حاصل نشان داده که کار میدانی گسترده برای نهیه نقشه های تغییرات منطقه مورد مطالعه نیاز است.

واژگان کلیدی: بیابانزایی، تشخیص تغییرات، بلایا، ETM، TM، MSS

* اصل مقاله به زبان انگلیسی است لطفاً به صفحه ۵۱ از بخش انگلیسی مجله رجوع شود

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Change Detection and Desertification Based on Geographic Information System and Multi – Spectral Satellite Data (Case Study : Damghan Playa)

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Abstract

Multi- temporal remotely sensed data is a useful information source for the detection of surface changes. Land cover changes, due to human activities, are the main subjects of regional planning. Changes detection is a major application of remotely sensed data. In this study, which carried out based on visual –and digital procedures, various changes are identified, and were detected during 23 years for three times. The digital images of MSS (20 July, 1977), TM (7 Sep., 1988) and ETM+ (20 July, 2000) were used. The three multi-source images were geometrically and radiometrically calibrated to each other and then the different methodologies, such as overlaying, images differencing and post classification comparisons were applied. The obtained results have shown that during 23 years, drastic changes occurred in relation to desertification and 68% of the occurred changes are in between 1985-2000. Based on the obtained results we concluded that Landsat MSS, TM, and ETM+ data are powerful to map the changes. From the obtained results we concluded that extensive fieldwork are necessary to map the occurred changes for the study period.

Key words*: Desertification, Change detection, Landsat, Playa, ETM+*

1. Introduction

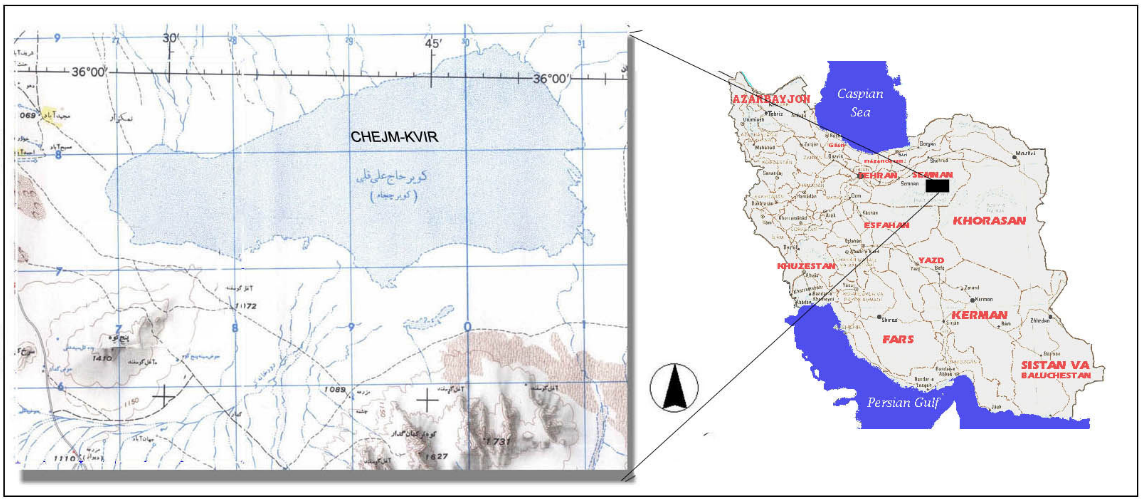
Several regions around the world are currently under going rapid wide-ranging changes in land cover and surface features, much of this activity is centred in desert. This change detection has become a major application of remotely sensed data because of repetitive coverage at different intervals.

Desertification has been variously defined in the literature with no single definition being unanimously accepted. According to UNCOD (1978), it refers to the diminution or destruction of the biological potential of the land that can lead ultimately to desert-like conditions. This definition is adopted here with the modification that the process is limited toan arid environment. The expansion of desertified areas or their rehabilitation to *productive use is inevitably accompanied by changes from vegetated to denuded cover or vise versa. Monitoring of these changes is ideally accomplished from multi-temporal*

remotely sensed data. Remote sensing has successfully been applied to the monitoring of desertexpansion(Luk,1983) and the assessment of the factors that may cause desertification (Hanan, et al.,1991).Visual interpretation of Landsat enable us to identify areas endangered by desertification in desert areas.

