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Estimation of Dynamic Changes and Desertification Rates in the Maysan Province, Iraq Using Remote Sensing Technique

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Abstract **Original Research Article**

Remote Sensing techniques have been used in the present study to estimate desertification rate and dynamics change in the Maysan Province, Iraq. A combined database have been build up from the available data and data generated from Digital satellite of Landsat TM, ETM + and OLI. These data include thematic maps (Layers) for Normalized Difference Vegetation Index (NDVI), Normalized difference, Water index (NDWI), Salinity Index (SI), Eolin Mapping Index (EMI) that can have a direct influence on desertification. Layers have been classified and integrated to detect the dynamic changes of land covers and desertification rate in the study area. The result shows that the rate change in NDVI, NDWI, EMI, and SI is positive for 1989 and 2015 and negative during 2002. Further the visual interpretation of the change rate observed in satellite image for the periods of 1989 to 2002 and 2002 to 2015, and information obtained during field surveys shows that the sandy area and salty land has increased during 1989, decrease during 2015, and highly increase in 2002, while both the NDVI and NDWI, are relatively high in 1989 and low in 2002 and 2015. It is noted also that the areas that have high sensitivity rate to desertification can be located in the northern and western parts of the study area due to shortage in water resources, increase in soil saltation, expanding of sand dune and loss in the vegetation cover.

Keywords: Desertification, Remote Sensing, Maysan, Iraq.

INTRODUCTION

Change detection is a process extraction of information by comparing two or more images of an area that are acquired at different times which provides significant information on the resources at risk. Change detection has been widely used to assess shifting cultivation, deforestation, urban growth, impact of natural disasters, earthquakes, and Land use/land cover changes etc. There are four aspects of change detection which are important when monitoring natural resources. These are detecting the changes that have occurred, identifying the nature of the change, measuring the area extent of the change and assessing the spatial pattern of the change. There are many well developed techniques for land cover change detection using digital remotely sensed imagery. Accurate change detection of Earth's surface features provides the foundation for better understanding of the relationships and interactions between human and natural phenomena to better manage and use resources. Change of major factors causing the problem of desertification in Iraq has increased relatively and become a threat to food security in the country. Desertification in Iraq in general and in the southern provinces in particular has become a serious problem. Maysan province is one of the southern provinces suffers from the problem of desertification due to increasing population, increasing demand for food in addition to the presence of sand dunes, lack of water and soil erosion. Thus, there is an urgent need to identify and control sensitive areas of desertification in the province using modern techniques in order to find appropriate solutions to solve this problem. This study attempts to use remote sensing and GIS technique to detect the dynamics change and desertification rate in the Maysan Province, Iraq. Geographic Information System (GIS) is a powerful technology that combines remote sensing and data technologies with the ability to analyze and process data [1]. Many researchers at the local level have been used this technique to monitor and evaluate desertification in Iraq such as Ziboon [2], Benni [3] Hassan [4] Alaa [5] have proven that this technique is excellent in desertification control; reduces effort, time and cost. International studies have also been used this technique to monitor and evaluate desertification such as Saha *et al*. [6] Mushtaq and Jabbar [7] Harahsheh and Tateishi

[8] Emam *et al*. [9] Panah and Ehsani [10] Shilong [11] Symeonakis [12] Zubair [13] Khiry [14].

Area of study

The study area is located in the south eastern part of Iraq; on the bank of the Tigris River with the total area about 16,072 Km^2 comprise 3.7% of the total area of Iraq. It is bounded by longitude 47° 05 ' 21.16" E to 47° 40' 53.52" E and latitudes 32° 03' 25.52 " N to 32° 30' 30 " N in zone 38N according to UTM projected coordinate system as shown in Figure (1). It is far away about 400 km distance far from Baghdad represents a commercial center for agricultural crops, fish, and cattle and linked to the provinces of Basra and Wasit and Thi Qar.

