Barren Land Index to Assessment Land Use-Land Cover Changes in Himreen Lake and Surrounding Area East of Iraq

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Abstract
The study area lies in the eastern part of Iraq, within Diyala and small parts of Salah Al-Din and Sulamanyah Governorates. The eastern boundary of the map represents Iraqi-Iranian International borders; it covers about (7010) Km².
The present study depends on two scenes of Thematic Mapper (TM5) data of Landsat, these data are subset by using area of interest (AOI) file and made use of a nearest neighbor polynomial correction within the ERDAS 9.2 software. The images carried out with WGS84 datum and UTM N38 projection using nearest neighbor resampling.
Barren Land Index (BLI) was adopted as a practical tool for study and assessment the changes in Himreen lake and surrounding area.
The obtained result showed the distributions of Land use - Land cover classes in the study area for the years 1976-1992-2010 and the change which occurred in the periods (1976-1992) and (1992-2010) represented by bare soil and salt flat classes, mixed barren land class, exposed rocks and sandy area classes.
Keywords: Land use - Land cover (LULC), Image processing, Thresholding, Barren Land Index (BLI), Change detection.

1. Introduction

Change detection refers to the process of identifying differences in the state of land features by observing them at different times. (Lu D.et.al 2003), (Singh 1989). This process can be accomplished either manually or with the aid of remote sensing software. Manual interpretation of change from satellite images involves an observer or analyst defining areas of interest and comparing them between images from two dates. Remote sensing based change detection applies comparison of a set of multitemporal images covering the time period of interest using specific change detection algorithms. There are many changes detection approaches. They can be classified according to different criteria. Among the most common methods of change detection using remote sensing data is image differencing, principal component analysis (PCA), post-classification comparison, spectral mixture analysis, change vector analysis and integrating GIS into the analysis (Lu D.et.al 2003), as well as a combination of different methods of change detection (Jensen 2005).

Change detection is useful in such diverse applications as land use analysis, monitoring shifting cultivation, assessment of deforestation, the study of changes in vegetation, seasonal changes in pasture production, damage assessment, crop stress detection, disaster monitoring, day/night analysis of thermal characteristics as well as other environmental changes (Singh 1989). Change detection may also be important for tracking urban and economic growth.

The information derived from remote sensing change detection may provide a better understanding of the biophysical relationships in an ecosystem, than is possible with field data alone. With this understanding, managers can use remote sensing as a tool for sustainable environmental management (Jensen 2000, Mas 1999).

In this study Barren Land Index (BLI) was used to analyze and output data related to the change in the environment, it included a description of physical conditions of the classes. The base of this study depended on Landsat data for the years (1976-1992-2010).

1.1 Objective of the study

The main objectives are study and assessment the changes in Himreen lake and surrounding area for the periods (1976-1992) and (1992-2010).

1.2 Location of the study area

The study area lies in the eastern part of Iraq, within Diyala and small parts of Salah Al-Din and Sulamanyah Governorates. The eastern boundary of the map represents Iraqi-Iranian International borders, it covers about (7010) Km² and it is determined by the following coordinates (Fig.1).

Longitude	44° 34' 48″	45° 39' 01″
Latitude	33° 44' 51″	34° 33' 20″

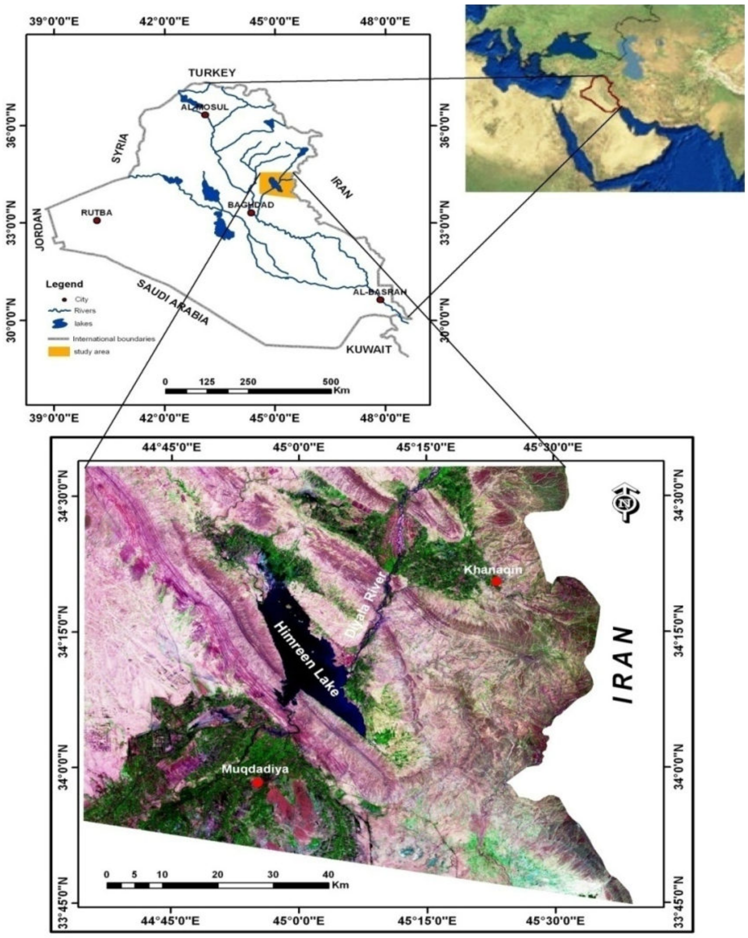

Figure 1. Location map of the study area

1.3 Climate of the study area

The climate is one of the important environmental components of environmental change studies because it plays an important role effect in the other environmental components such as desertification, transportation, weathering, erosion, precipitation and water quality.