Remote sensing and GIS are land-related technologies and are therefore very useful in the implementation of the land component of a suitable development strategy (Anthony Gar-on Yeh and Li, 1996). Townshend et al. (1989) used Landsat TM data to formulate a dynamic process-based model to delimit processes in the Chott el. Djerid, in which the contributions of dissolved salts, surface run-off and aeolian processes, and their changes over time are evaluated. Change detection involves the use of multitemporal data sets to discriminate areas of land cover change between dates of imagery (Lillesand and Kiefer, 1994). Goossens and Van Ranst (1996) showed the possibility of multitemporal analysis using TM and MSS classification images in the Nile delta in Egypt. Ideally, a change detection method should be based on a system that; 1) has a systematic period between overflights (e.g. 18 days), 2) reduces displacement effect, 3) records imagery of the same area at the same time of the day each time to minimise the sun angle effects, 4) keeps the same scale and, 5) records reflected radiant flux in useful spectral regions. Ideally, change detection methods should involve data acquired by the same sensor with the same spectral and spatial resolution. Agricultural crops typically have unique crop calendars in each geographic region. Analysis of two-date imagery of the same area and the same time can provide information on how some land cover types are changing in a period. It should be noted that the nature of change detection problem in general is so that digital change detection is complex (Jensen, 1983), especially change detection methods that use two different remote sensor data. When two different remote sensor data are used some important considerations, such as difference in resolution must be taken into account. The selected area is located in the Central Iranian Deserts. This area is located in northeast of Iran between longitude 35° 30′ to 36° 5′ and latitude of 54° 5′ to 54° 58′ (fig. 1). The mean average of annual temperature of studied area is 17.1 °C.

Fig. 1: Location of study area



The TM is a scanning optical - mechanical sensor that detect reflected or emitted energy from the earth invisible and IR wave lengths. TM band 1-5 and 7 collects reflected energy; band 6 collect emitted energy. The TM sensor has a spatial resolution of 120 m for the thermal IR band and 30 m for the six reflective bands. Solomons (1984) suggested that it appears the TM can be describe as being twice as effective in providing information as the Landsat MSS. The nearest satellite in the Landsat series, Landsat 7 was launched on April, 15, 1999 and carries the enhanced thematic mapper plus (ETM+) with 30 m visible and IR bands 60 m spatial resolution thermal band. Since TM and ETM+ bands 1-5 and 7 have the same spatial resolution they can be compared. The purposes of this study area is as following:

1- Comparing information content of MSS, TM and ETM+ thermal and reflective bands.
2- Comparing the efficiency of information content of TM and ETM+ thermal and reflective bands for change detection.
3- Studying and detecting various changes, soil salinity and land use/cover maps.

2. Materials and Methods

For this study following documents also were used ;
1. Digital data of ETM+ dated 20 July 2000 and TM dated 5 Sep. 1988 and MSS
2- Soil map at 1:50.000 scale
3- Topographic map at 1:50.000 scale
4- Geographic map at 1:100.000 scale
5- Aerial photos at 1:20.000 scale
6- Published reports
7- Fieldwork.

The softwares such as ILWIS 3, ARC VIEW 3.1a, PHOTOSHOP 7.0 and EXCEL were used. In this study TM and ETM+ and MSS data using true ground point and GPS were geometrically and radiometricaly calibrated to each others. Figure 2, shows the study area. In this study remotely sensed data from Landsat MSS and TM, and ETM+ obtained on *different dates of images of MSS (20 July, 1977), TM (7 Sep., 1988) and ETM+ (20 July, 2000 with some other maps and data have been used for multitemporal analysis. In this method the images from three dates are independently classified and compared. Valuable source of information such as soil/soil salinity observations, explanatory reports corresponding to the time of recorded data and interviewing with farmers were used to improve the field knowledg.*

