Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 3, No.2, 2013

Using Indexes to Detect the Environmental Changes of Hor Al-Dalmaj and Surrounding Areas in Central Sector of Mesopotamia Plain

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Abstract

The study area has large desertification areas which covered by salty soils and sand dunes and sand sheet. It lies in Wassit, Al-Qadissiya and Karbala Governorates in central sector of the Mesopotamia plain.

The study area depends on Thematic Mapper (TM) data of Landsat 5 for two scenes acquisition in 1990, Enhancement Thematic Mapper (ETM) data of Landsat7 for two scenes Acquisition in 2002, 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.

Different types of indexes were adopted as practical tools for monitoring of Hor Al-Dalmaj and surrounding areas such as Normalized Differential Vegetation Index (NDVI), Water Index (WI), Eolian Mapping Index (EMI) and Salinity Index (SI) to study environmental changes from 1990to 2002, 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 (WI), Eolian sediments determined by using Eolian Mapping Index (EMI) and to detect the salinity soil used Salinity Index (SI).

The obtained result showed that the desertification lands have increased during the period from 1990 to 2002.

Keywords: Environmental Changes, Normalized Difference Vegetation Index (NDVI), Water Index (WI), Eolian Mapping Index (EMI), Salinity Index (SI).

1. Introduction

Change Detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times; it involves the ability to quantify temporal effects using multi-temporal data sets, and one of major applications of remotely-sensed data obtained from satellites is change detection, because of repetitive coverage at short intervals and consistent image.

The present study area has large desertification areas which covered by salty soils and sand dunes and sand sheet. In this study, different types of indexes were used to analyze and output data related to the change in the environment such as sand dunes and sand sheet, soil salinity, water and vegetation. The base of this study depended on Landsat data for two periods.

1.1 Location

The study area lies in Wassit, Al-Qadissiya and Karbala Governorates in central sector of the Mesopotamia plain (Fig.1), it covers about 3514 km^{2,} it is determined by the following coordinates:

44° 56′50″, 45° 44′52″ E , 31° 49′ 00″, 32° 38′ 40″N

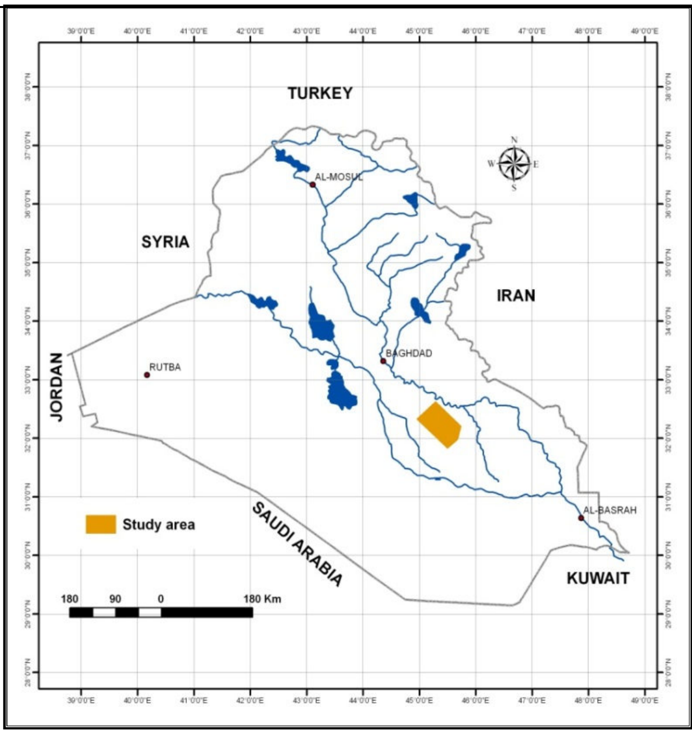

Figure 1. Location map of the study area

1.2 Aim

The main aims are monitoring and detect the environmental changes of Hor Al-Dalmaj and surrounding areas from1990 to 2002.

1.3 Climate

The study area has an arid climate during the period from 1990 to 2002 (Fig.2) 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 2005.

