Assessment Environmental Changes in Al-Habbaniya Lake and Surrounding Areas in the Central Part of Iraq

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Abstract

The study area lies in the central part of Iraq, in Al-Anbar Governorate, it covers about (4400) km^2.It includes Al-Habbinya Lake which represent touristic region and waterish reserves used for water balance management of Euphrates River.

The present study depends on Thematic Mapper (TM) data of Landsat 5 acquisition in 1990, Enhancement Thematic Mapper (ETM) data of Landsat7 acquisition in 2001, these data are mosaic and subset it 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.

Types of image ratioing were adopted as practical tools for monitoring of Al-Habbinya Lake and surrounding areas such as Normalized Differential Vegetation Index (NDVI), Water Index (WI) and Salinity Index (SI) to study environmental changes from 1990 to 2001, by using ERDAS 9.2 Imagine and Arc GIS 9.3 programs.

The vegetation distribution determined by Normalized Differential Vegetation Index (NDVI), Water determined by using Water Index and to detect the salinity soil used Salinity Index (SI).

The obtained result shows increase in area of vegetation, and decrease in area of water, salty soil and sabkha during the period from 1990 to 2001.

Keywords: Environmental Changes, Image Ratioing, Thresholding, Normalized Difference Vegetation Index (NDVI), Water Index (WI), Salinity Index (SI)

1. Introduction

The changing, dynamic relationship of the environment and land use may permanently alter the environment (in a potentially negative manner) and therefore, requires intensive monitoring over time (Lunetta, 1998; Yuan *et al.,* 1998; Franklin, 2001). One of the key elements involved in the global monitoring of environmental change is the accurate, reliable mapping, and quantifying, of physical changes such as land use - land cover across small-and-large scale natural environments. Remotely sensed data are very useful in mapping land use - land cover change; it has been shown many times in the literature and in practical mapping applications that spectral response of pixels acquired by different sensors over time can differ significantly for the same area if the land cover of that pixel has changed (Singh 1989). The process of determining that differences are significant has become known as 'change detection'. 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).

Integrating remote sensing images and other data in Geographic Information Systems (GIS) may provide a way to produce more accurate land-use and land-cover maps especially for use in change detection. Change detection is useful in such diverse applications as land use analysis, monitoring shifting cultivation, assessment of deforestation, 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.

In this study, some types of image ratioing were used to analyze and output data related to the change in environment, it included a description of physical conditions like, salinity, water, and vegetation. The base of this

study depended on Landsat data for period (1990-2001).

1.1 Objective of the study

The main objectives are monitoring and assessment the environmental changes in Al-Habbinya Lake and surrounding area from 1990 to 2001.

1.2 Location of the study area

The study area lies in the central part of Iraq, within Al-Anbar Governorate, it covers about (4400) Km^2, it is determined by the fallowing coordinates (Fig.1).

43° 02́ 04″ - 43° 52 ́37 ″ E   ,   33° 08′ 46″- 33° 39′ 16″ N

1.3 Climate

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 months of November to April. The present study depends on basically on the climate data obtained from Iraqi Meteorological Organization.(I.M.O 2005).