2.1 . Field work and representative training sites

The fieldwork as one of the most important steps was carried out. Localisation, was one of the main problems for the collection of data and information from the study area. In order to choose representative training sites and to overcome the problems of time and season differences between the last fieldwork and when the remotely sensed data were collected, the following steps were included:

1) *the playa surface conditions were carefully studied with attention being paid to stabilized crusted surface, region of loose, vulnerable, disturbed/non disturbed and coarse clastic particles. A visual comparision between the standard FCC, s of MSS and TM and ETM+ images and Photomorphic Unit Analysis (PMU) were used to improve the field knowlede in the study for training classes.*

Table 1 : Characteristics of training area

code	Class	Description
A	Vegetation	Include of pistachio, farm vegetation and agricaltural lands This class is seen at north of area.
B	Salt crust	Covering the surface of kavir, hard surface ground water table is less than 10 cm.
C	Puffy salty lands	Very saline and sodic, low slope, puffy and sparse vegetation. These lands has a progressively trend.
D	Brown silty - clay lands	These area located in south of wet zone of Kavir. Their formation is very dependent on water regimes of playa. Low slope, very sodic.
F	Desert lands (non changed)	Including of mountains, sand dunes, sandy lands and pediments

2) 2.2 . Spectral signatures evaluation

The validity of the training data was evaluated both from visual examination and from quantitativecharacterisation. The spectral signatures of the training samples was evaluated by using the reflective and also TM thermal band as the most informative bands based on the obtained result from the calculation of Optimum Index Factor (OIF). Image analysis and image processing methods were made to enhance and to evaluate detected changes (Figures 2, 3 and 4).

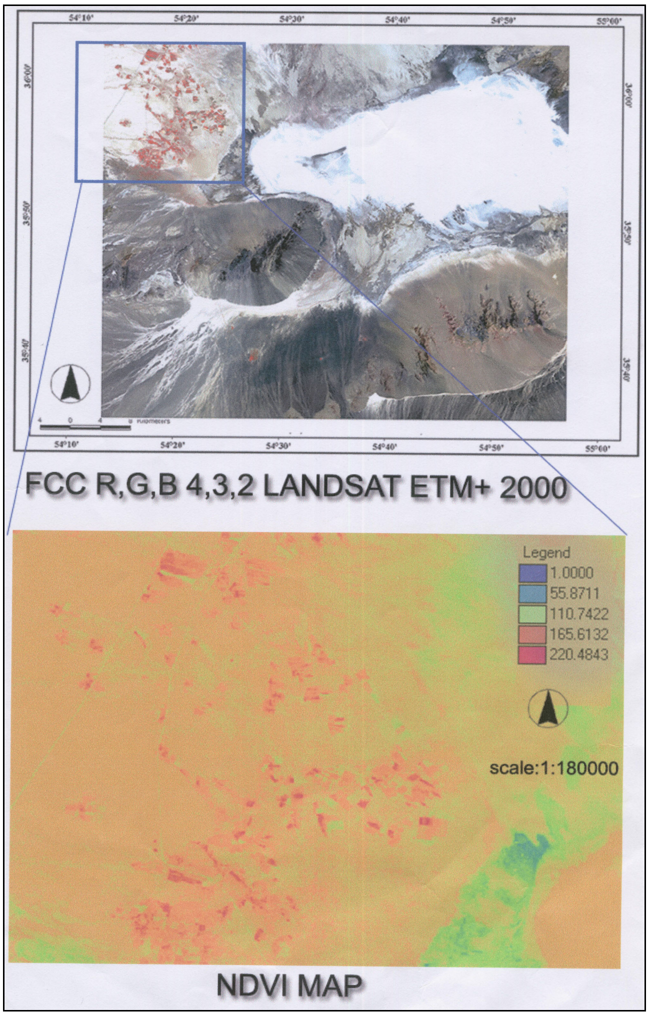


Fig.2: FCC 432, ETM+ 2000 and NDVI.