The climatic data of Khanaqin station is used to evaluate the climate in the study area depending on Iraq Meteorological Organization (I.M.O. 2008) .The elements of climate included ; temperature, rain full, relative humidity, evaporation, wind speed and direction, for the period 1976-2008. Depend on the elements of the climate above mentioned the study area has an arid climate and characterized by hot summer and cold winter with seasonal rainfall, the major portion of rainfall is received during the months of December to May.

1.4 Geological Setting

The study area is located within the foothill zone and Mesopotamian zone. It is characterized by undulated plains, hilly and mountainous areas that increase in elevation toward the East and Northeast. Quaternary sediments are covering part of the study area represented by River Terraces, Polygenetic Deposits, Slope Deposits, Flood Deposits, Valley Fill Deposits, Sheet-runoff Deposits, Aeolian Deposits, Gypcrete, Anthropogen Deposits, Depression Fill Deposits, Inland Sabkha Deposits, Alluvial Fan Deposits. Pre-quaternary Deposits, belong to Tertiary (Middle Miocene -Pliocene) are represented by Fatah, Injana, Mukdadiyah , and Bai Hassan Formations (Ahmed and Al-Saady 2010, Barwary and Slewa 1991, 1993, Sissakian and Ibrahim 2005, Fouad 2010) (Fig.2).

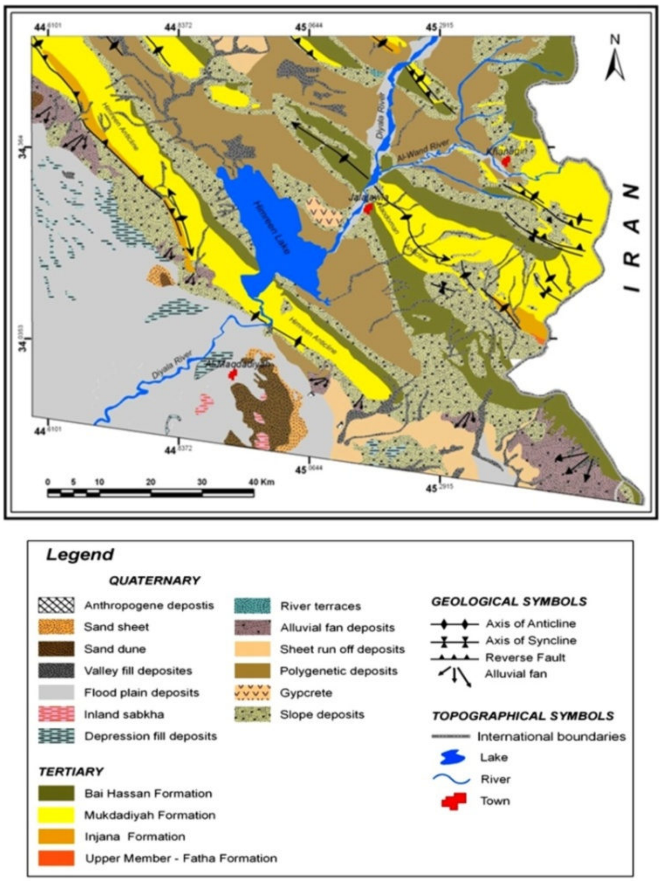

Figure 2. Geological map of the study area

2. Methodology

2.1 Data Collection

The present study depends on the following available data:

Two scenes of Thematic Mapper (TM5) data of Landsat (Path/Row 168/36) Acquisition in 9/8/1992, and 2/7/2010 in spatial resolution 30m and six spectral bands (b1, b2, b3, b4, b5 and b7) downloaded from the Website of USGS (http://glovis.usgs.gov/), (Fig.3), (Table1) and ancillary data from the Iraq Geological Survey (GEOSURV) besides the field data.

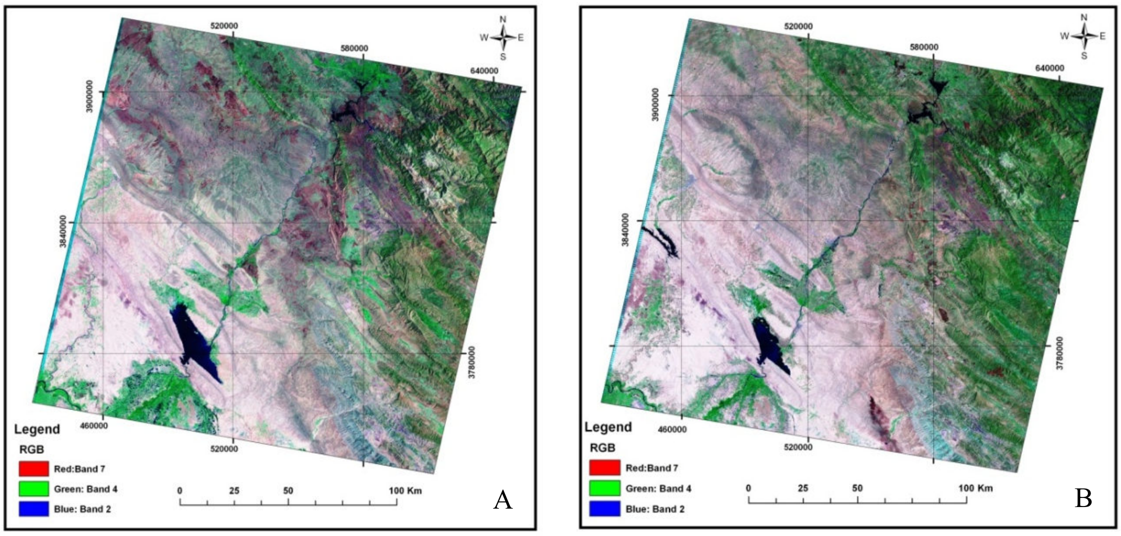

Figure 3. A-TM scene-1992, B-TM scene-2010

Table 1. Landsat image characteristics (Lillesand and Keifer 2000)