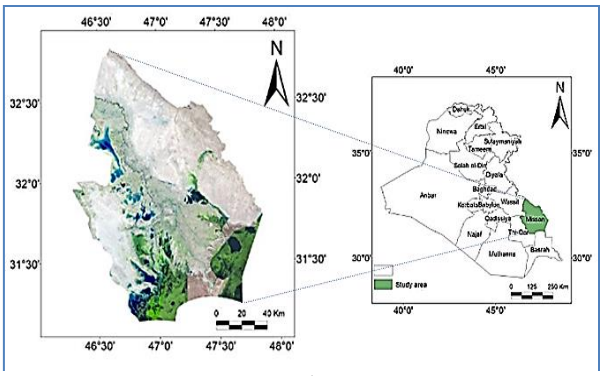

Fig-1: Location of the study area

METHODOLOGY & DATA USED

Three Landsat satellite images acquired in 1989, 2002 and 2015 were gathered covering the study area for estimation of dynamic changes and desertification rates. The time series for the study area is distributed within three periods every ten years. Images were downloaded from the United States Geological Survey (USGS) website. Images were Landsat-5. Thematic Mapper (TM) acquired in 1989, Landsat-7 Enhancement Thematic Mapper Plus (ETM+) in 2002 and Landsat-8 Operational Land Imager (OLI) in 2015. The images (path 167/row 38) were with spatial resolution 30m.The algorithm used for correction was incorporated in the (ERDAS 13) software is a process for combining multiple images into a single image. The Area of Interest (AOI) does not cover by a single satellite image so; it has needed to assemble the satellite images which cover the individual parts of AOI to form a single composite. This composition process is known as ‘Mosaicking which makes sense to cut out a subset of this larger image to simplify analysis and focus on the portion of the scene that is of primary interest as shown in Figure 2.

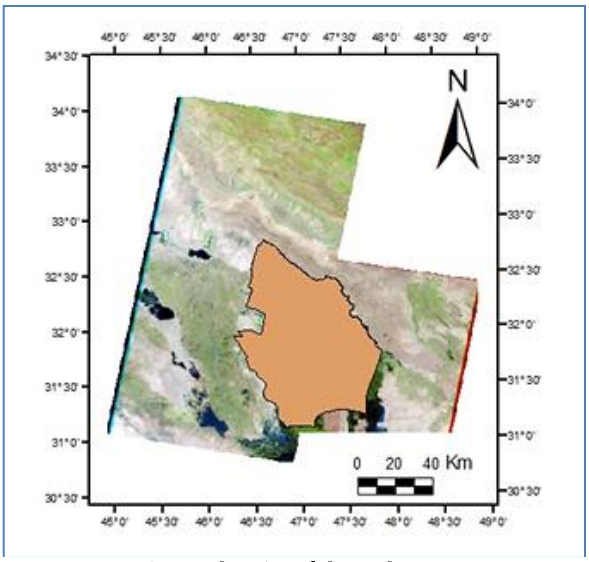

Fig-2: Subsetting of the study area

Image processing software (ERDAS 13) is used to enhance satellite image for monitor the variations and spatial distribution of desertification phenomenon and a combined geo-database have been build up over 26 years the study span. Supervised classification has been used in the present study. The results obtained are often displayed in the form of thematic map. A thematic map is produced by color-coding each individual pixel, to represent the class into which it has been assigned by classification algorithm. The thematic map is a graphically demonstrative way to present the information extracted by the classification process [15] and provides an informational description over a given area. Thematic maps of the indicators affect to desertification such as Normalized Difference Vegetation Index (NDVI), Normalized difference Water index (NDWI), Salinity Index (SI), Eolin Mapping Index (EMI) parameters have been prepared.

RESULT AND DISCUSSION

The details of the various thematic maps are discussed below for the purpose of determining the amount of changes that occurred in these indicators and thus determine the rate of desertification experienced of the study area

Normalized Difference Vegetation Index (NDVI)

It is one of the most common vegetation change detection methods, mostly due to its simplicity [16] and [17]. The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it by the sum of near-infrared and red bands which is band 3 (0.63 – 0.69 μm) 30 m and Band 4 (0.76 – 0.90 μm) 30 m. NDVI calculated from three periods of Landsat TM 1989, ETM 2000 and OLI 2015 data respectively on the basis of the following simple formula

NDVI = (NIR-RED)/ (NIR + RED) …… [20] …… (1)

In the present study the formula will be

NDVI = [(B4-B3)/ (B4+B3)] or [(B5-B4)/ (B5+B4)]……………….... (2)

The value of NDVI ranges from 1 to -1 where it is equal to 1 indicates a high density of vegetation and -1 indicates that a very low density of vegetation and zero means that the land is barren. The vegetation area for the years 1989, 2002 and 2015, and the ratio of vegetation to the total area displays in Figure (3), (4) and (5). The vegetation cover in the study area in 1989 amounted to 1838 km^2. The percentage of the vegetation cover 11% of the total area of study (16072 km^2), and decreased to 320 km^2 compose 2% of the total area of study in 2002 while total vegetation area was in 2015 (881 km^2) and the percentage is 5% of the total studied area.