1.4 Geological Setting

The study area lies on the eastern margin of the inner (stable) platform of Arabian plate (Fouad 2010). It is mostly covered by Quaternary sediments with local exposed of Lake Neogene Formations such as Injana Formation and Fatha Formation. (Yacoub & Dikran 1993, Sissakian & Salih 1995).
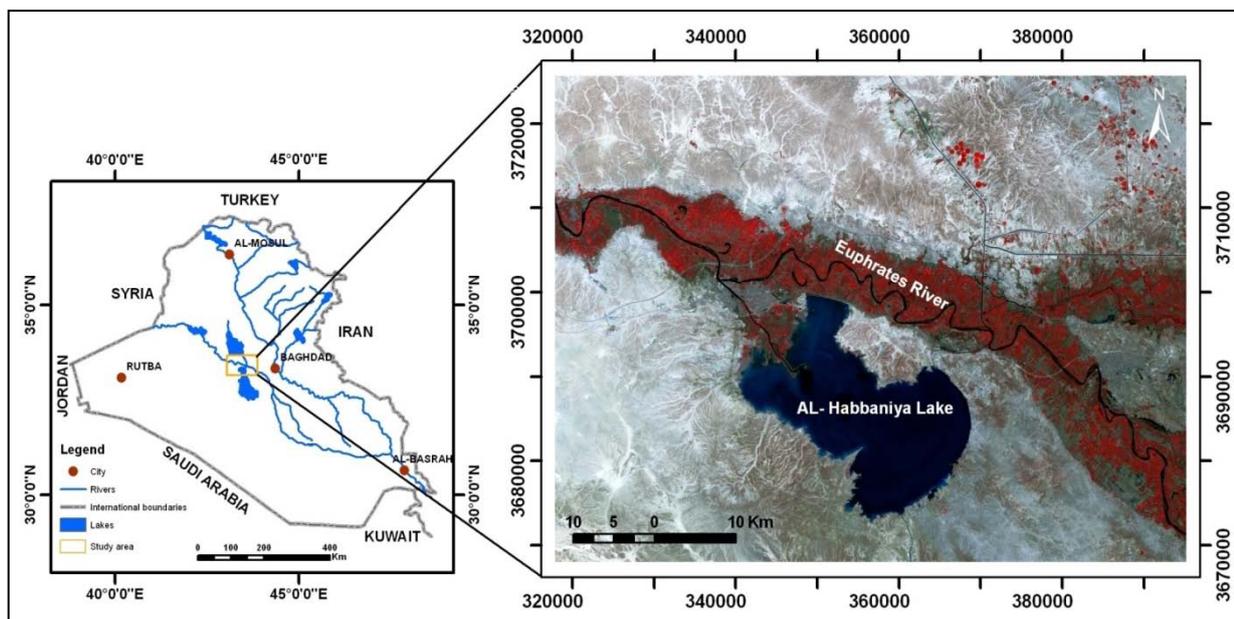

Figure 1. Location of the study area

2. Methodology

2.1 Data

The present study depends on the following available data:

Thematic Mapper (TM5) data of Landsat Acquisition in 4/3/1990, Scene169-37 in spatial resolution 30m, Enhancement Thematic Mapper (ETM) data of Landsat7 Acquisition in 18/3/2001, Scene.169-37 in spatial resolution 30m have been used.

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.

2.3 Pre-processing

One scene of TM images and one scene of ETM images, these data are subset it 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 was preferred to others resampling such as bilinear or cubic and bicubic convolution, because it is superior in retaining the spectral information of the image (Lillisand & Kiefer 2000).

2.4 Image Processing

2.4.1 Change Detection in Semi-arid and Arid Environments

To extract the change between two images of different dates. The change is identified and quantified using different thresholds. The only major considerations that need to be taken into considerations when using methods in this category are which bands of the following: Normalized Difference Vegetation Index (NDVI), Water Index (WI), Salinity Index (SI), and thresholding techniques have to be used. The initial rationing of bands, often before performing vegetation index differencing, has the advantage of reducing topographic effects and normalizing radiometric errors between multi-date images (Singh 1988). The one recognized disadvantage of this category is the lack of any change matrices that indicate directions of change; instead it merely provides an indication of change, and no change data. There are numerous examples of researchers using this method, often in combination with other methods, in order to detect change (Khiry 2007).

2.4.2. 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.

3. Image Ratioing

3.1 Normalized Difference Vegetation Index (NDVI)

The NDVI is a calculation used to identify vegetation and its health through the Levels of chlorophyll detected in the leaves. NDVI is calculated from the visible and near-infrared light reflected by vegetation. Healthy vegetation absorbs most of the incoming visible light, and reflects a large portion (about 25%) of the near infra-red (NIR) light, but a low portion in the red band (RED). Unhealthy or sparse vegetation reflects more visible light and less NIR light.

To apply the NDVI the following formula is used: (Tucker1979, Sabins 1987, Jensen1996)

NDVI = (NIR – RED) / (NIR + RED)   (1)

The equation then provides a ratio of the change in reflectance of an object from the visible to the NIR in a scene, which allows evaluation of the level of chlorophyll present in plants.

In this study period of Landsat, TM, ETM tried to explain the observed change in NDVI, by using the NDVI algebra to explore and estimating green vegetation cover and monitored it. It has interval grey scale from -1 to 1 with 8 bit and all vegetation pixels has pixel value more than zero. The thresholding that used in NDVI (TM-1990) was148, in NDVI (ETM-2001) was 163. (Figs.2) shows NDVI images of 1990 and 2001.

The maximum density of vegetation located in TM 1990 image in central part of the study area along the Euphrates River, while in ETM 2001 image the maximum density of vegetation located along the Euphrates River and in the areas that the water level of Al-Habbaniya Lake have dropped. The vegetation cover 428.3km^2 (9.60%) in 1990 and increased in 2001 to be 436.2 km^2 (9.77%). The change in vegetation area of two dates displays in (Table1). (Figs.3) shows some locations of vegetation in the study area.