Instrument	Landsat 5	
Sensor	TM	
Acquisition date	9/8/1992	2/7/2010
Path / Row	168/36	168/36
Spectral bands (µm)	7 bands (10)- 0.45-0.52 (blue) (20)- 0.52-0.60 (green) (30)- 0.63-0.69 (red) (40)- 0.76-0.90 (near-infrared) (50)- 1.55-1.75 (mid-infrared) (60)-10.4-12.5 (thermal bands) (70)- 2.08-2.35 (mid-infrared)	
Ground resolution	30m*30m for multispectral bands, 120*120m for thermal bands	
Dynamic range (bit)	8 bit	

2.2 Software

ERDAS Imagine V. 9.2 and Arc GIS V.9.3 softwares have been used. ERDAS Imagine 9.2 software was used for image processing and change detection. Arc GIS 9.3 software was used for data analysis and map composition. In order to obtain accurate location point data for each LULC class in field survey, the Global Positioning System (GPS) was used.

2.3 Pre-processing

Two scenes of TM images are subset by using Area of Interest (AOI) file. The images carried out with WGS84 datum and UTM N38 projection using nearest neighbor resampling. The nearest neighborhoods resampling procedure were preferred to others resembling such as bilinear or cubic and bicubic convolution, because it is superior in retaining the spectral information of the image (Lillisand and Kiefer 2000).

2.4 Field Observations

Field observations carried out in 2012 and spent approximately ten days touring including taking field notes, taking photos and collecting GPS coordinates representing final output categories. The field data was useful for image analysts to have a better understanding of the relationships between the satellite images and actual ground conditions.

2.5 Image processing

2.5.1 Implementing Change Detection uses remote sensing technology

The basic principle of change detection from remote sensing images is based on the difference in reflectance or intensity values between the images taken at two different times due to changes on the Earth's surface. A necessary requirement for change detection from remote sensing images is the accurate registration of temporal images. That mean; the images must be aligned with each other such that corresponding locations in the images are present at identical pixel positions. A registration accuracy of less than one-fifth of a pixel has been recommended to achieve a change detection error within 10 percent (Dai and Khorram 1998). Any registration errors (or misregistration) present in the images may lead to incorrect change detection. Due to its paramount importance as a pre-processing step for applications like change detection and image fusion, image registration has been an active area of research for many years and a number of new image registration algorithms have been developed (Brown 1992, Zitova and Flusser 2003). The effect of registration errors on change detection has earlier been studied by (Townshend et al. 1992) and (Dai and Khorram 1998).Also, no relative comparison of the performance of different change detection algorithms in the presence of registration errors has been performed, as the studies are based on a particular algorithm devised only by them.

In general, implementing change detection using image-processing software requires a number of steps (all or some steps) depending on available data, (Fig.4).

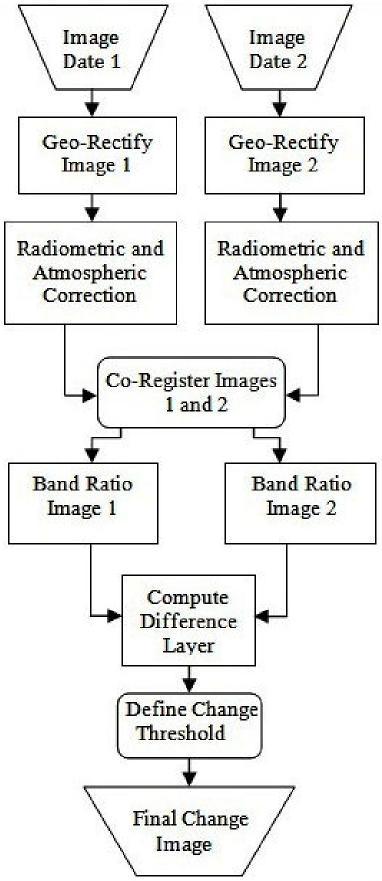

Figure 4. General steps of implementing change detection

2.5.2 Thresholding

The threshold selection is commonly based on a normal distribution characterized by its mean and its standard deviation threshold values are scene-dependent, they should be calculated dynamically based on the image content. However, the thresholds can be determined by three approaches: (1) interactive, (2) statistical and (3) supervised. In the first approach, thresholds are interactively determined visually tests. The second approach is based on statistical measures from the histogram of techniques for selecting appropriate thresholds are based on the modelling of the signal and noise (Radke et al. 2005 , Rogerson 2002, Rosin 2002), which is carried out in this study. Third, the supervised approach derives thresholds based on a training set of change and no-change pixels.

2.5.3 Change Detection using Barren Land Index (BLI)

The Barren Land Index is used for change detection of multi-spectral images and successfully used for studies of vegetation, land use - land cover and geology. Barren Land Index (BLI) can be obtained by linear combination of measurements in the spectral domains of the bands green (G), red (R) and near infrared (NIR). It can used to evaluate bare soil and desertification processes .In addition, bright soils have been shown to reduce the values in vegetation indices such as NDVI (Heute et al. 1985), and water areas such as WI. Barren Land Index (BLI) is well suited to arid and semi arid areas where dominant vegetation types such as shrubs and other small vegetation are often photosynthetically inactive (Escadafal and Bacha 1996). A decrease in brightness can be due either to the wetting of the soil surface, soil roughness, or in degraded soil (Escadafal and Bacha 1996).