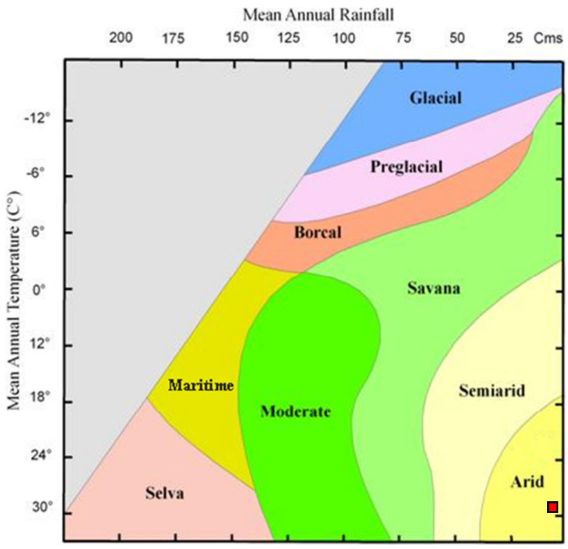

Figure 2. Climatic boundaries of the morphogenetic regions (After Peltier, 1950 in Fookes1971)

1.4 Geological Setting

The study area covered totally by Quaternary sediments (Domas, R. J. 1983) which include: Marsh sediments, Flood plain sediments, Eolian sediments, Shallow depression sediments, Anthropogen sediments.

2. Methodology

2.1 Data

The present study depends on the following available data:

Thematic Mapper (TM) data of Landsat 5 for two scenes acquisition in 28/8/1990 in spatial resolution 30m(Fig.3.a,b), Enhancement Thematic Mapper (ETM) data of Landsat7 for two scenes acquisition in 6/9/2002(scene1) and 22/9/2002(scene2) in spatial resolution30m(Fig.4.a,b),(Table1)Shows the spectral and spatial characteristics of Landsat images.

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

Two scenes of TM images, two scenes of ETM images, these data are mosaic and 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).

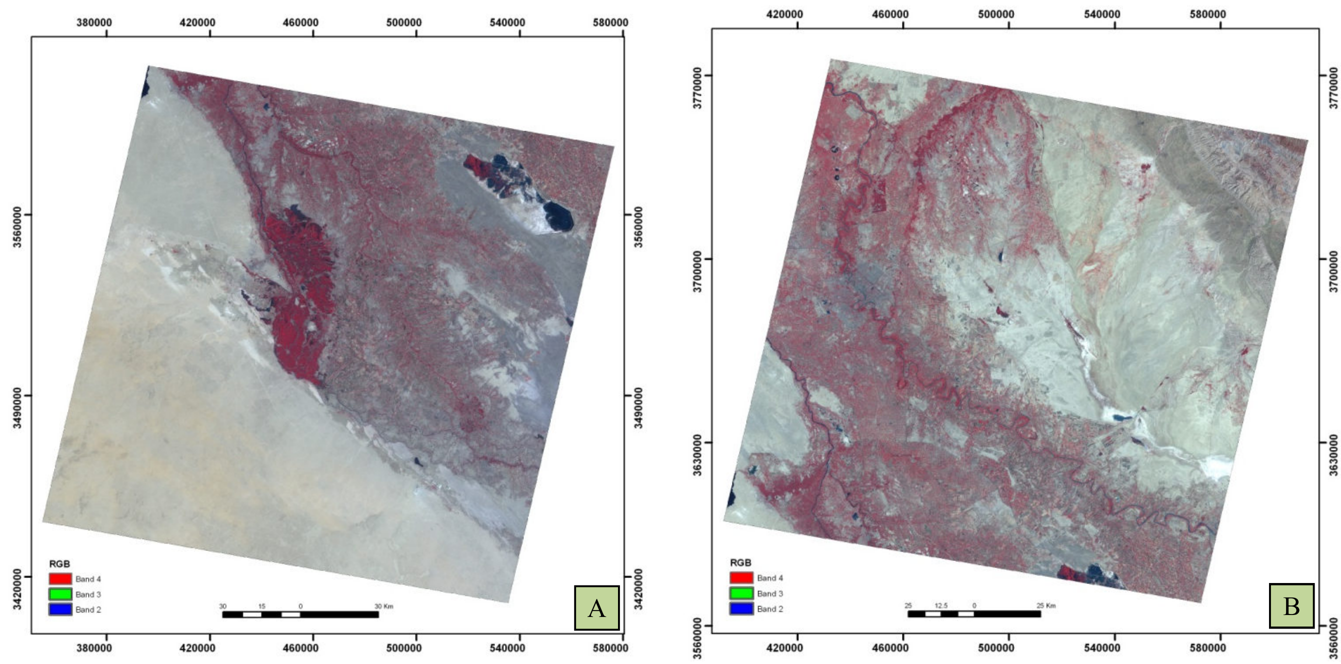

Figure 3. (A) Landsat 5 (TM) Image (scene1), (B) Landsat 5 (TM) Image (scene2)