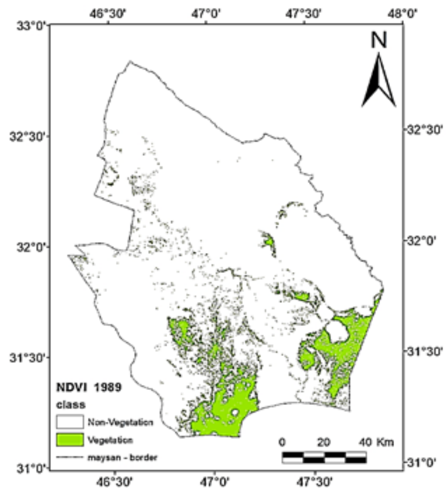

Fig-3: NDVI map for 1989

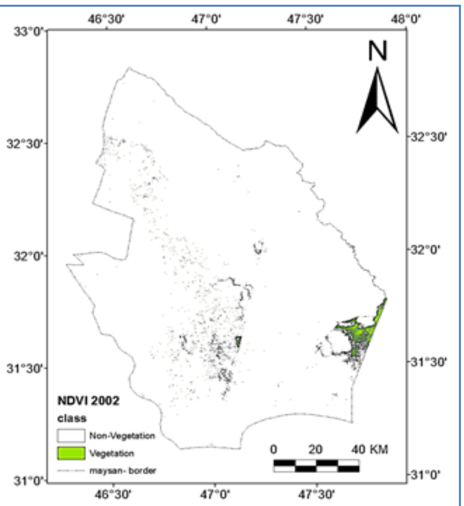

Fig-4: NDVI map for 2002

The changes in the vegetation areas and the expansion of the desertification have been computed by subtracting the first data image from the second data image; pixel by pixel for image (1989 – 2002), Image (2002- 2015) and (1989 – 2015) and the classes are defined by change thresholds as shown in Figure (6), (7) and (8) respectively. Comparison between the change in vegetation cover for (1989- 2002), (2002-2015), and (1989-2015).