The equation used for this index has been created by the researcher after so many attempts which uses the MSS and TM images as follows

$BLI = G^2 + R^2 + NIR^2 / 60$

(Fig.5) shows Model of Barren Land Index. (Table 2, 3 and 4) show Statistics of BLI images for the years 1976, 1992 and 2010 respectively, (Fig. 6 and 7) show the BLI image and Histogram for the year 1976, (Fig. 8 and 9) show the BLI image and Histogram for the year 1992 and, (Fig.10 and 11) show the BLI image and Histogram for the year 2010.

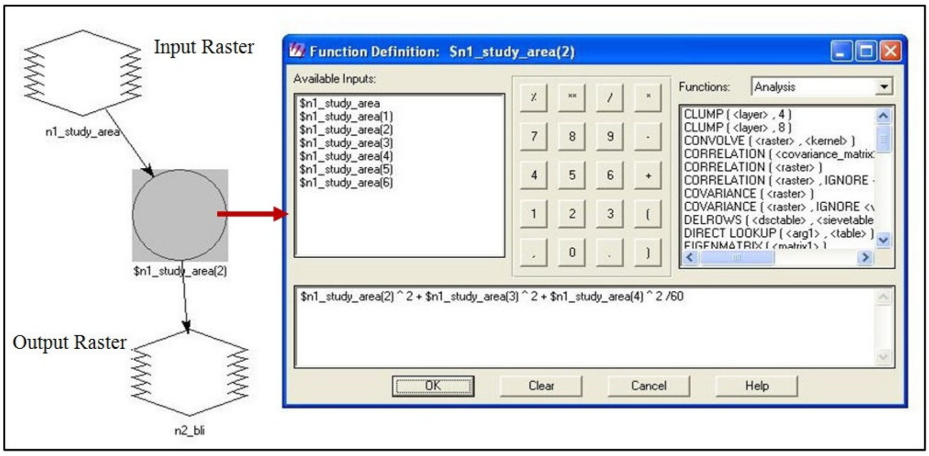

Figure 5. Model of Barren Land Index (BLI)

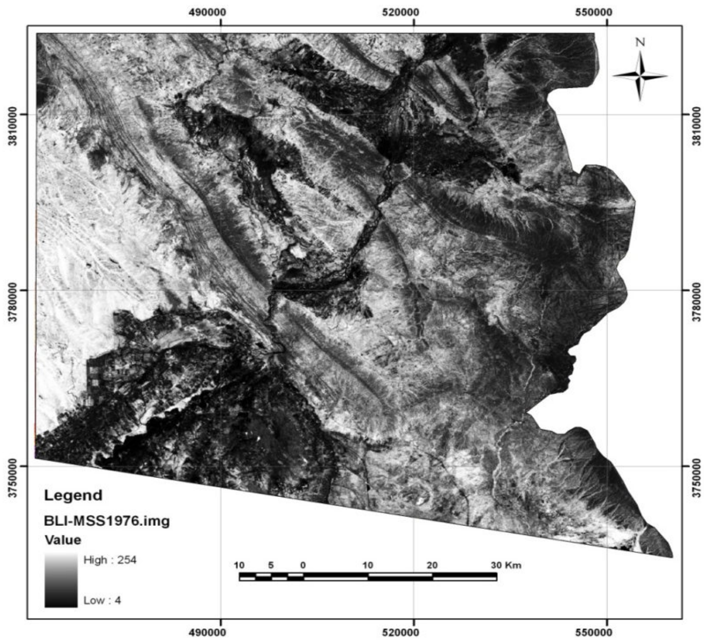

Figure 6. BLI image in 1976

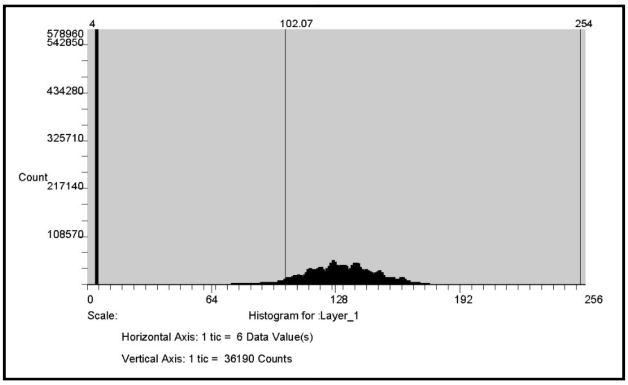

Figure 7. Histogram of BLI image in 1976

Table 2. Statistics of BLI image in 1976

	Histogram	Area-km²
Count	153	153
Total	1971872	6406.61
Mean	12888	41.87
Minimum	0	0
Maximum	55292	178
Std.dev.	16579	53.87