The increase of vegetation in period 1990-2001 due to the development of irrigation system and construction many canals in the study area. That lead to improve the cultivation at that period. In addition to retreat the water of Al-Habbaniya Lake. That conduced grow the main types of crop land includes barley, wheat, also there are different types of wild vegetation which are distributed in different location of the study area (Field observation by the author).

Table 1. Variations of vegetation area and percentage for two dates

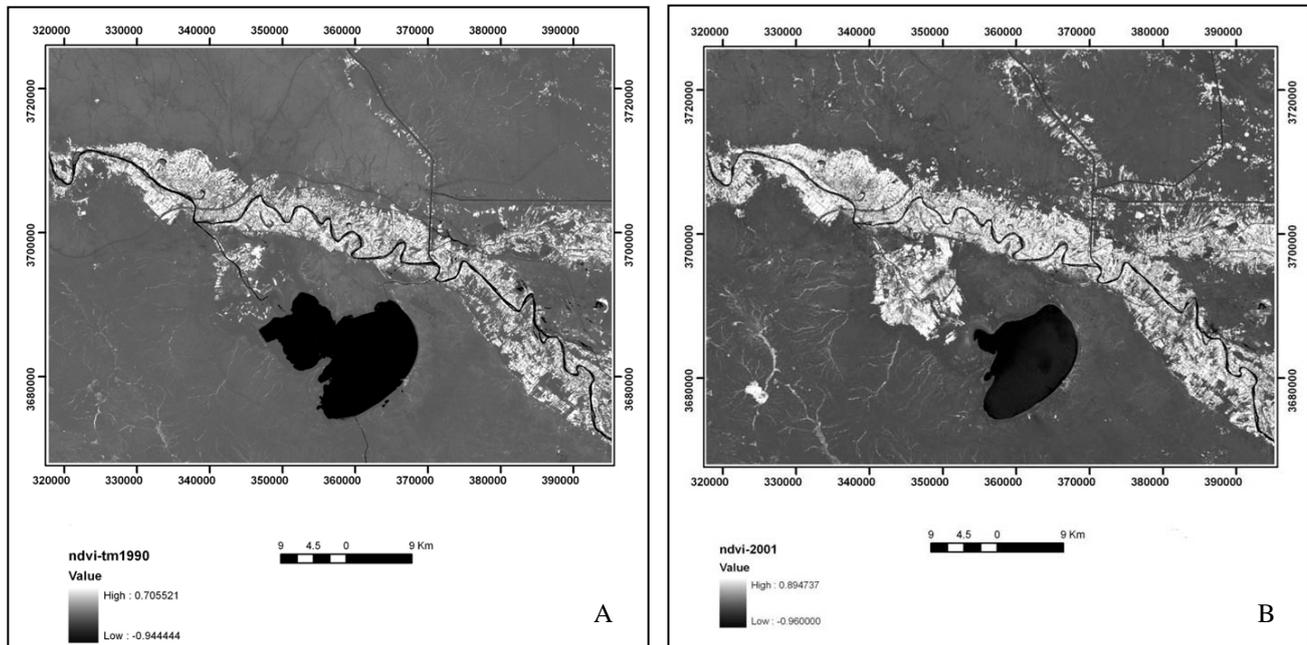| Class index	1990 km²	1990%	2001 km²	2001%
NDVI index	428.3	9.60	436.2	9.77

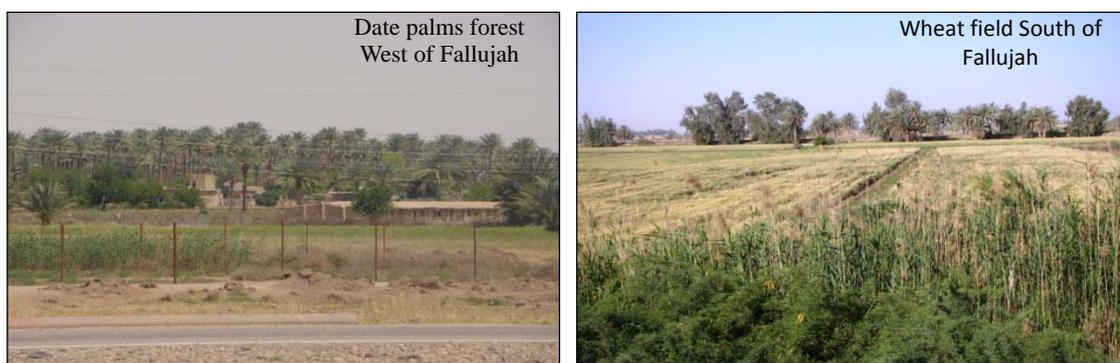Figure 2. (A) NDVI Image in 1990, (B) NDVI Image in 2001

