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STUDY AND ANALYSIS OF DESERTIFICATION PHENOMENON IN KARBALA GOVERNORATE BY REMOTE SENSING DATA AND GIS

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ABSTRACT

One of the most important issues facing Iraq is the threat of continued desertification resulting from climatic factors and human activities. Geographic Information System and satellites imageries play major role in developing a global and local operational capability for monitoring desertification in dry lands.

This study intends to prove the capability of Remote Sensing data and Geographic Information System to monitor and study the desertification phenomenon. Part of Karbala Governorate, with an area of 768 Km^2 is selected as study area.

Four cloud free Landsat MSS, TM, ETM+, and SPOT5 scenes covering the study area were selected for analysis. Images were acquired for years 1976, 1990, 2001 and 2011. A site area was selected from the whole study area to investigate the possibilities of image classification and extract the indices images for the MSS, TM, ETM, and SPOT respectively. Normalized Difference Vegetation Index (NDVI) was used to create a map and extract the vegetation cover in the study area. Normalized Difference Water Index (NDWI) was used to create a map and define water bodies in the study area. Eolin Mapping Index (EMI) was used to map the areas which are subjected to wind erosion hazard.

In order to identify the changes which took place during the four periods, three methods are used. Firstly; direct detection of change in indices images between different years is analyzed using visual interpretation in addition to statistical analysis. Secondly, differencing change detection analysis is applied to determine and to analyze the land cover changes over the four periods. Thirdly, the supervised classification is used to classify the images and to analyze the land cover changes during the four periods.

The analysis shows that the study area suffers from severe desertification because it has suffered from erosion by wind and sand dunes, urban expansion, and lack of water resources especially in its western parts. The analysis also shows that the desertification decreased in the period between 1976 to 2001, and increased in the period 2001 to 2011 due to the increase in sand dunes to about 8.78 $Km^2 . year^{-1}$, the appearance of water logged area problem that increased to about 0.65 $Km^2 . year^{-1}$, the increase in urban area to about 0.38 $Km^2 . year^{-1}$, in addition to geological factors, and the effect of bad climatic conditions.

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دراسة وتحليل ظاهرة التصحر في محافظة كربلاء باستخدام بيانات التحسس النائي ونظم المعلومات الجغرافية

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المستخلص

ان أحد القضايا المعاصرة التي تواجه العراق هي استمرارية تدهور الترب والتصحر، نتيجة عوامل المناخ والنشاط البشري. ويعاني العراق من مشكلة التصحر لعدة عقود. نظم المعلومات الجغرافية والصور الفضائية والتي تراقب الوضع باستمرار وبشكل دوري، تلعب الدور الأساسي في تطوير قابلية العمليات التي تراقب هذا التدهور في التربة وظاهرة التصحر في الأراضي الجافه كما هو الحال في العراق. لذا جاءت هذه الدراسة لتعمل على إثبات قابلية بيانات التحسس النائيي ونظم المعلومات الجغرافية في مراقبة ودراسة ظاهرة التصحر. حيث تم اختيار جزء من محافظة كربلاء كمنطقة للدراسة وبمساحة 768 كم^2.

تم اختيار أربعة مشاهد خالية من تأثيرات الغيوم تغطي منطقة الدراسة الحالية للقمر الصناعي لاندسات وللمتحسسات (MSS، TM، ETM+) والقمر الصناعي سبوت (SPOT5) للسنوات 1976 و1990 و2001 وسنة 2011 على التوالي لغرض تحليلها ودراستها. وتم تحديد منطقة مختارة من ضمن المشاهد أعلاه لغرض الدراسة والتحري وإجراء العمليات الخاصة عليها والتي تشمل تصنيف الصور واستخلاص الادلة منها. وقد استخدمت مجموعة من الأدلة في هذا البحث وهي ودليل النباتات (NDVI) ودليل الترسبات الريحية (EMI) ودليل المياه (NDWI). لغرض استخلاص وعمل خارطة للغطاء النباتي في منطقة الدراسة تم استخدام دليل النباتات (NDVI). لغرض معرفة وتمييز الأجسام المائية في منطقة الدراسة تم استخدام دليل المياه (NDWI). ولغرض تحديد المناطق المتاثرة بخطر التعرية الريحية تم استخدام الدليل (EMI).

لمعرفة التغير الحاصل للغطاء الأرضي للفترات الزمنية الأربعة تم استخدام ثلاثة طرق لهذا الغرض، الطريقة الأولى اعتمدت على الكشف المباشر للتغييرات الحاصلة من خلال التفسير الوصفي والكمي لصور الأدلة أعلاه التي استخدمت في عزل وحدات الغطاء الأرضي. وأما الطريقة الثانية فقد استخدمت لتحديد وتحليل تغييرات الغطاء الأرضي خلال تلك الفترة من خلال استخلاص الفروقات بين صور الأدلة جبريا وأما بالنسبة للطريقة الثالثة فقد تم استخدام عملية التصنيف الموجه لتصنيف الصور وتحليل التغييرات الحاصلة للغطاء الأرضي خلال تلك الفترة أيضا.