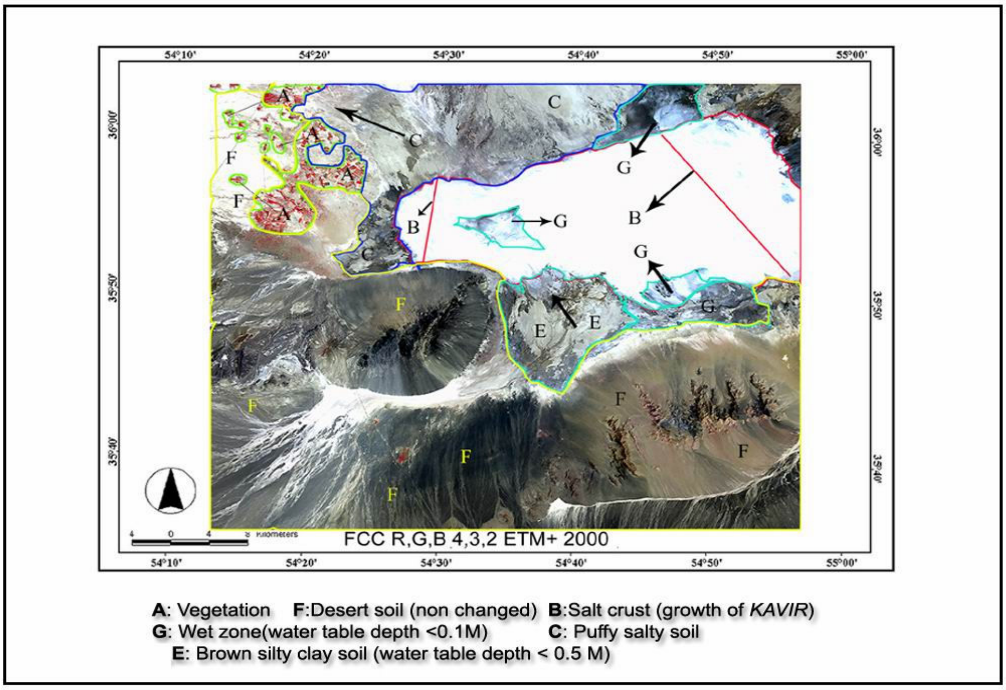


Fig.3: Visual interpretation of changed area

2.3. Sampling techniques

Lillesand, and Kiefer (1994), indicated that all spectral classes constituting each information class must be adequately represented in the training set statistics used to classify an image. In this study the training samples were taken on the conventional FCC where field observations were made. A large enough sample is often needed because the distribution of the sample mean approaches normality as the size of the sample increases. The sampling was performed by displaying the conventional FCC on the colour monitor and then the training samples were carefully assigned. In addition to visual assessment of training samples, during the sampling the class statistics was shown for the given time of sampling. As a result, the land cover types having inherently similar spectral pattern were detected. Finally the classes were determined not only by the occurrence in the field but also by their separability and their spectral signature evaluation. The training samples of TM/ETM+ and MSS imagery are listed in a tables. Therefore the classes of the MSS classified image are not completely comparable with the obtained TM/ETM+ classes. Comparing the land cover classification at every pixel in an image with a reference source would appear to ensure adequately accurate assessment. While such "wall - to - wall " comparison is expensive and defeats the purpose of performing a remote sensing based classification, the training area accuracy indicates very little about the performance of the classifier in other areas (non trained area) in a scene. Therefore other areas of representative land cover type (test areas) different from training samples are used to assess the accuracy of the classified image.

In this study three maximum likelihood classifications with the same threshold were applied based on the training samples (before merging), and b) the classification based on the training samples (after merging. To evaluate the classification accuracy, the same method as

TM was used. The test areas were sampled for the assessment of the MSS classification accuracy. The reference sources of data were crossed with the classified images based on the defined classes and the result was tabulated in a contingency table.