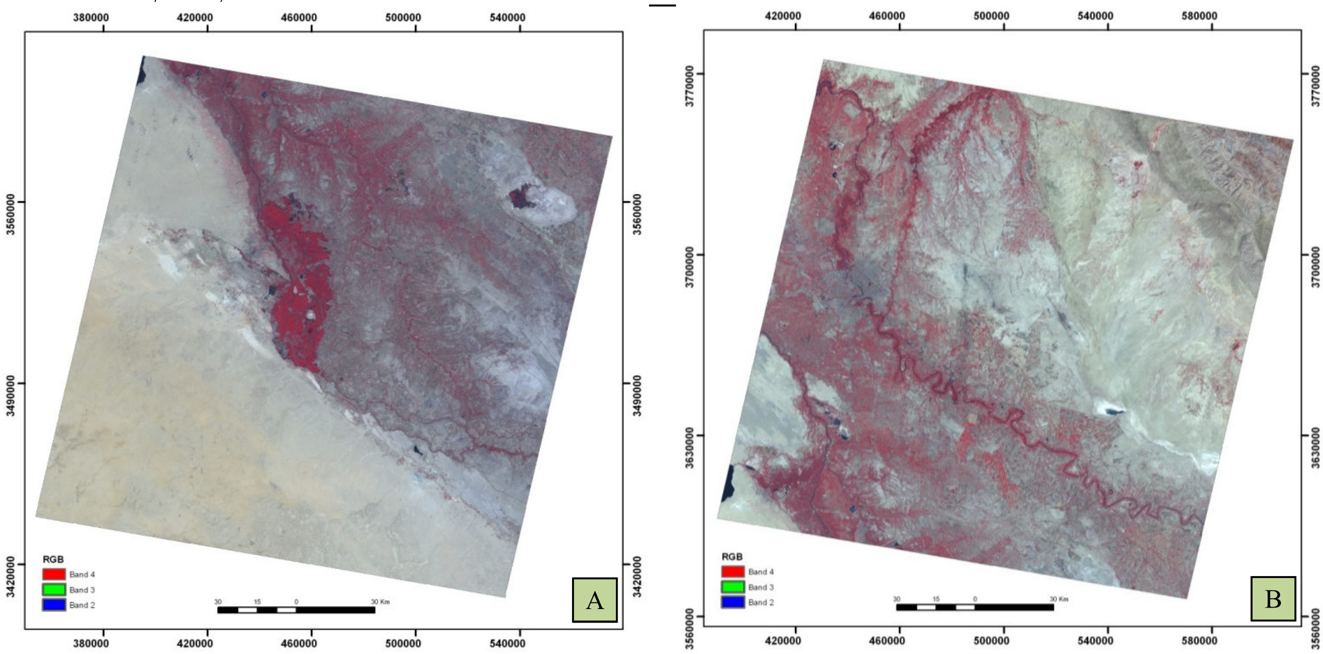

Figure 4. (A) Landsat 7 (ETM) Image (scene 1), (B) Landsat 7 (ETM) Image (scene 2)

Table 1. The spectral and spatial characteristics of Landsat images (Lillesand & Keifer 1987)

ID	Sensor	Scene No.	Band	Spectral Resolution (wavelength in µm)	Spatial Resolution In meter	Scene Cover Area in km^2	Data
1	TM5 Thematic Mapper	168-37 168-38	1	0.45-0.52	30	185	1990
			2	0.52-0.60			
			3	0.63-0.69			
			4	0.76-0.90			
			5	1.55-1.75			
			6 Thermal	10.4-12.5	120		
			7	2.08-2.35	30		
2	ETM+7 Enhanced Thematic Mapper	168-37 168-38	1	0.45-0.515	30	185	2002
			2	0.525-0.605			
			3	0.63-0.69			
			4	0.75-0.90			
			5	1.55-1.75			
			6_1-6_2 Thermal	10.4-12.5	60		
			7	2.09-2.35	30		
			8 Panchromatic	0.50-0.90	15		

3. Change Detection

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: (Tucker 1979, Sabins 1987, Jensen 1996, Erdas Imagine 2005).

$$NDVI= (NIR - RED) / (NIR + RED) \quad (1)$$

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 two periods of Landsat TM, ETM tried to explain the observed change in NDVI, by using the NDVI algebra to estimating green vegetation cover and monitored it (Fig.5) 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-2002) was 118.