أظهرت نتائج التحليل إن منطقة الدراسة تعاني من تصحر شديد لأنها عانت من التعرية بواسطة الريح والكثبان الرملية، التوسع الحضري، قلة المصادر المائية وخاصة في الجزء الغربي منها. وكذلك بينت نتائج التحليل أيضا بأن نسبة التصحر قد قلت في الفترة من سنة 1976 ولغاية سنة 2001 وازدادت خلال الفترة من سنة 2001 ولغاية سنة 2011 بسبب ازدياد تعرض المنطقة للكثبان الرملية وبمعدل 8.78 كم^2 في السنة وظهور مشكلة الأراضي المشبعة وازديادها بمعدل 0.65 كم^2 في السنة وازدياد المساحة الحضرية بمعدل 0.38 كم^2 في السنة بالإضافة الى العوامل الجيولوجية وتأثيرات الظروف المناخية السيئة خلال تلك الفترة.

INTRODUCTION

Desertification is the end-product of a combination of both natural and man – made factors of the environment which work together to produce a desert condition in an area. There are other Geo-climatic effective factors such as temperature, evaporation and wind (El-Baz A., 1990).

Desertification phenomenon is considered one of the dangerous international environmental phenomena, for its effects are not confined to certain places, rather they generally cover large areas of the world, and particularly in the dry and semi-dry environments, besides the semi- wet areas. Destruction of arable land is jeopardizing development while, simultaneously, lack of development is preventing any action against desertification.

Action can only by successful if it is an integral part of a comprehensive development plan and strategy, which takes fully into account the communities directly, affected by drought or desertification. The causes of drought and desertification in west of Iraq have been identified as meteorological, pedological, geological and agricultural problems. Loss in soil fertility, movement of desert environment, population migration, and great losses in human and material resources are the main outcome (Al-Nasiri, 2002). Because of the dynamic nature of this phenomenon and the inconstancy of its inputs, geographical information system (GIS) is used in this study. The geographical information system (GIS) is one of the most important technique used after the introduction of computers in the various fields of scientific applications. Furthermore, this system combines the remote sensing techniques and the necessary data to analyze and process the geographical data into the information bank management system. In this study, digital images of MSS (1976), TM (1990), ETM+ (2001), and spot (2011) are used.

The study area is a part of Karbala Governorate in the middle part of Iraq. It is bounded by the coordinate (from 43 57 31.98 E to 44 15 12.09 E) and (from 32 20 51.05 N to 32 35 52.16 N) occurring in the zone 38N according to UTM projected coordinate system. It covers an area of 768Km^2, (Fig.1).

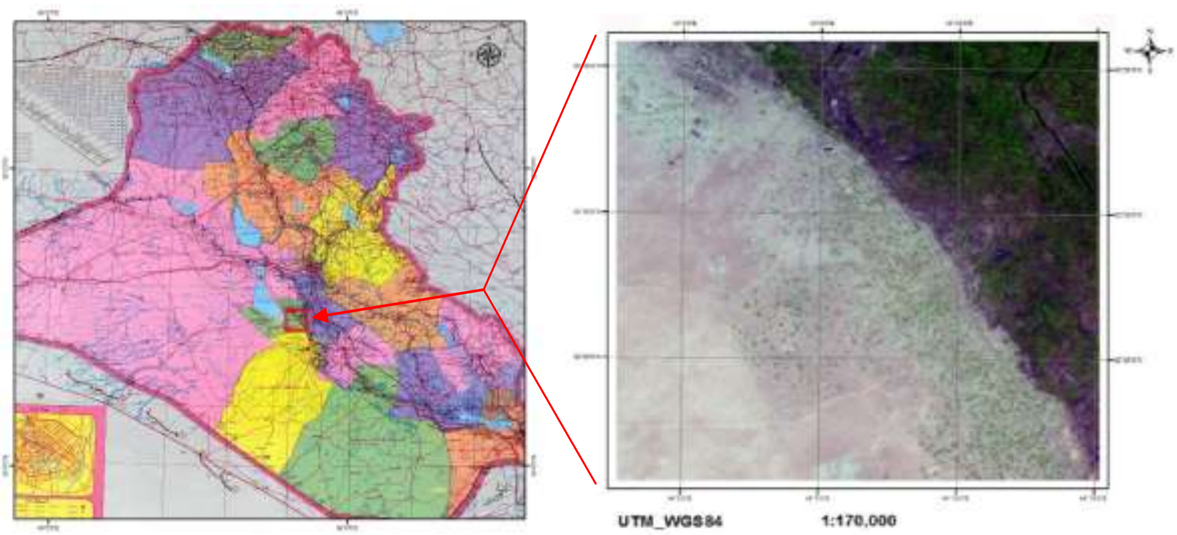

Fig.1: Location and satellite image of the study area

CAUSES OF DESERTIFICATION

Factors leading to desertification can in general be divided into two categories: Natural processes and Socio-economic processes, (White, 2007).

▪ Natural or Climatic Factors

There are three main Natural or climatic Factors that influence the onset and continuation of desertification processes:

1. The occurrence of droughts (periods of below-average rainfall), which can last for years.
2. High temperatures which cause a high rate of evapotranspiration (The loss of moisture from the Earth’s surface by a combination of direct evaporation and transpiration from plants) and therefore a high rate of moisture loss from soils.
3. Infrequent and often intense periods of rainfall which compacts soils, increasing their erodibility.

▪ **Socio-economic Factors**

There are four main Socio-economic factors which accelerate desertification: overgrazing, over-cultivation, deforestation and poor irrigation.