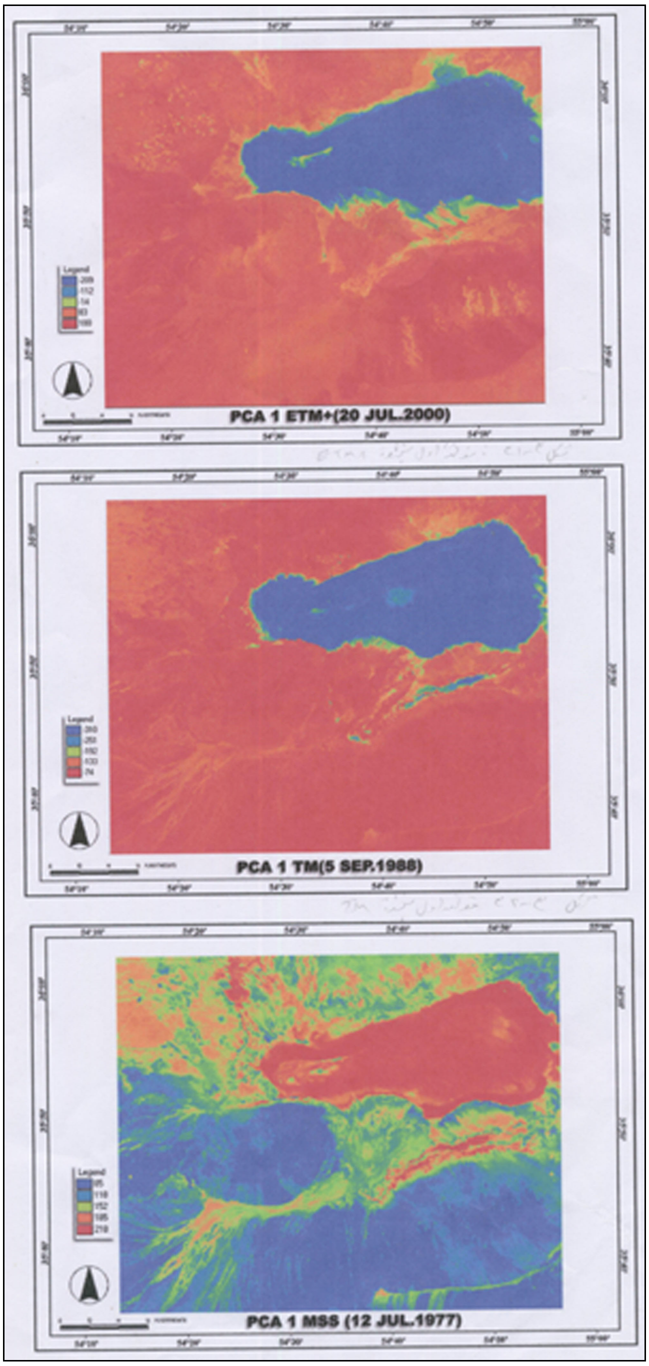


Fig.4: The result of Principle component analysis for three data set of remotely sensed data

2.4. Regrouping

The classes mainly can be regrouped on the purpose of the user. A high classification accuracy was obtained for TM and ETM+ classification images and a high classification accuracy is needed for MSS classification images. Otherwise an accurate result for change detection can not be obtained. Therefore it was necessary to regroup MSS classified image into broad classes in order to increase the classification accuracy. It is also very important to note that the TM and ETM +classified image was also necessary to be regrouped in a logic way to be comparable with the MSS classified image. The same class definitions must be reached with the data sets of different spatial resolution to allow a comparison to be made. For the purpose of this study, a comparison of the two classified images was valid provided that: a) a comparison was made at a land cover classification level no finer than it could be accurately determined by the lower resolution sensor (Landsat MSS), b) appropriate generalisation of the higher resolution data was carried out, c) generalisation of classes was carried out based on the purpose of change detection and increasing accuracy.

2.5. Registration for change detection purpose

The MSS, TM and ETM+ images were geometrically corrected toward the UTM co-ordinates. Then a 3 by 3 majority class filter was applied to the classified TM data set prior to registration. This algorithm was similar to that used by Todd et al. (1980) served to generalised the data to the level of the MSS and reduce the scattered isolated pixels.

2.6. Image classification and accuracy assessment

The training samples which are used to estimate the statistical characteristics of the spectral classes should be typical and represents the norm for each class. The MSS, TM and ETM+ band combinations were examined for classification of MSS, TM and ETM+ imagery with the same method. The accuracy per category were computed by the number of correctly classified pixels by the total number of pixels that were classified in each category (row total). The overall accuracy was also computed by dividing the total number of the correctly classified pixels of each class to the total number of classes.