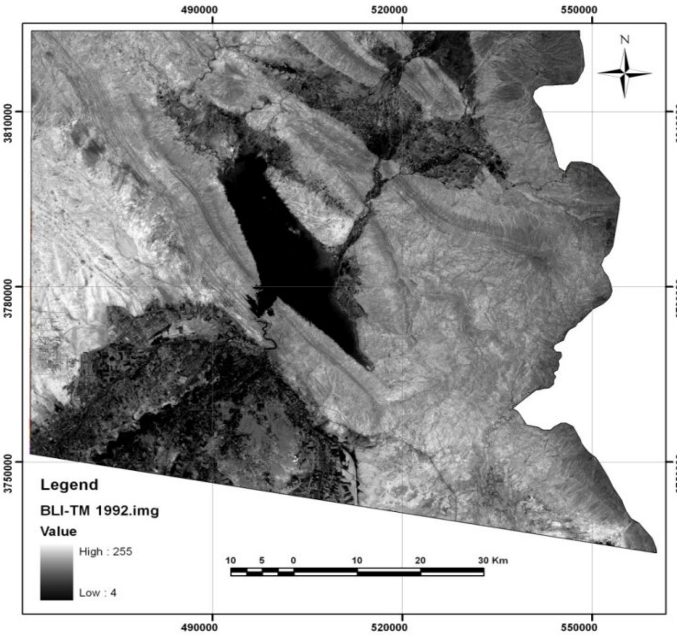

Figure 8. BLI image in 1992

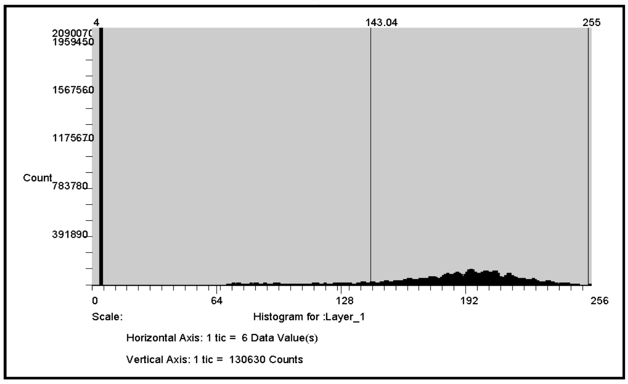

Figure 9. Histogram of BLI image in 1992

Table 3. Statistics of BLI image in 1992

	Histogram	Area-km²
Count	103	103
Total	6219648	5598
Mean	60385	5435
Minimum	2439	2.19
Maximum	135783	122
Std.dev.	34318	31.63

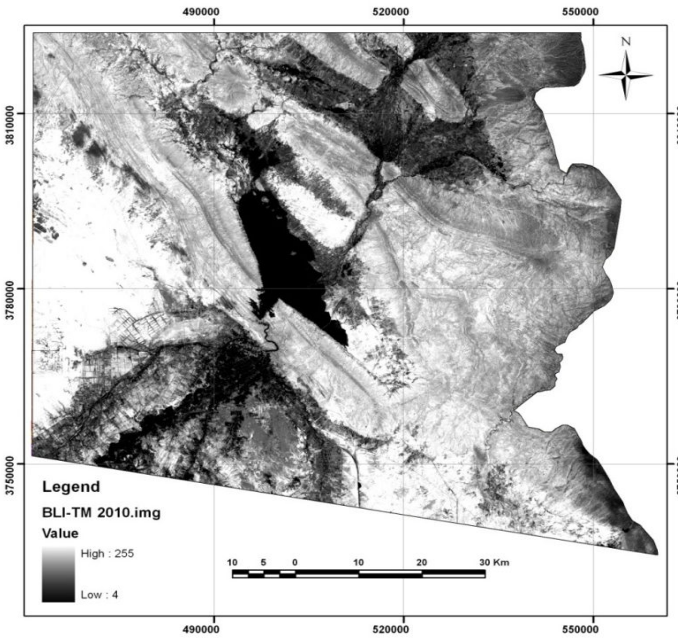

Figure 10. BLI image in 2010

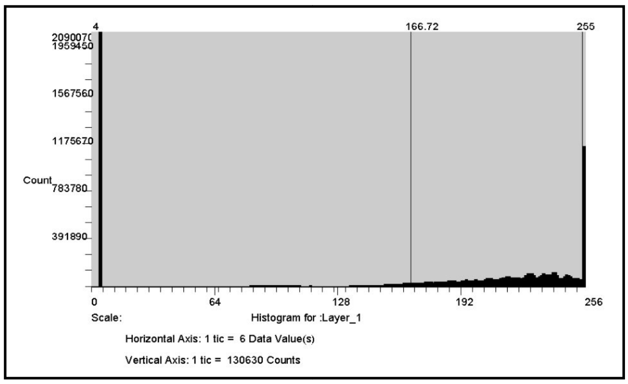

Figure 11. Histogram of BLI image in 2010

Table 4. Statistics of BLI image in 2010

	Histogram	Area-km²
Count	89	89
Total	6663501	5997
Mean	74871	67.38
Minimum	29475	26.53
Maximum	1151829	1037
Std.dev.	117724	106

3. Result of Change Detection for Barren Land Index

Barren land is a land use-land cover category used to classify lands with limited capacity to support life and in which less than one-third of the area has vegetation or other cover. In general, it is an area of thin soil, sand, or rocks. Vegetation, if present, is more widely spaced and scrubby than that in the Shrub and Brush category of Rangeland. Categories of Barren Land are: Dry Salt Flats, Beaches, Sandy Areas other than Beaches; Bare Exposed Rock; Strip Mines, Quarries, and Gravel Pits; Mixed Barren Land, besides river wash; mud flats. (Anderson et al. 1976).

In the study area barren Land is represented by: Bare soil and Salt flats classes, Mixed barren Land class, and Exposed rocks and sandy areas classes. (Table 5) shows BLI thresholding of the three dates, (Fig.12, 13 and 14) show the classes of BLI index of 1976, 1992 and 2010 respectively. (Table 6) shows distributions of BLI area of the three dates. (Table 7) shows the LULC change (BLI) for the periods (1976-1992) and (1992-2010). (Fig.15) shows a plot diagram of LULC change (BLI) for two periods, and (Fig.16) shows some locations of barren lands in the study area.