The area of vegetation in 1990 was 347.09km^2 (9.88%) from total area, in 2002 was 300.29 km^2 (8.55%). The decrease in area of vegetation was (46.8) km^2 (1.33%).

The decrease of area of vegetation in period 1990-2002 due to scarcity of the water supplied into Hor Al-Dalmaj, that's lead to dry the northwestern part of the marsh and die majority of vegetation.

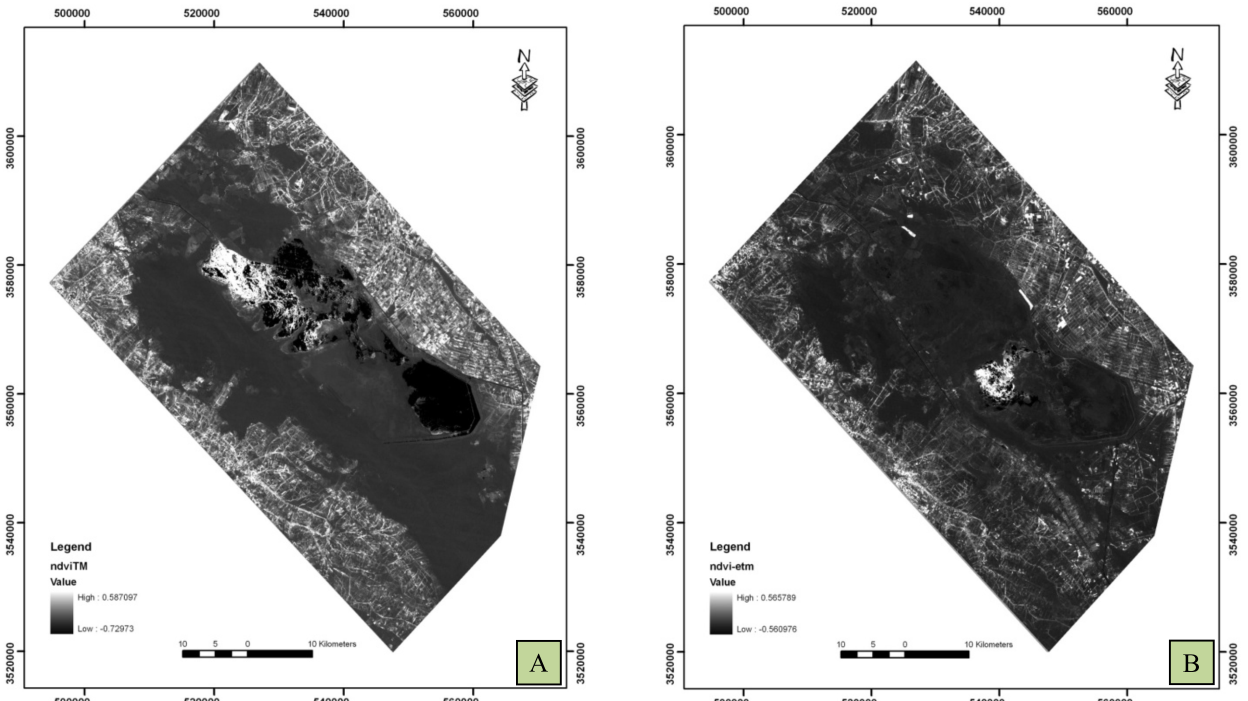

Figure 5. (A) NDVI in1990 image, (B) NDVI in 2002 image

Figure 6. 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 for (WI-TM-1990) (less than 33), (WI-ETM-2002) (less than 73). 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).

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

The area of water bodies for TM-1990 covered 190.41 km^2 (5.45%) from total area, and for ETM-2002 was 135.45 km^2 (3.85%).The decrease in water was (54.96) km^2 (1.56%). (Fig.7) shows water index 1990 and 2002.The decrease in water attribute to scarcity of the water supplied into Hor Al-Dalmaj particularly in northwestern part of the marsh due to close artificial canal at that part and open another artificial canal from Almasab Al-Aam canal into Hor Al-Dalmaj.