1. Overgrazing. This occurs where herd sizes exceed the carrying capacity (the number of cattle that can graze an area sustainably (i.e. without long term damage). If this capacity is exceeded:
   a- Vegetation changes, e.g. drought-resistant species replace edible species.
   b- Soil quality is reduced, e.g. grazing animals compact and break down the soil structure, increasing its vulnerability to erosive processes.
   c- The health of livestock and their productivity decreases.
2. Over-cultivation. May occur when increasing food production is needed:
   a- To support increasing populations.
   b- When rural people are encouraged to grow 'cash crops' for sale in city markets and for export.

   A common feature of all cash crops is that they are extremely demanding in their nutrient requirements. If farmers lack natural or artificial fertilizers or are unable to allow sufficient fallow periods, fertility will rapidly decline. Declining fertility may lead people to cultivate marginal areas i.e. those which are inherently incapable of sustaining food production e.g. steep slopes which are highly erodible or areas which receive irregular and/ or insufficient rainfall. Fertility will inevitably fall if vulnerable lands are left fallow (uncultivated) for shorter periods. Nutrient contents falland soil structure deteriorates. This leads to reduced crop yields and vegetation cover, leaving soils exposed to erosion by wind and rain.
3. Deforestation and excessive fuel wood cutting. Forest is cleared for agriculture or fuel wood. This leads to reduced shade and greater desiccation of the soil, a lowered water table and an increase use of dung (otherwise used as fertilizer) as a fuel source. The resulting loss of organic matter reduces both the 'stickiness' of the soil peds and the water-holding capacity of the soil; its erodibility therefore increases.
4. Inappropriate irrigation practices. Fertility is reduced through salinization (the buildup of salt around the roots of plants) and waterlogging (caused by poor drainage and the formation of an impermeable salt crust on the soil surface).

MATERIALS AND METHODS

▪ **Remote Sensing Data**

Multi-temporal Landsat MSS (dated March 10, 1976), TM (dated August 28, 1990), ETM+ (dated March 27, 2001) and SPOT (dated May 15, 2011) imageries remotely sensed dataset were assembled and analyzed for desertification phenomenon analysis. The spatial resolution of one pixel of MSS, TM, ETM and SPOT images were 80 m, 30 m, 15 m and 10 m respectively.

▪ **Geometric Correction**

In the present study Geometric correction was performed by means of the image-to-image method as the Spot 2011, which was selected as the reference image, was already corrected. The remotely sensed data (MSS 1976, TM 1990 and ETM 2001) were geometrically corrected to the datum WGS 84 and projection UTM N38 using the first order (linear) of polynomial function and Nearest Neighbor rectification re-sampling. The RMS error of the image-to-image rectification comes 0.43, 0.39 and 0.33 pixels for MSS, TM, and ETM respectively.

▪ **Vegetation, Sand, and Water Indices**

The geometrically rectified MSS, TM, ETM+ and SPOT images bands were used to derive the studied indices. Satellite derived indices images were produced to portray surface changes.

– **The Normalized Difference Vegetation Index (NDVI):** The Normalized Difference Vegetation Index (NDVI) derived from the ratio of NIR band and Red band in Landsat MSS, TM, ETM and SPOT images data was applied for monitoring vegetation changes in the study area within the years from 1976 to 2011.

NDVI= (NIR – RED) / (NIR + RED) (Fadhil, 2008)

– **The Normalized Differential Water Index (NDWI):** The Normalized Difference Water Index (NDWI) developed by Mc Feeters (1996) was used for delineation of water bodies and waterlogged areas. This index is calculated as follows:

NDWI = [R (G) – R (NIR)] / [R (G) + R (NIR)]

Where, R (G) is spectral reflectance in G band and R (NIR) is spectral reflectance in NIR band. The range of NDWI is from +1 to –1 (KAUL and INGLE, 2011).

▪ **Eolin Mapping Index (EMI)**

EMI is a simple model which has been derived from the combination of IR, R, and (R/IR) spectral bands of images used as (RGB) components in order to make color composite respectively (Khiry, 2007). This was applied for analysis to evaluate the wind erosion and an eolin deposits detection in the study area within the years 1976, 1990, 2001 and 2011.

CHANGE DETECTION

In order to detect, assess, and map the changes of the study area during the period from 1976 to 2011, Landsat MSS, TM, ETM, and SPOT imageries dataset were used. Change detection involves the use of multi-temporal image data sets to discriminate the changes between dates of Imaging. Change detection is the process of identifying differences in the state of an object or phenomena by observing it at different times (Singh, 1989). It is useful in such diverse applications as land use change analysis, monitoring of shifting cultivation, assessment of deforestation and so on. It is essential for studying change on the earth’s surface (Arnous, 2006). The change detection methods are grouped into seven categories: namely (1) visual analysis, (2) algebraic, (3) transformation, (4) classification (5) advanced models, (6) Geographical Information System (GIS) approaches, and (7) other approaches. (Lu E.A, 2004).

In this study three methods are used for changes identification. The first depend's on the visual analysis of the changes of multi-temporal data sets by providing direct visual examination observing and analysis of changes of different land cover in the study area. The second depend's on the algebra techniques which is based on subtraction to extract the change between two images of different dates, while the third depend's on the analysis of change according to classification process.

In order to provide an accurate Land cover classification of study area supervised classification of MSS 1976, TM 1990, ETM+ 2001 and SPOT 2011 was use in this study.

Locations were selected using a portable GPS device (TOPCON GMS2) during field work to collect the ground truth and to perform the field checking for the obtained results. An accuracy assessment of the classification undertaken with used indices was done. The results of the classification were presented in figures (2, 3, 4 and 5).