3. Results and Discussion

Using aerial photos, visual interpretation, field working, the training area were defined (table 1) and changed area were mapped (fig.5).

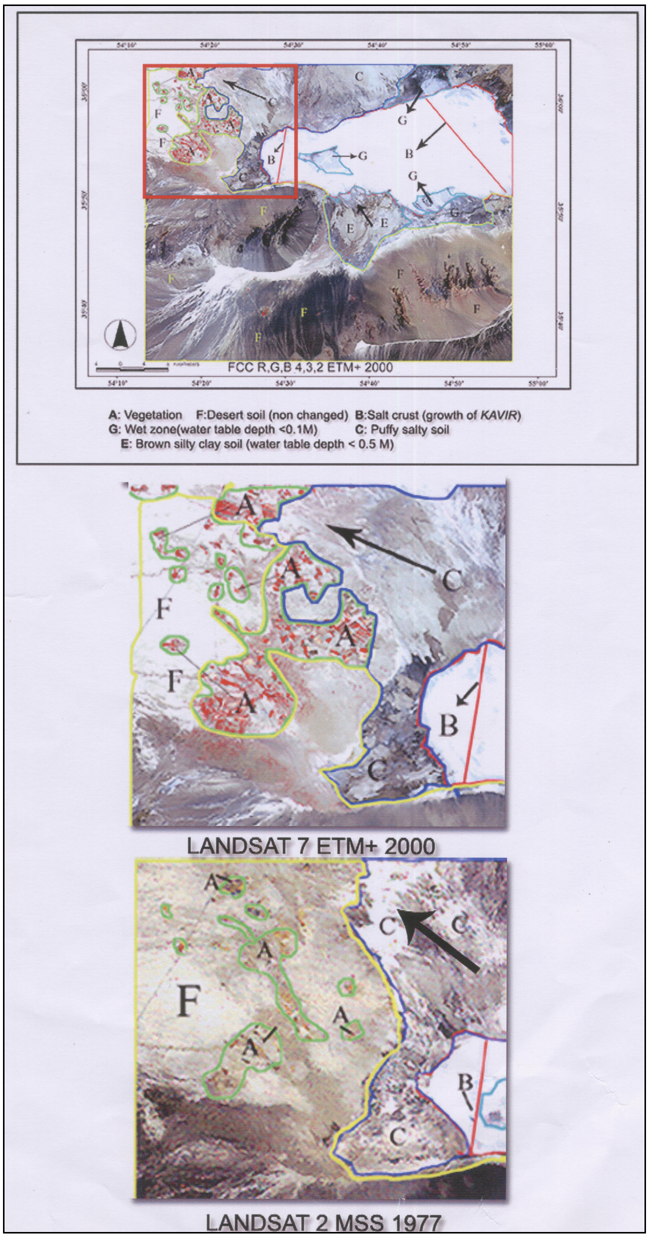


Fig.5: Map of visual interpretation of changed area

Using various change detection methods and post classification comparison, changes were detected and finally the changes map were produced (fig.6). Then changed areas were masked from TM and ETM+ bands.