It is worth to mention that the water fluctuation in the Hor Al-Dalmaj was still manually controlled. (Fig.8) shows water of (Hor Al-Dalmaj) in the study area.

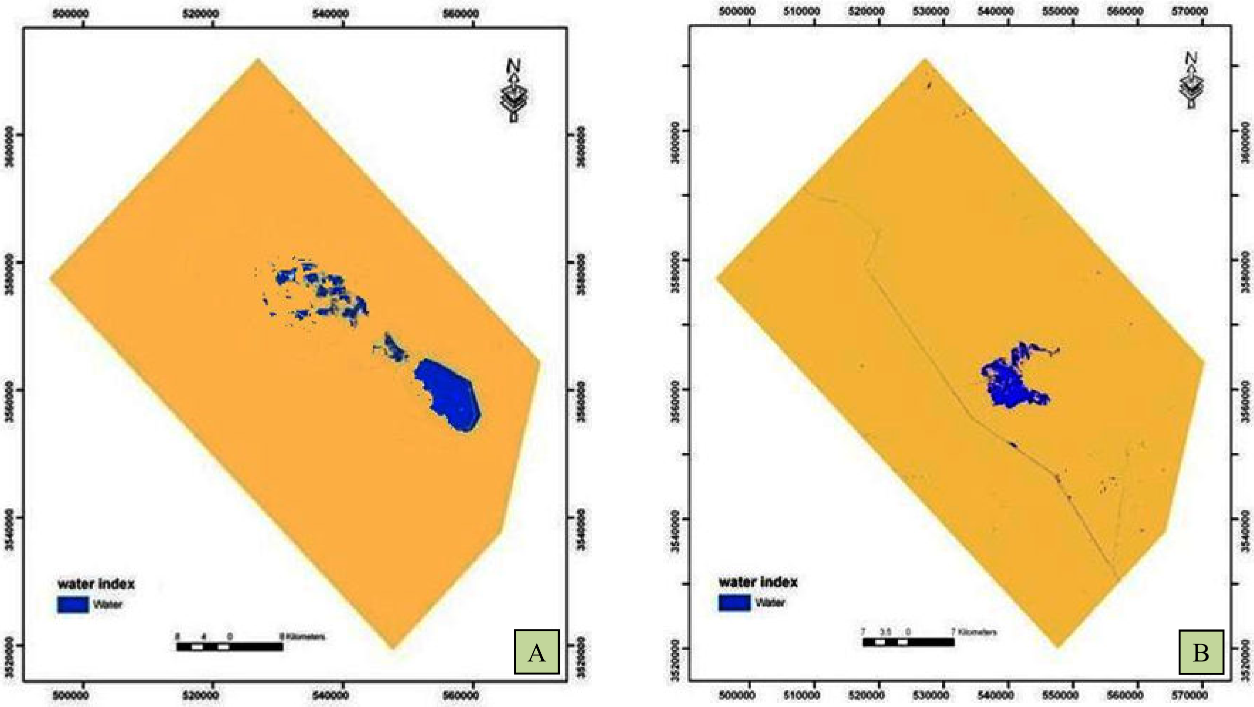

Figure 7. (A) WI in 1990 image, (B) in 2002 image

Figure 8. Water of (Hor Al-Dalmaj) in the study area

3.3 Eolian Mapping Index (EMI)

EMI is a simple model, which has been developed to generate an image that emphasizes areas with low vegetation density and high soils reflectance.

The index used the red and near-infrared (R/NIR) spectral bands from the Landsat image to generate an image that emphasizes areas with a low percentage cover/density and/or high surface-soil reflectance. The near-infrared and red spectral bands, along with the ratio of the red to near-infrared bands (NIR, R and R/NIR) are used as the red, green and blue (RGB) components to make color composite respectively (Khairy 2007).

The produced image shows various shades of yellow color indicating levels of low vegetation density and high soils reflectance.