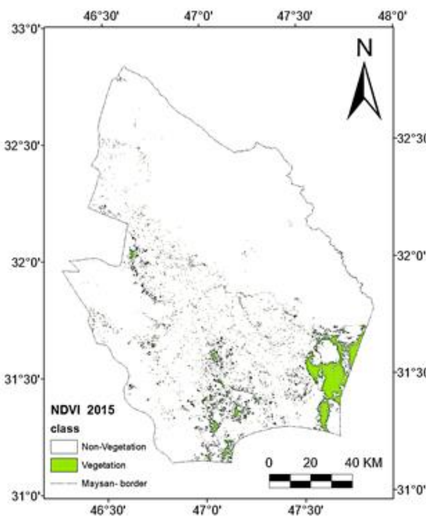

Fig-5: NDVI map for 2015

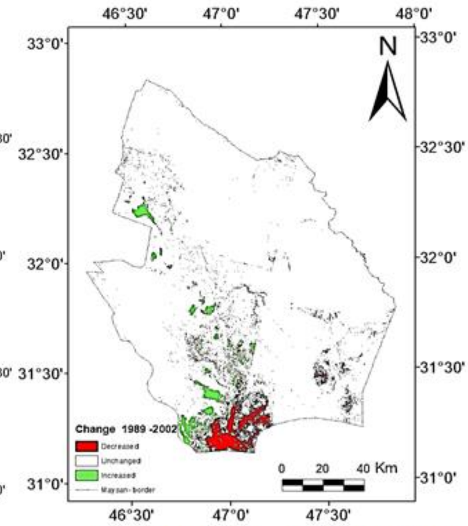

Fig-6: NDVI change for the 1989-2002

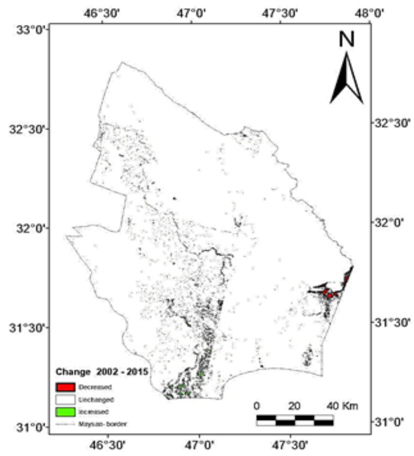

Fig-7: NDVI change for the 2002 to 2015

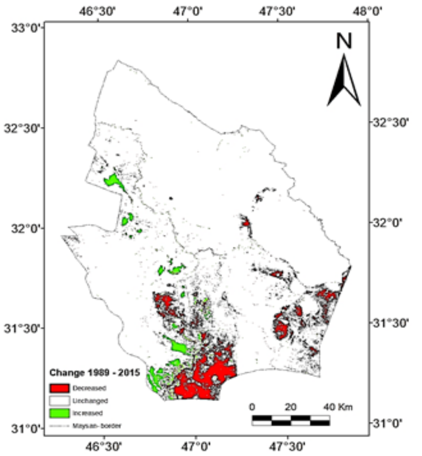

Fig-8: NDVI change for the 1989 to 2015

Period observed that the positive change spatial distribution of the NDVI was in the. Period of 1989 to 2002 and negative change was in the period of 2002 to 2015. Also good. Statuses of vegetation cover are observed during 1989 due to better growing conditions. For vegetation and precipitation is high in the period of 1989 to 2002 with a total rainfall of 206 mm/ year. The distribution of the vegetation is higher and denser in the south, south east and center part of the study area, with clear decrease and the disappearance of full agricultural areas in the, north, north east and western part of the study area.

Normalized difference Water index (NDWI)

NDWI calculated from data of the related Landsat bands of TM, ETM and OLI within the periods of 1989, 2002 and 2015 respectively, represents the state of water bodies in the study area displayed in blue color as shown in Figure (9), (10) and (11). It was noted that there's a noticeable increase in water in 1989 amounted to 816 km^2 and constitute about 5 % of the total area of study. Water areas showed a decrease during the period of 2002 amounted to 589 km^2 and constitute about 3 % of the total area. This is due to the drying up of marshes, lakes, rivers and streams, as well as the decline in water revenues due to the natural and human conditions that have led to the aggravation of drought in the study area to large levels as well as to the lack of rainfall in the study area. In 2015, the area of water bodies increased to 737 km^2 and compos about 4 % of the total studied area, hence this led to increase the vegetation cover in study area for this year.

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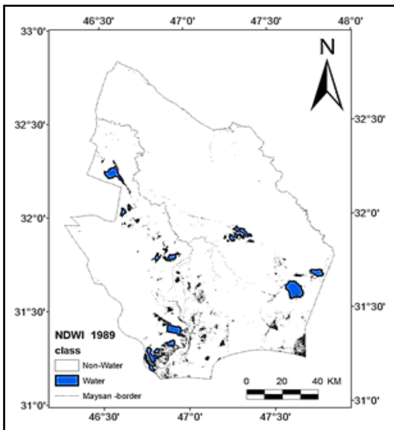

Fig-9: NDWI image for 1989

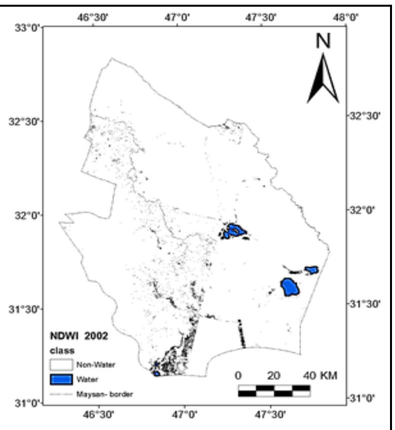

Fig-10: NDWI image for 2002

Salinity Index (SI)