Figure 3. Some location of vegetation in the study area

3.2 Water Index (WI)

The water index was used to monitoring the situation of water in the study area. The lowest digital number, (WI-TM-1990) (less than 32), (WI-ETM-2001) (less than 38), for the mean of near infra-red (NIR) and short wave infra-red (SWIR) (equation 2), spectral region was thresholded to clearly enhanced water bodies. This equation is used with ETM, TM depending on bands 4 and 5. (CPM 2003).

$$WI = NIR + SWIR / 2 \qquad\qquad (2)$$

The area of water bodies for TM-1990 was 264.8 km^2 (5.93%) and for ETM-2001 was 204.26 km^2 (4.57%). (Figs.4) shows WI Images in 1990 and 2001.The amount of water decrease between 1990-2001.due to scarcity charging of water, that lead to dropped water level of Al-Habbaniya Lakes. (Fig.5) shows some locations of water in the study area. The change in water of two dates displays in (Table 2)

Table 2. Variations of water area and percentage for two dates

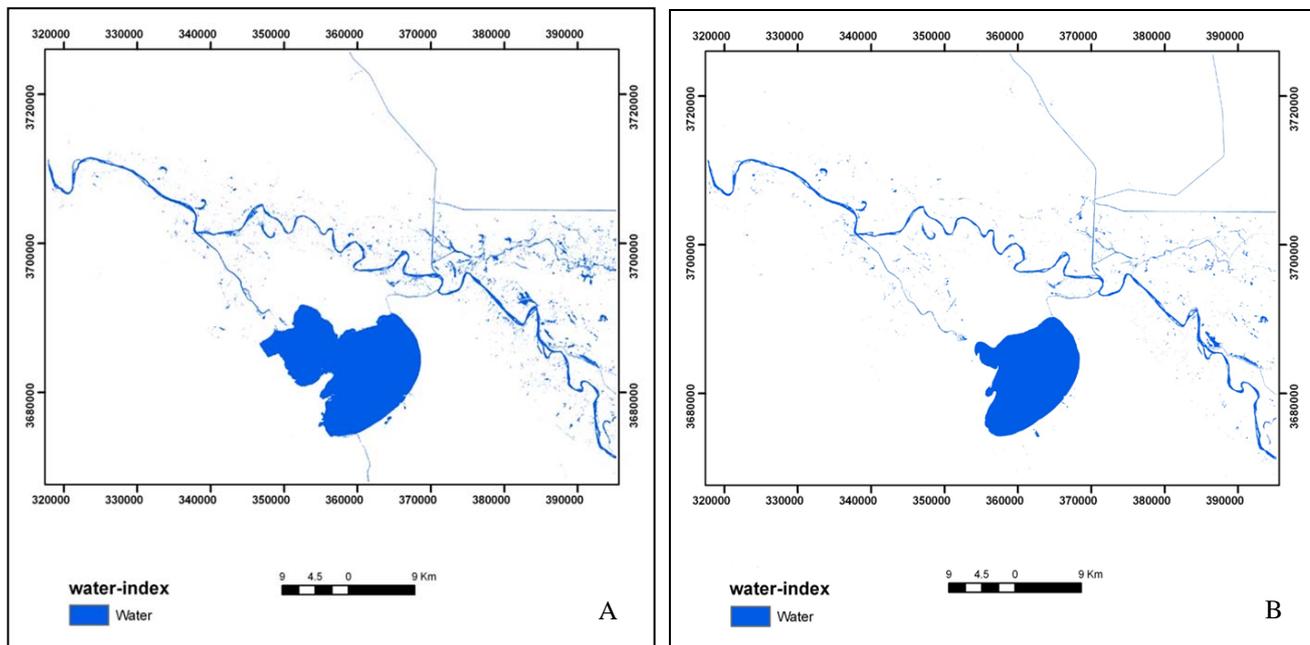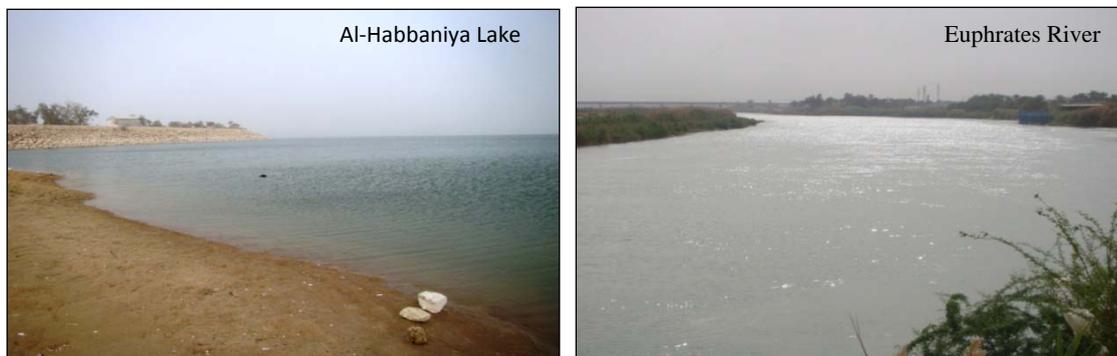| Class index	1990 km²	1990%	2001 km²	2001%
Water index	264.8	5.93	204.26	4.57