From visual interpretation of EMI imagery for, 1990, 2002 the tone of yellow color which close to red color indicates the high density of vegetation cover and low reflectance of soil. The brighter tone of yellow color indicates the low density of vegetation cover and high reflectance of soil. EMI of TM 1990 explains that brighter tone of yellow occurs in midst part of image and the bright of yellow color decrease in sand dunes and sand sheet area that represent wide strip NW-SE trending and another parts of image (Fig.9a).EMI of ETM 2002 explains that brighter tone of yellow also occurs in midst part of image and the bright of yellow color decrease in northwestern part and another parts of image (Fig.9b).

The sand dunes and sand sheet in 1990 covered (1277.87) km^2 (36.37%) from the total area. in 2002 covered (1212.14) km^2 (34.49%).The eolian sediments decrease (65.73) km^2 (1.87%) between 1990-2002, that decrease attribute to expansion some agriculture lands in the study area, in addition to fixing some area of sand dunes by cover it with layer of mud. (Fig.10) shows sand dunes and sand sheet in the study area.

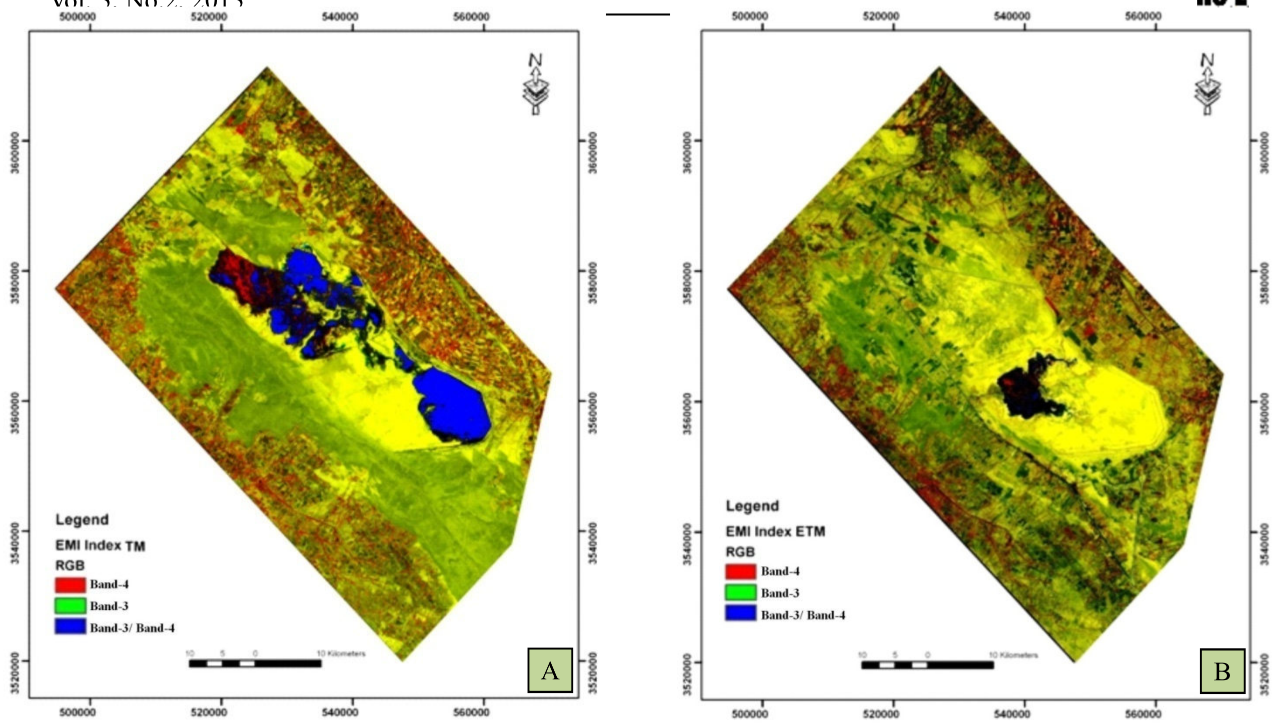

Figure 9. (A) EMI index in 1990 image, (B) in 2002 image

Figure 10. Sand dunes and sand sheet in the study area

3.4 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 paste.

The present study shows the possibilities to detect the salinity by using the, 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 Figs. (11a, 11b,) respectively to determine the saline soil.The higher reflection represent high saline soil (Abbas & khan 2007).

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

The salty soil covered different areas during the period from 1990 to 2002; in 1990 was 444.63 km^2 (12.65%) from the total area, in 2002 was 486.42 km^2 (13.84%).