The detailed descriptions of these classes are described hereinafter:

3.1 Bare soil and Salt flats classes

3.1.1 Bare soil class

The Bare soil class covers a huge area distribution in different location of the study area. The results of image processing are showing change in the area of this class. It is decreased from 1976 to 1992 then increased in 2010.

3.1.2 Salt flats class

Salt flats represent accumulation place of water in rainy seasons and be dry in the summer that led display the salt flat on the surface. The salt flats have a different spectral reflection depending on water content, dry salt flats tend to appear white or light toned because of the high concentrations of salts at the surface as water has been evaporated, resulting in a higher albedo than other adjacent desert features. The area of salt flats is decreased from 1976 to 1992 then increased in 2010.

3.2 Mixed Barren Land class

The Mixed Barren Land category is used when a mixture of barren land features occurs such as a desert region where combinations of salt flats, sandy areas, bare rock and surface extraction, in the study area it covers wide area. It is decreased from 1976-1992 as a result of growth in agricultural lands and expansion in the area of water due to the construction of the dam and development of Himrren Lake, also Mixed Barren Land is decreased from 1992-2010 due to increase the other classes in the study area such as (bare soil, salt flats) and (exposed rocks, sandy areas).

3.3 Exposed Rocks and Sandy Areas classes

3.3.1 Exposed Rocks class

The Exposed Rock category includes areas of bedrock exposure, scarps, talus, slides, and other accumulations of rocks represented by sedimentary rocks that are exposed in the study area, which belong to different geological formations. It is decreased from 1976-1992 due to expansion in the area of Himrren Lake, and increased from 1992-2010 due to retraction the water level in Himrren Lake.

3.3.2 Sandy Areas class

Sandy Areas composed primarily of dunes-accumulations of sand transported by the wind. Sand accumulations most commonly are found in deserts although they also occur on coastal plains, river flood plains, and deltas. In the study area the most sandy areas are represented by sand dune and sand sheet occur in the study area particularly in the Southwestern part. It is decreased from 1976-1992 due to growth in agricultural lands and expansion in the area of Himrren Lake, and increased from 1992-2010 due to retraction the water level in Himrren Lake and degradation of agricultural lands.

Table 5. BLI Thresholding

Land use - Land cover (BLI)	Thresholding		
	1976	1992	2010
Bare soil, Salt flat	254-159	255-232	255
Mixed barren land	158-123	231-185	254-216
Exposed Rocks, Sandy area	122-102	184-153	215-167