- **Ancillary Data and Software Packages**

Meteorological data and software such as ERDAS 9.2 for image processing, Arc GIS 9.3 for analyzing and presenting the results, and Microsoft Excel were utilized in this research.

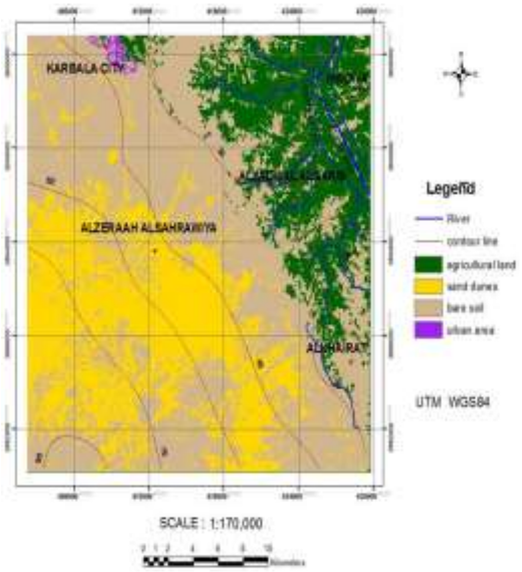

Fig.2: Land cover map 1976

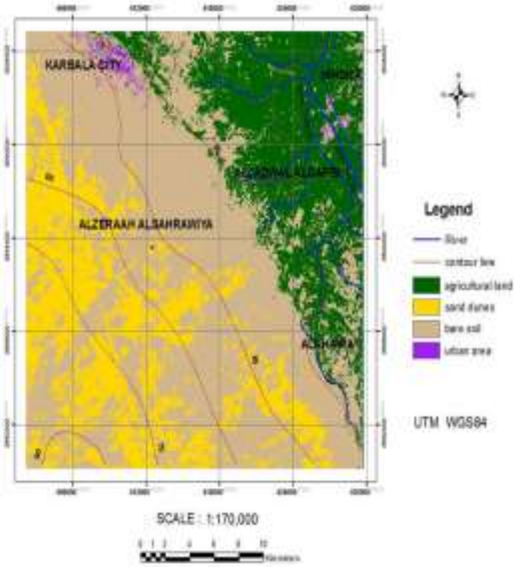

Fig.3: Land cover map 1990

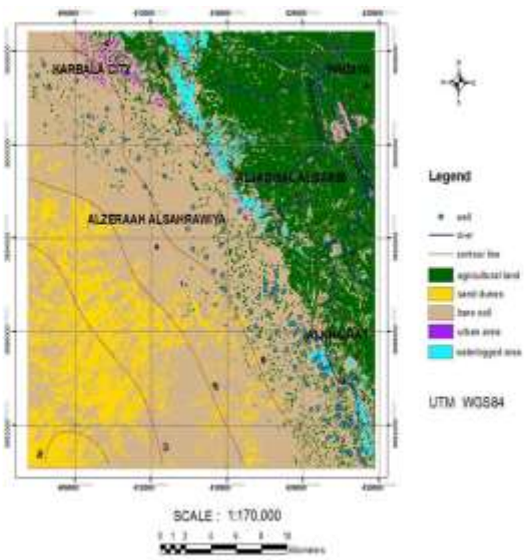

Fig.4: Land cover map 2001

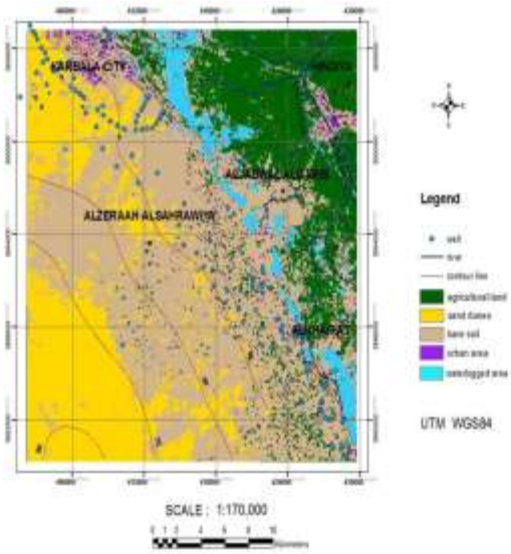

Fig.5: Land cover map 2011

RESULTS AND DISCUSSION

NDVI, NDWI, EMI indices and land cover maps were computed in multi-temporal images and analysis of the desertification changes with respect to agriculture, water, meteorological data, and people activities are made. The studied indices have produced relative results based on electromagnetic spectrum recorded in the images. Principally the NDVI shows brighter in healthy vegetation areas whereas NDWI seen as brighter in Water bodies. The sand can be seen as yellow in EMI index.

▪ NDVI Index Change Detection

This is used for vegetation monitoring, location, extent, and detect vegetation change in the study area, Qualitative and quantitative analyses of NDVI images for Landsat MSS 1976, TM 1990, ETM 2001 and spot 2011 were used. The visual interpretation of NDVI images is shown in Figures (6), (7), (8), (9), and (10). Statistical calculation highlights the differences in NDVI vegetation cover between 1976 and 1990, between 1990 and 2001 and between 2001 and 2011(Figs.11, 12, 13 and 14).

From the above, one can get an idea of the spatial distribution of the supposed change. Much of the positive change in the period 1976 to 2001 and the negative change between 2001 to 2011 are observed. In addition, signs of good status of vegetation cover during 2001 area is seen. This can be attributed to better growing conditions for vegetation during 2001 as well as differing spatial extents. In the north and eastern part of the study area distribution of the vegetation is higher and denser, with decreasing significance towards the west part of the study area.