Soil salinization is the process of enrichment of soil with soluble salts that result in the information of salt affected soil and it is a major form of land degradation in agricultural areas [18]. Salinity commonly occurs in irrigated soils due to the accumulations of soluble salts resulted from continuous use of irrigation waters containing high or medium quantity of dissolved salts. The results of Salinity Index (SI) analysis for TM 1989, ETM+ 2002 and OLI 2015 have presented in Figure (12), (13) and (14). The visual interpretation of this results show that considerable white patches of salt soil mainly in the north and west parts of the study area due to high albedo of salt soil showing a very bright tone. The changes which took place during the periods of 1989 to 2015 appears to decrease and highly decreased during 2015 while the highest increase of saline land was in 2002. The saline area covers about 1281 km^2 in 1989 compose percentage about 8 %, and become 862 km^2 in 2015 and compose about 5 % form the total area. The highest increase of saline soil happened in 2002 when it reached up to 2071 km^2 by the percentage of 13 % due to irrigation, the absence of drainage facilities and other intensified agricultural activities.

Eolain Mapping Index

Current analysis and field work were used to evaluate the accuracy of the model by validating and quantifying wind erosion susceptibility. The results of Eolian Mapping Index (EMI) analysis for TM 1989, ETM 2002 and OLI 2015 are revealed in Figures (15), (16) and (17) respectively. EMI allows for mapping the level of vulnerability of surfaces to wind erosion in the area of study [19].

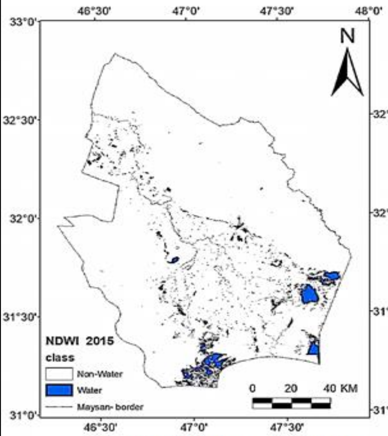

Fig-11: NDWI map of (2015)

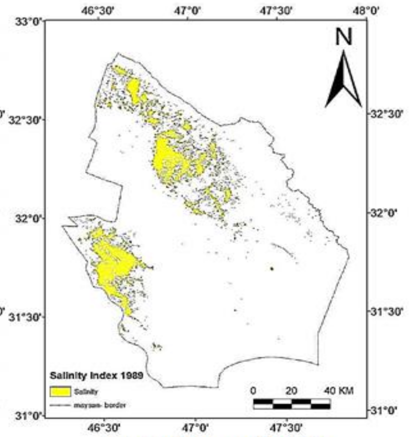

Fig-12: SI map of (1989)

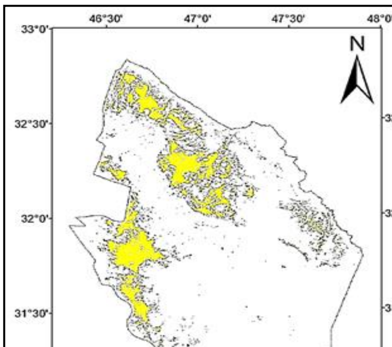

Fig-13: SI map of (2002)

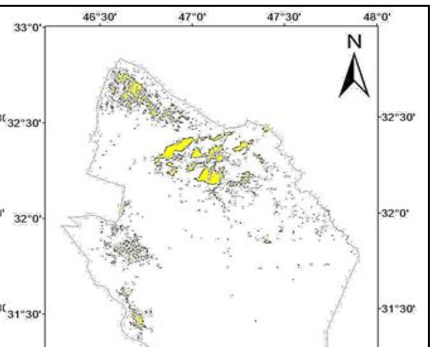

Fig-14: SI map of 2015

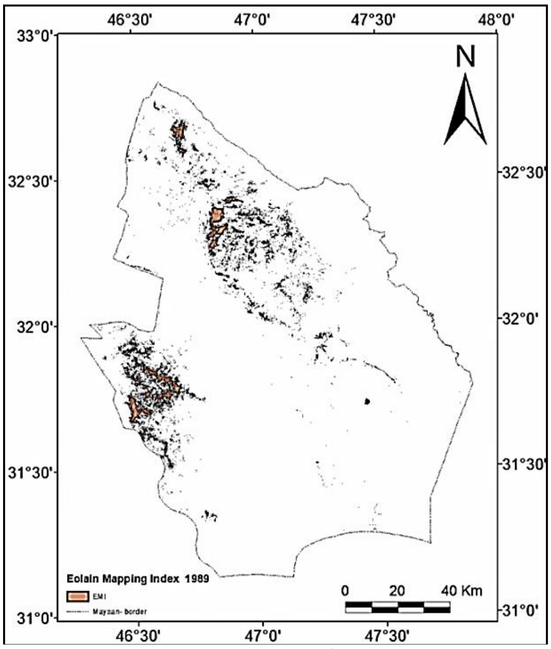

Fig-15: EMI map of (2002)