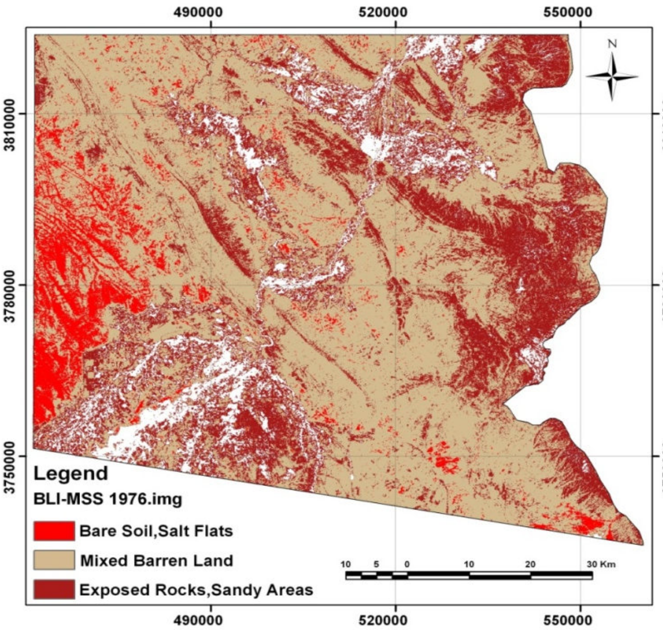

Figure 12. Classes of BLI in 1976

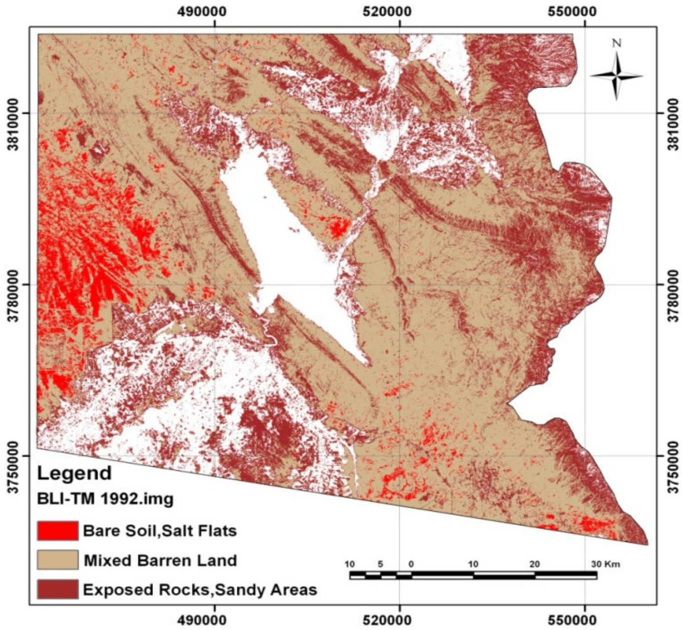

Figure 13. Classes of BLI in 1992

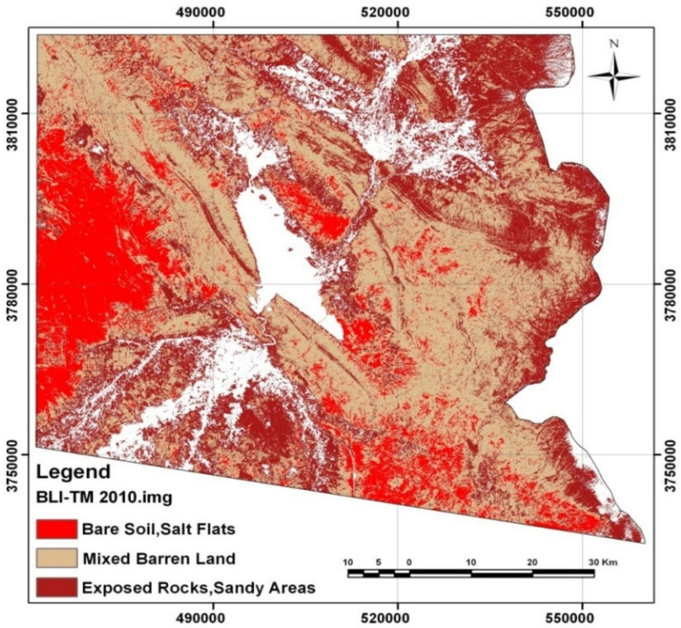

Figure 14. Classes of BLI in 2010

Table 6. Distributions of BLI area

Land use - Land cover (BLI)	Surface area in km²					
	1976	p.%	1992	p.%	2010	p.%
Bare soil, Salt flat	470.9	7	397.4	7	1036.7	17
Mixed barren land	4077	64	3531.9	63	2882	48
Exposed Rocks, Sandy area	1858.7	29	1668.4	30	2078.5	35

Table 7. LULC change (BLI) for two periods

Land use - Land cover (BLI)	Surface area in km²	
	1976-1992	1992-2010
Bare soil, Salt flat	-73.5	639.3
Mixed barren land	-545.1	-649.9
Exposed Rocks, Sandy area	-190.3	410.1