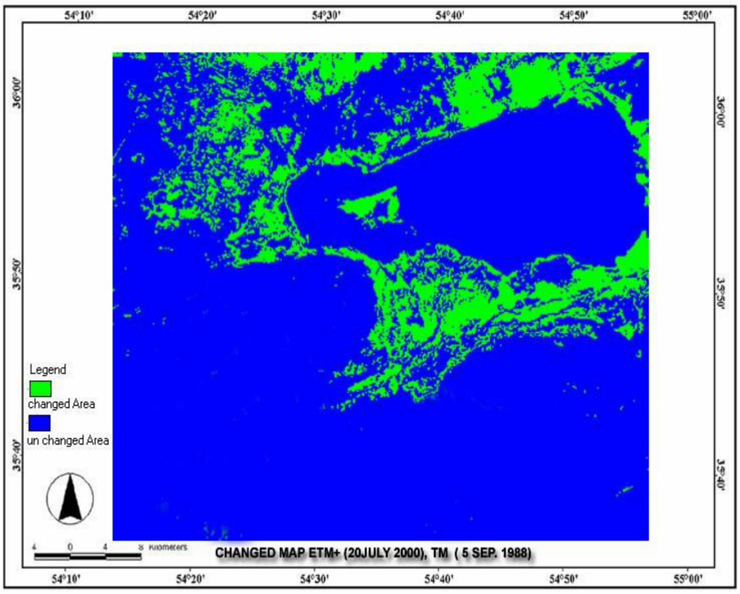


Fig. 6: Map of changed area

Based on this research we can conclude that;
1- The main land cover / land use types and soil salinity changes can be detected.
2- The TM and ETM+ thermal bands contain complementary information to the TM and ETM+ reflective bands and combination of them may provide a strong tool for classification and separating of marginal playa lands.
3- By comparison correlation of thermal and reflective TM and ETM+ bands we can conclude that generally these correlation in ETM+ band is lower than TM bands, indicating more information of thermal ETM+ bands cause to higher spatial resolution (60×60m).
4- Ideally change detection methods should involve data acquired by the sensor with the same spectral and spatial resolution. Nature of change detection is complex especially with remote sensed data. But from the obtained result we may conclude that in detecting the nature of materials or land cover types the difference between spatial resolution of reflective bands might not be so important and more detected spectral information relevant to the physical and chemical composition can be more important. But in the same condition because higher resolution ETM+ thermal band may provide more useful information for soil studies.
5- Further research is necessary for comparison between the information content of TM and ETM+ data with the same data of recording.

4. Conclusion

In this study desertified land in Damghan playa was mapped from 1977 and 2000. The overlay analysis of the two land cover maps revealed that there is an imbalance in the spatial distribution of desertified areas. The marginal part of playa is mostly changed and desertified. By comparison its western part is better covered by vegetation. The changed land in desertified land is closely correlated with changes in salt and water, but loosely change with vegetation in total. In addition to the need for high accurately classified scenes the detection of changes and hence the monitoring capability and Landsat is dependent on change in the spectral characteristics of various habitats through times. The reflectance characteristics of land and water surfaces are influenced by a number of factors. Additional factors that can influence the change are reflectance between three different. Landsat *provides imagery of the earth surface on a regular basis for this reason, it is ideally suited to monitoring or detecting change over time. In spite of this there appear to have been few attempts to incorporated Landsat data into environmental monitoring programs. It is suggested that there are two main reasons for this. first many of the changes that occur are in too small a scale to be detected and mapped using Landsat data. In such cases aerial photography is more suitable and there are many examples in the literature where conventional photogrammetric or photointerpretation methods have been used to study changes in the natural environment.*

From the above results, we may conclude that there are some problems in relation to the resolution for a multi-temporal analysis based on Landsat MSS and TM/ETM+ images, but these problems can be mainly solved by training the broad classes in MSS images and regrouping the finer TM/ETM spectral classes to the classes corresponding to MSS classes. These post classification processes are not only necessary to obtain the same meaningful classes in both MSS and TM/ETM+ classified images, but are also useful to increase the accuracy of classification and consequently the accuracy of change detection. Therefore we concluded that the Landsat MSS and TM/ETM+ images and GIS are useful tools for change detection. From the result of multi-temporal analysis we concluded that some drastic land cover changes took places in the area in period 1977-2000. The TM/ETM+ satellite images and GIS are offering a valuable contribution to fulfilling the information need in the natural resources management in the marginal part of the playa. Although in may be advisable to avoid mixing sensors and spatial resolution, currently, and even more in the future, the problem of overlying remotely sensed data from new sensors with higher spatial resolutions: hence establishing new algorithms for classification are necessary.

ACKNOELEDGMENT

The authors thank the Vice Chancellor for affected research, University of Tehran for partial financial support of this research. The authors are indebted to Iranian Aerospace Organisation (Iran remote sensing ceter) and indebted to D.R Gholam Reza Zehtabian for assistant with preliminary stage of this work.

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