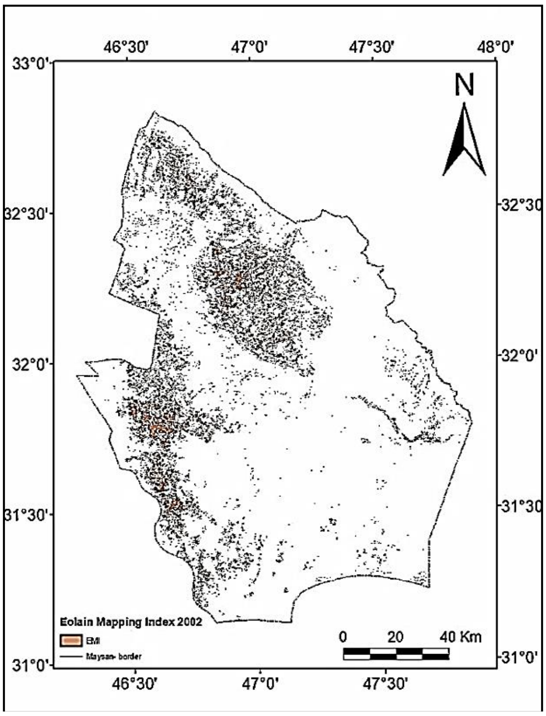

Fig-16: Fig-16: EMI map of (2002)

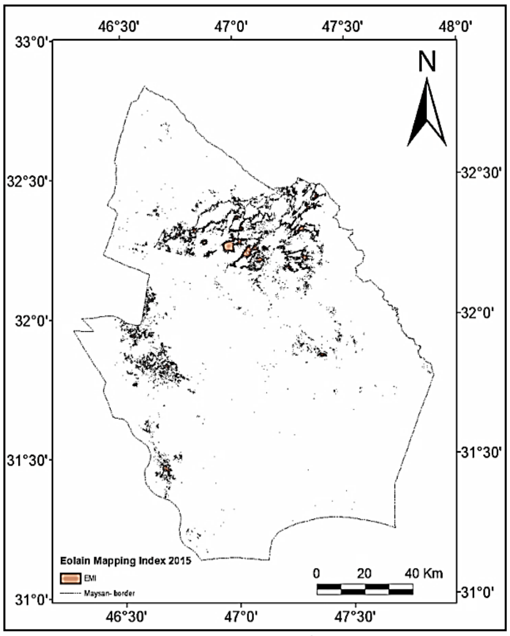

Fig-17: EMI map of (2015)

The visualization and interpretation of the resulting EMI images indicates that the sand dunes increased from the northeast towards western part of the area. The visual analysis for figures above reveals that sand encroachment significantly increasing slightly during the period from 1989 to 2002 and decreasing during the period from 2002 to 2015 with the major dominant change taking place in the area located in the northeast part of study area. Sand sheet occupied area of 764 km^2 for 1989, 1664 km^2 for 2002 and 704 km^2 for 2015. It has been observed that the percentage of the sandy area for year of 2002 is highest percent (10 %) as shown in Figure (17). Vegetation index analysis of Landsat ETM+ 2002 shows that the decrease of vegetation cover led to the increase in the susceptibility of topsoil to wind erosion and the encroachment of sand eastwards in the study area.

Desertification rate and dynamics of change

The desertification rate of the area for the three periods presented in Table (1) and Table (2) shows that the areas are sensitive to desertification when the NDVI and WI rate has a value of less than one. Also when the value of (SI) and (EMI) rate more than one the areas will be sensitivity to desertification. Table (1) illustrates the rate of change of major factors causing desertification during the periods 1989 and 2002.