▪ EMI Change Detection

The result of Eolin Mapping Index (EMI) analysis for the period 1976, 1990, 2001 and 2011 are revealed in Figures (15), (16), (17), and (18). The figures show the capability of EMI for the potential wind erosion and detecting the change of sand soil in the study area. The visualization and interpretation of the resulting EMI images indicates that the sand dunes and sand sheet are distributed and increased from the west towards the east.

In order to get a further idea of where and when most of the change was taking place, visual analysis of the figures above reveals that sand encroachment significantly decreased during the period from 1976 to 2001 and increased during the period from 2001 to 2011, with the major dominant change taking place in the west part of the study area.

Vegetation index analysis of Landsat ETM 2001 shows that the increased vegetation cover has led to the decrease in the susceptibility of topsoil to wind erosion and the encroachment of sand westwards, and vice versa in Vegetation index analysis of MSS 1976, TM 1990, and SPOT 2011.

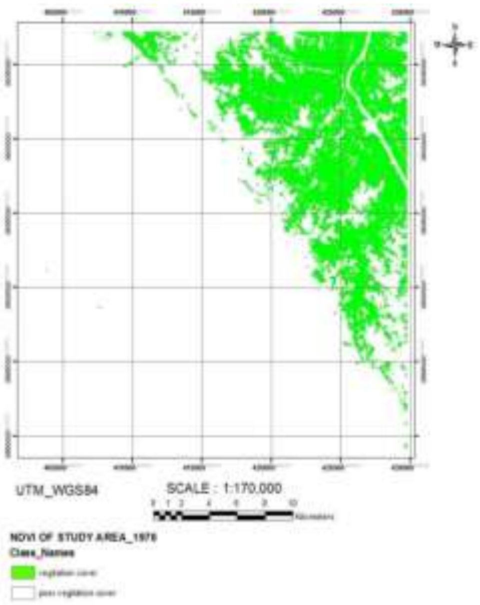

Fig.6: NDVI image 1976

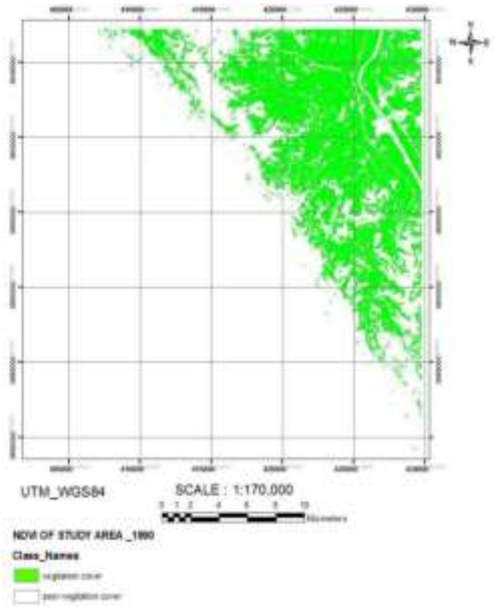

Fig.7: NDVI image 1990

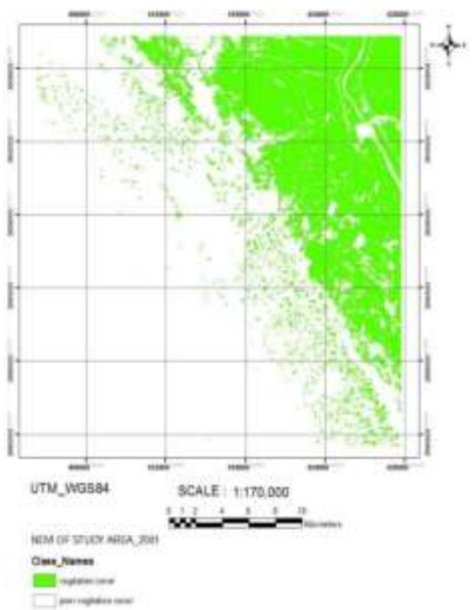

Fig.8: NDVI image 2001

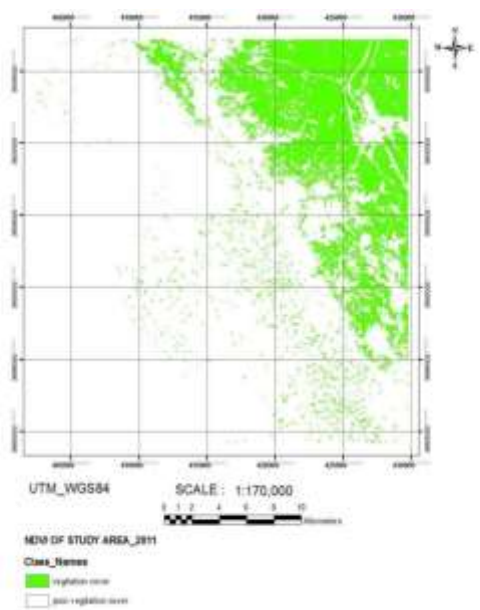

Fig9: NDVI image 2011

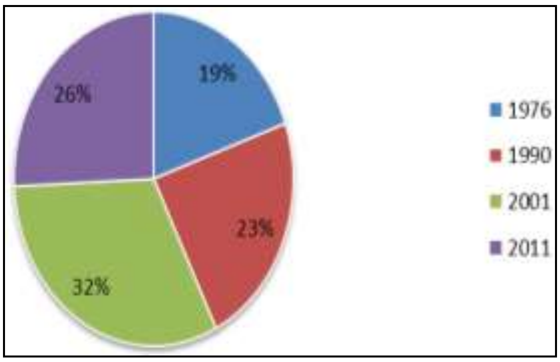

Fig.10: Percentage of vegetation cover for the period 1976 – 2011

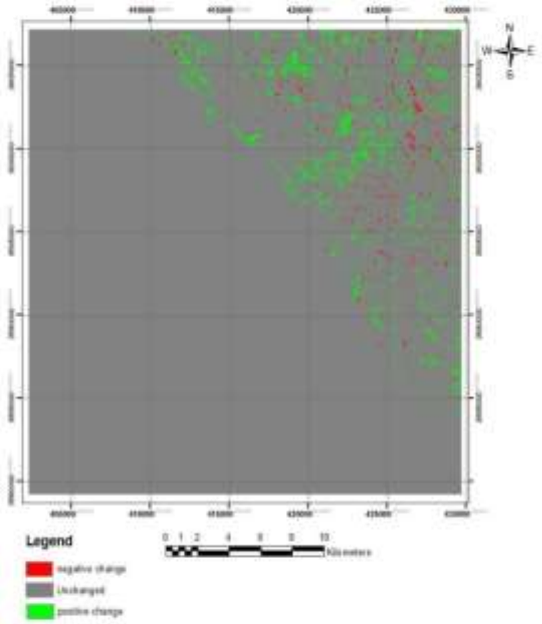

Fig.11: NDVI image differencing
Change for period 1976 – 1990

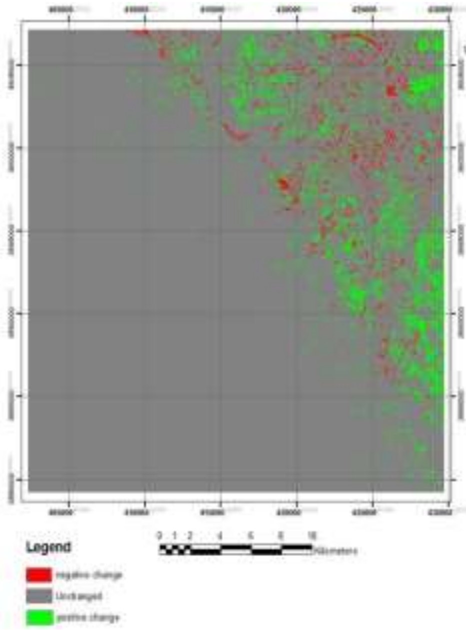

Fig.12: NDVI image differencing
Change for period 1990 – 2001

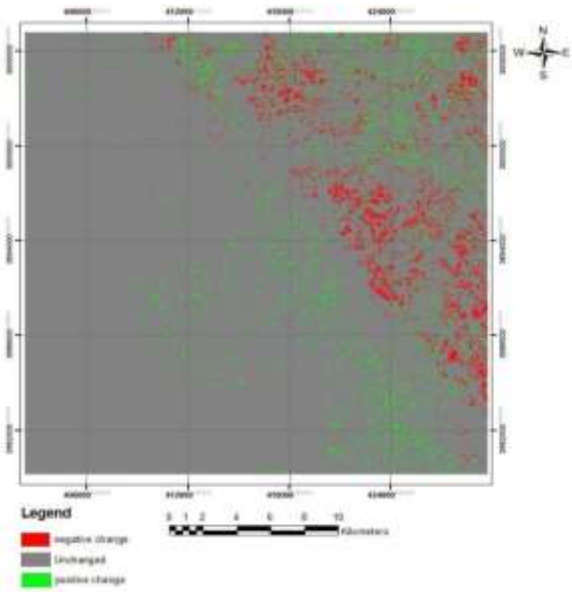

Fig.13: NDVI image differencing
Change for the period 2001 – 2011

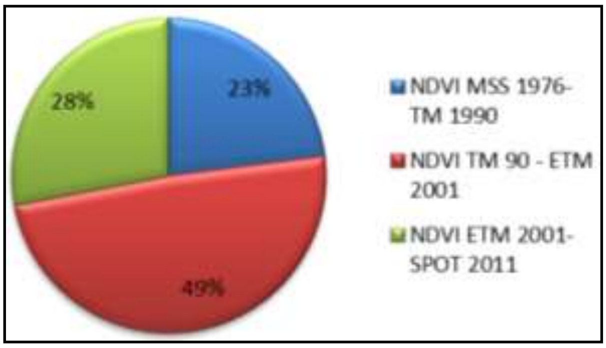

Fig.14: Comparison between the change in vegetation cover for the addressed period (1976 – 1990), (1990 – 2001) and (2001 – 2011)