Figure 4. (A) WI Image in1990, (B) WI Image in 2001

Figure 5. Some location of water in the study area

3.3 Salinity index (SI)

Soil salinity, as a term, refers to the state of accumulation of the soluble salts in the soil (Al-Khaier 2003). Soil salinity can be determined by measuring the TDS of solution extracted from water- saturated soil.

The present study shows the possibilities to detect the salinity by using TM and ETM Landsat salinity index for soil using green and red bands and these two bands have been used repeatedly to detect salinity soil. The equation (3) is doing at Landsat TM, ETM and showing in (Fig.6) to determine the saline soil. The higher reflection represent high saline soil. (Abbas & khan 2007).

$$SI= (GREEN + RED) / 2 \qquad\qquad (3)$$

The salty soil covered different areas; in 1990 was 241 km^2 (5.40%), in 2001was 95.53 km^2 (2.14%).The decrease of salty soil area attribute to variation in the climate factors at acquisition date of two images. The change in area and percentage of salinity area displays in (Table 3). (Fig.7) shows location of salty soil in the study area.

The area of salty soil decreased in 2001 especially around the Al-Habbaniya Lake, this could be attributed to

seasonal fluctuation of water level in the lake.

It is worth to mention that during period of field observation (April-2010) the situation of Al-Habbaniya Lake was differ than the mentioned periods, so updating of the environmental situation is high recommended for future studies.

Table 3. Variations of Salinity area and percentage for two dates

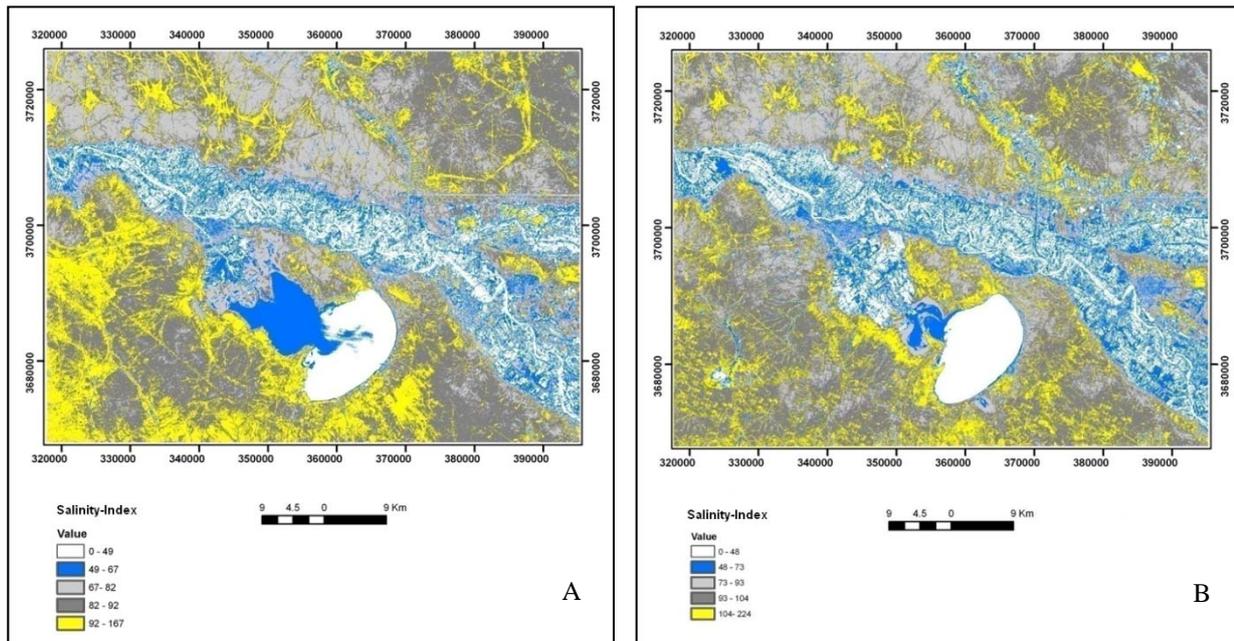| Class index	1990 km²	1990%	2001 km²	2001%
Salinity index	241	5.40	95.53	2.14