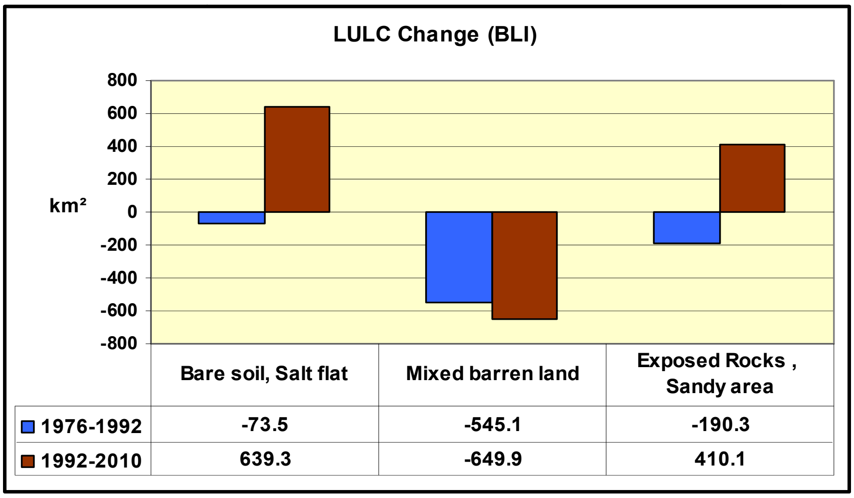

Figure 15. Plot diagram of the LULC change (BLI) for two periods

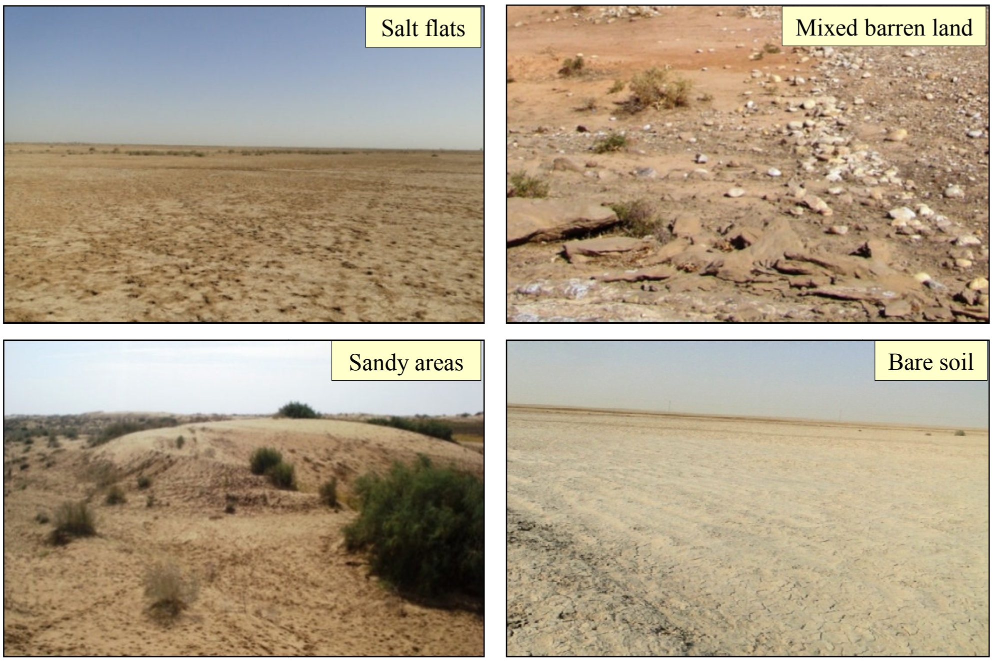

Figure 16. Some locations of barren lands in the study area

4. Conclusion

Many approaches have been applied for the monitoring land use-land cover change; each method has some advantages and disadvantages. Many factors such as selection of suitable change detection approach, suitable band and optimal threshold, may affect the success of the classification. This research aimed to examine the benefit of the Barren Land Index. This method proves its ability for detecting land use - land cover changes in the study area. Presented study allows estimating the amount of significant land use - land cover changes occurred in the study area during the periods (1976-1992) and (1992-2010). The changes of LULC in Bare soil and Salt flat classes were negative of the period (1976-1992) and positive of the period (1992-2010) while the changes of LULC for Mixed Barren Land class were negative of the period (1976-1992) and also negative of the period (1992-2010), and the changes of LULC for Exposed rocks and sandy areas classes were negative of the period (1976-1992) and positive of the period (1992-2010). However the combination of barren Land Index with other techniques such as image differencing, image rationing, image regression and advanced classification perform and provide better change detection details results of the land use-land cover than simple method. Besides this research demonstrated the efficiency of RS and GIS as tools for detecting and monitoring land use - land cover processes. The authors recommend using a spectrometer device to measure the spectral signature for different features of land use - land cover and will be more effective for the assessment and monitoring land use-land cover processes. Also updating land use - land cover maps are highly recommended for the future studies in the study area because it is undergoing continues changes especially in agricultural lands and water level of Himreen Lake.

References

Anderson, J., Hardy, E., Roach, J. and Witmer, R., 1976. A Land Use and Land Cover Classification System for use with Remote Sensor Data, United States Government Printing Office, Washington. 18PP.

Ahmed M.A.and Al_Saady Y.I., 2010. Series land use - land cover maps of Iraq scale 1:250 000, Baghdad Quadrangle, sheet. Ni-38-10 (LULCM 20), geosurv, Baghdad, Iraq.

Barwary, A.M. and Slewa, 1991. The geological map of Sammara quadrangle, sheet Ni-38-6, geosurv, Baghdad, Iraq.

Brown, L.G., 1992. A survey of image registration techniques, *ACM Computing Surveys*, 24:325–376.

Barwary, A.M. and Slewa, 1993. The geological map of Khanaqin quadrangle, sheet Ni-38-7, geosurv, Baghdad, Iraq.

Dai, X., and S. Khorram, 1998. The effects of image misregistration on the accuracy of remotely sensed change detection, *IEEE Transactions on Geoscience and Remote sensing*, 36:1566–1577.

Escadafal R. and Bacha S., 1996. Strategy for the dynamic study of desertication. proceedings of the ISSS International Symposium Ouagadougou, Burkino Faso, 6–10 February 1995 (Paris: Orstom editions), pp 19–34.

Fouad, S.F.A., 2010.Tectonic and structural evolution of the Mesopotamia Foredeep, Iraq. Iraqi bull. Geol. and Min. Vol. 6. No.2, P 41-53.

Huete, A.R., Jackson, R.D. and Post, D.F., 1985. Spectral response of a plant canopy with different soil backgrounds. *Remote Sensing of Environment*, 17, 37-53.

I.M.O. (Iraqi Meteorological Organization), 2008. "Climatological section", Baghdad, Iraq.

Jano A., Jefferies R.L. and Rockwell R.F., 1998. The detection of vegetational change by multitemporal analysis of Landsat data: the effects of goose foraging. J. Ecology. 86:93-99.

Jensen, J.R., 2000. Remote sensing of environment: an earth resource prospective. Prentice Hall, upper saddle River. N. J, UAS.

Jensen J.R., 2005 Introductory Digital Image Processing: a remote sensing perspective, 3rd Ed., Ch. 12: Digital Change Detection, p. 467 – 494.

Lillesand, T.M. and Kiefer, R.W., 2000. Remote Sensing and image interpretation, 4^{th} edition, John Wiley and Sons, New York.

Lu, D., Mausel, P., Brondizio, E. and Moran, E., 2003. Change detection techniques. *International Journal of Remote Sensing*, 25, 2365-2407.

Mas, J.F., 1999. Monitoring Land-Cover Changes: a Comparison of Change Detection Techniques. *International Journal of Remote Sensing*, *20* (1), 139-152.

Radke, R., Andra, S., Al Kofahi, O. and Roysam, B., 2005. Image change detection algorithms: A systematic survey. Ieee Transactions on Image Processing, 14 (3): 294–307.

Rogerson, P., 2002. Change detection thresholds for remotely sensed images. Journal of Geographical Systems, 4 (1): 85–97.

Rosin, P., 2002. Thresholding for change detection. Computer Vision and Image Understanding, 86 (2): 79–95.

Singh, A., 1989. Digital Change detection Techniques Using Remotely Sensed Data. *International Journal of Remote Sensing*, *10*, 989-1003.

Sissakian, V. K. and Ibrahim, F.A., 2005. Series of Geological Hazard Maps of Iraq, scale 1:250 000. Kanaqin quadrangle, sheet NI-38-7 (GHM 15), geosurv, Baghdad, Iraq.

Townshend, J.R.G., C.O. Justice, and C. Gurney, 1992. The impact of misregistration on change detection, *IEEE Transactions on Geoscience and Remote Sensing*, 30:1054–1060.

Zitova, B., and J. Flusser, 2003. Image registration methods: A survey, *Image and Vision Computing*, 21:977–1000.

http://glovis.usgs.gov/