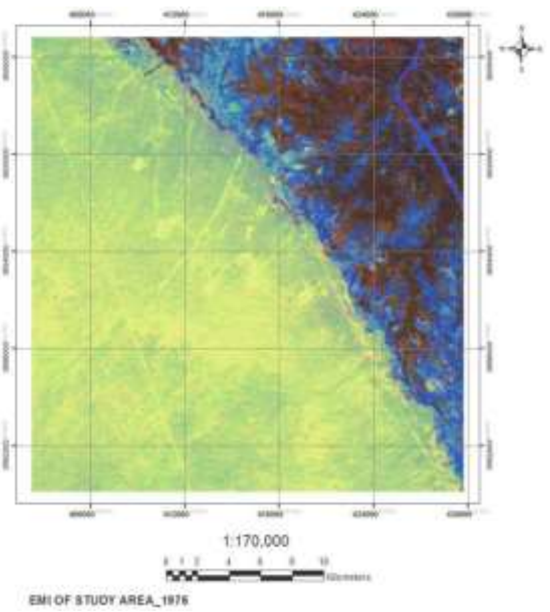

Fig.15: EMI image of 1976

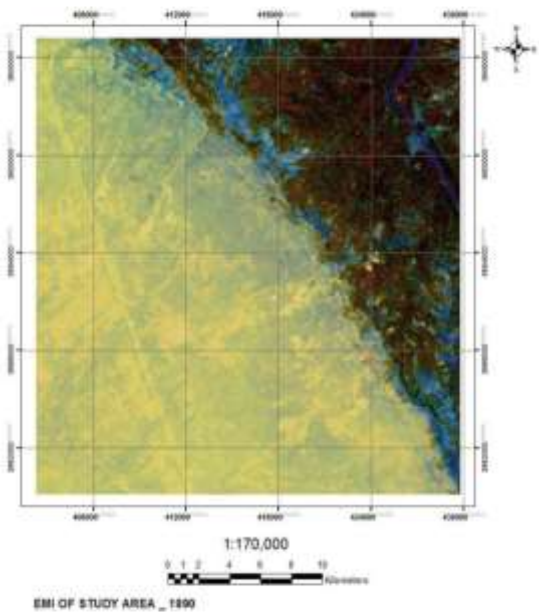

Fig16: EMI image of 1990

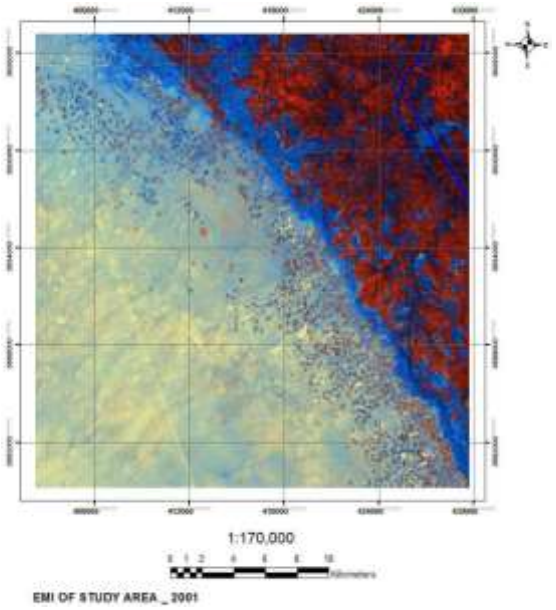

Fig.17: EMI image of 2001

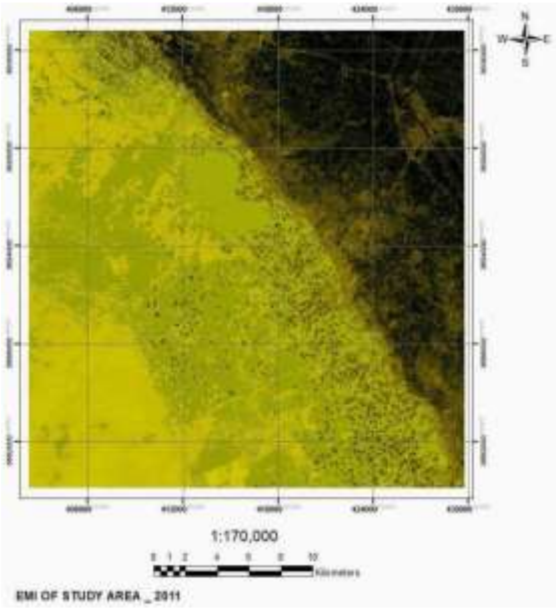

Fig.18: EMI image of 2011

- **NDWI Change Detection**

Normalized Water index was calculated from data of the related Landsat bands of MSS, TM, ETM+ and spot within the periods 1976, 1990, 2001 and 2011 respectively (Figs.19, 20, 21 and 22).

The water bodies in these figures represent two factors; the water bodies and the waterlogged areas in the study area are displayed in white color. Visual analysis for the figures above reveals that the water bodies increased during period 1976 to 1990, 1990 – 2001 and decreased during 2001 – 2011. Vegetation index analysis of Landsat ETM 2001 shows that vegetation cover was increased because of increasing of water bodies and the number of wells in the region and especially in the western part of the study area. This led to increase the vegetation cover for this year. And vice versa in Vegetation index analysis of MSS 1976, TM 1990, and spot 2011 because of Lack of surface water resources and groundwater as a result of random drilling of wells. The west part of study area depends on the wells as resource to irrigate its vegetation.

The second factor in the Normalized Deference Water Index (NDWI) is the waterlogged area. The visual interpretation of NDWI images it is noted that the waterlogged area problem appears in the area in the year 2001 and it increased in 2011.