Figure 6. (A) SI image in 1990, (B) SI Image in 2001

Figure 7. Salty soil in the study area

4. Conclusions

From reviewing the research the followings could be concluded:

1.   NDVI algebra results show an increase in area of vegetation from1990 to 2001.

2.   WI algebra results show decrease in area of water from1990 to 2001.

3.   SI algebra results show decrease in area of saline soil from1990 to 2001.

4.   The study area has adequate conditions of climate and soil; therefore the agricultural lands and touristic areas can be developing especially the adjacent areas of Al-Habbaniya Lake.

5.   This research demonstrated the efficiency of RS and GIS as a tool for detecting and monitoring land cover processes of multispectral analysis with all spectral bands for different temporal intervals.

5. Recommendation

1.   Using spectrometer device to measure the spectral signature for different features of land cover will be more effective to the assessment and monitoring land cover processes.

2.   Updating land cover maps is high recommended for future studies in the study area because it is undergoing continues changes detection especially in vegetation cover and water level of Al-Habbaniya Lake.

3.   The advantage of analyzing different methods of remote sensing data brings new questions about the accuracy of the change detection results. Therefore the method and application of remote sensing may develop and provides efficient processing.

References

Abbas, A. and Khan, S., 2007. Using remote sensing techniques for appraisal irrigated soil salinity, 2632-2638.

Al-Khaier, F., 2003. Soil salinity defection using satellite remote sensing, M.Sc. Thesis, ITC, p 49.

CPM, 2003. Processing Technique for Marsh surface condition index, Univ. of Marry land, Global land covers Facility, coastal Marsh project.

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.

Franklin, S.E. (2001). *Remote Sensing for Sustainable Forest Management.* Lewis Publishers. Boca Raton, Florida.

I.M.O. (Iraqi Meteorological Organization), 2005.Baghdad, Iraq.

Jensen, J. R. 1996.Introductory digital image processing: A remote sensing perspective. Second edition, New Jersey, U.S.A: Prentice Hall, 257-278.

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

Khiry M.A., 2007. Spectral Mixture Analysis for Monitoring and Mapping desertification processes in semi – arid area in north Kordofan state, Sudan, PhD thesis, Univ. of Dresden, p 126.

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

Lunetta, R.S. & Elvidge, C.D. (1998). *Remote sensing change detection; environmental monitoring methods and applications.* Ann Arbor Press. Chelsea, MI, United States.

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

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

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.

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

Singh, A. (1988). Review Article: Digital change detection techniques using remotely-sensed data.*International Journal of Remote Sensing*, 10, 989 – 1003.

Sissakian, V., K., and Salih, S., M., 1995, the geology of AL- Ramadi quadrangle sheet NI-38-9, GEOSURV int. rep.no.2315.

Sabins, F. F., Jr. (1987). Remote Sensing Principles and Interpretation. 2d Ed. New York: W. H. Freeman & Co.

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

Tucker, C. J. (1979). Red and Photographic Infrared Linear Combinations for Monitoring Vegetation. Remote Sensing of Environment, 8:127-150.

Yuan, D., Elvidge, C.D. & Lunetta, R.S. (1998). Survey of Multispectral Methods for Landcover Change Analysis. *In* Lunetta, R.S. and C.D. Elsevier. 1998. *Remote Sensing Change Detection, Environmental Monitoring Methods and Applications.* Ann Arbour Press, Chelsea, Michigain.

Yacoub, S.y., and Dikran, D., B., 1993, the geology of Baghdad quadrangle sheet NI-38-10, GEOSURV, int. rep.no.2255.

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