The area of salty soil increased (41.79) km^2 (1.19%) from the total area between 1990-2002 especially in Hor Al-Dalmaj area, this could be attributed to seasonal fluctuation of water level in the marsh particularly when big amount of water drained from the marsh, the soil exposed on the surface leaving salt crust after the intensive evaporation, besides human activities. (Fig.12) shows Saline soil in the study area.

It is worth to mention that during period of field observation (May-2009) the situation of Hor Al-Dalmaj was differ than the mentioned period, so updating of the environmental Situation is high recommended for future studies.

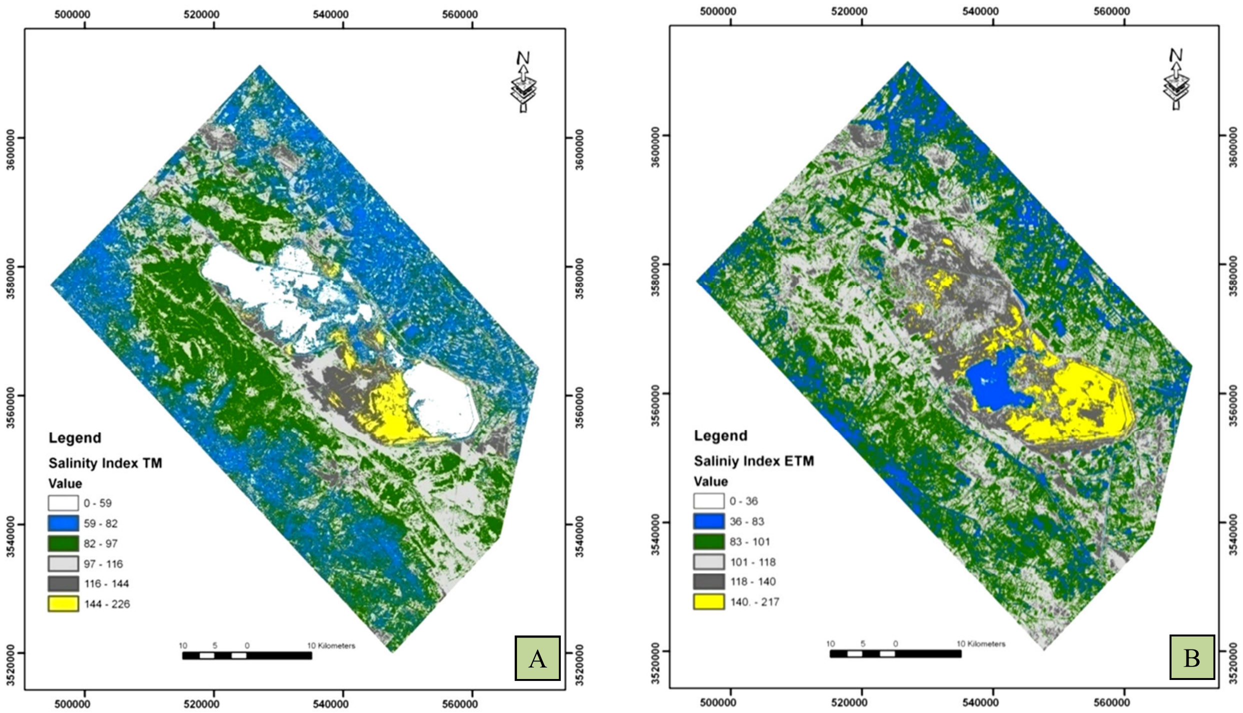

Figure 11. (A) SI index in1990 image, (B) in 2002 image

Figure 12. Saline soil in the study area

4. Conclusion

The study area underwent significant environmental changes during the twelve years. The results of indexes analyses for the study area represented in (table2) and (table3).

The conclusion from these tables was: The area which has Negative changes considered desertification lands ,while the area which has positive changes considered reformation lands, therefore the desertification lands have increased 77.82 km^2 (2.21%) from the total area during the period (1990-2002).

Table 2. Negative changes

Date / Index	Surface Area in km²		
	1990	2002	Negative changes
NDVI	348.65	300.76	46.8
WI	190.41	135.45	54.96
SI	444.63	486.42	41.79
Total			143.55

Table 3. Positive changes

Date / Index	Surface Area in km²		
	1990	2002	positive changes
EMI	1277.87	1212.14	65.73

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