It has been observed that the rate change of NDVI, WI, EMI, and SI are positive for 1989 while the rate of change presented in Table (2) shows negative change during 2002 and positive change in 2015. Figure (18) records the change in NDVI, WI, EMI, and SI which took place during the addressed periods from 1989 to 2015. Further the visual interpretation of the change rate observed in satellite image for the periods of 1989 to 2002 and 2002 to 2015, and information obtained during field surveys shows a significant differentiation over years. The findings of SI and EMI illustrate that the sandy area and salty land has increased during 1989, decrease during 2015, and highly increase in 2002, while both the NDVI and WI, are relatively high in 1989 and low in 2002 and 2015. It is noted also that the areas that sensitivity to desertification can be divided into five zones namely, very high, high, moderate, low and very low as shown in Figure (19). It has been observed that high rate sensitivity to desertification located in the northern and western parts of the study area. These parts have been severely affected by factors for dynamics of desertification in the study area. These factors include the shortage in water resources, the increase in soil saltation, the expanding of sand dune and the loss in the vegetation cover.

Table-1: Desertification rate and dynamics of change during the periods of 1989 and 2002

				1989			
2002	Area in Km^2			NDVI	NDWI	SI	EMI
				1838.	816.637	1281.946	763.683
	NDVI	320.548	Rate of change	5.73			
	NDWI	589.556			1.39		
	SI	2071.317				0.62	
	EMI	1663.811					0.46

Table-2: Desertification rate and dynamics of change during the periods of 2002 and 2015

				2002			
2015	Area in Km^2			NDVI	NDWI	SI	EMI
				320.548	589.556	2071.317	1663.811
	NDVI	880.996	Rate of change	0.36			
	NDWI	737.447			0.8		
	SI	862.804				2.4	
	EMI	704.384					2.36

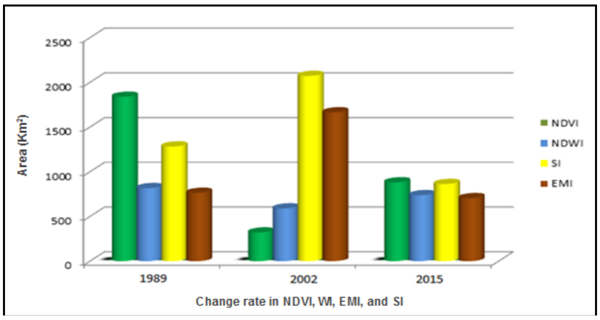

Fig-18: Change rate in NDVI, WI, EMI, and SI during the periods from 1989 to 2015

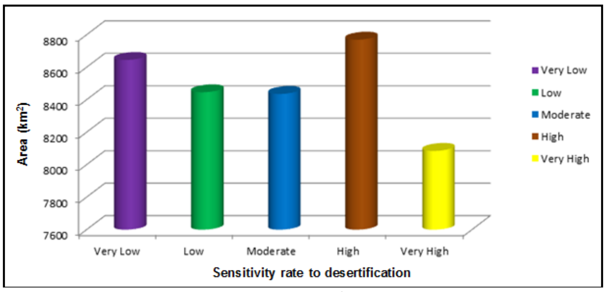

Fig-19: Sensitivity rate to desertification in the study area

CONCLUSION

The present study showed that Normalized Difference Vegetation Index (NDVI), Normalized difference Water index (NDWI), Salinity Index (SI) and Eolin Mapping Index (EMI`) indicators determinants of desertification dynamics in the study area. The visual interpretation of satellite image for the periods of 1989 to 2002 and 2002 to 2015, and information obtained during field surveys shows the positive change spatial distribution of the NDVI in the period of 1989 to 2002 and negative change in the period of 2002 to 2015. The rate change of water bodies area decrease during the period of 2002 while in 2015, increased to 737 km^2, hence this led to increase the vegetation cover in study area for this year in the south, south east and center part of the study area, with clear decrease and the disappearance of full agricultural areas in the north, north east and western part of the study area. The findings of SI and EMI illustrate that the rate change of sandy area and salty land increased during 1989, decrease during 2015, and highly increase in 2002. Through these changes it is possible to divide the entire study area into five zones vis-à-vis their desertification rate namely, very high, high, and moderate, low and very low. The results showed that the high sensitivity area to desertification is located in the north and west of the study area due to the presence of sand dunes and salinity, while the sensitivity rate to desertification decreases as we approach the center of the city due to rainfall and abundant vegetation and water. Spectral enhancement technique which is a process of creating new spectral data from available bands has been also used to monitor the variations and spatial distribution of desertification phenomenon.

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