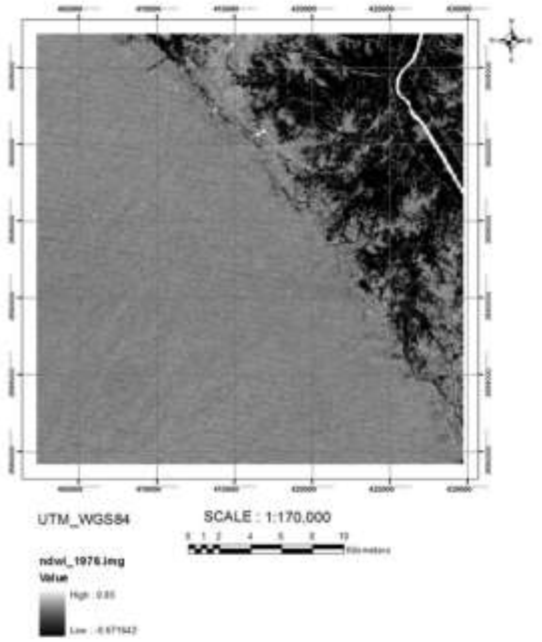

Fig.19: NDWI image 1976

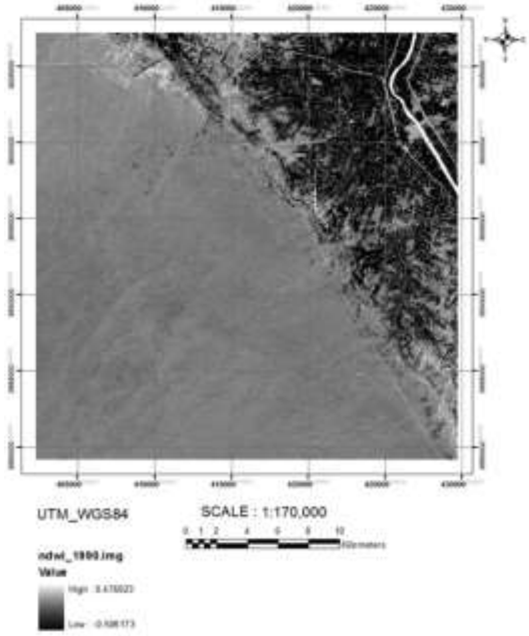

Fig.20: NDWI image 1990

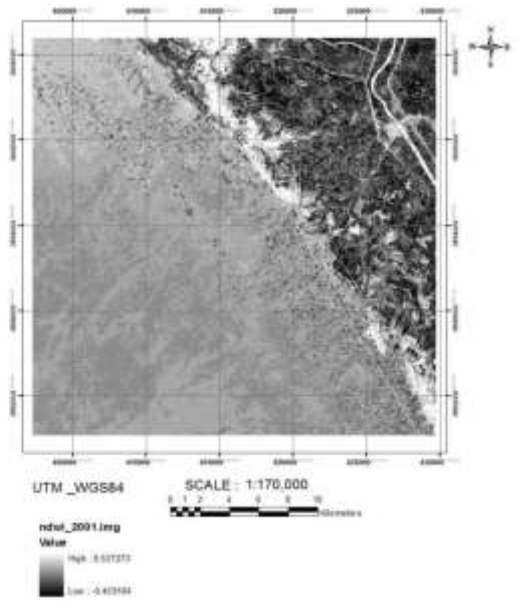

Fig.21: NDWI image 2001

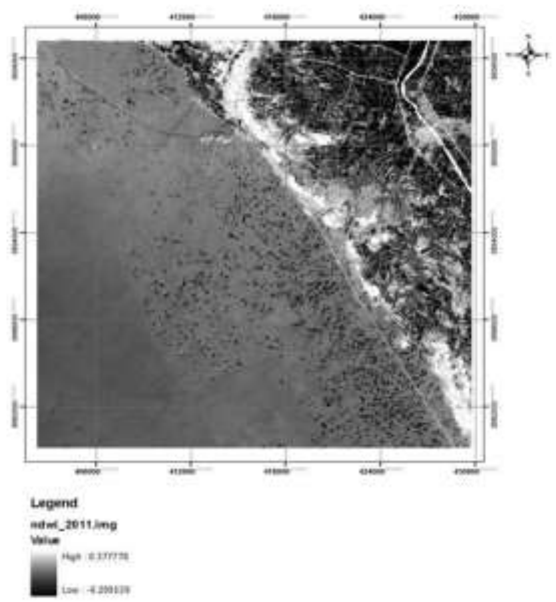

Fig.22: NDWI image 2011

▪ Time Series Analysis for the Land Cover Map

From statistical results of land cover maps, the change rates related to desertification in the study area can be obtained as shown in Tables (1). The statistical analysis of the classified images shows significant increase of agricultural land from 1976 to 1990 and from 1990 to 2001 and decrease from 2001 to 2011. The change rate of agricultural land for the period from 1976 to 1990 is 1.86 Km^2 $year^{-1}$; from 1990 to 2001 is 3.67 Km^2 $year^{-1}$; and from 2001 to 2011 is – 2.92 Km^2 $year^{-1}$. This refers to better growing condition during 2001.

Table 1: Change rates of landcover during period 1976 to 2011

Classes	1976 – 1990	1990 – 2001	2001 – 2011
	Change rate Km^2 $year^{-1}$	Change rate Km^2 $year^{-1}$	Change rate Km^2 $year^{-1}$
Agricultural land	1.86	3.67	– 2.92
Water	0.03	0.08	– 0.16
Sand dunes	– 3.19	– 7.37	8.78
Urban area	0.03	0.09	0.38
Water logged area		1.88	0.65

The comparison of the four land cover maps of the study area shows that the vulnerability to wind erosion is increased in sand dunes and sand sheet soils. The results obtained by classification analysis are compatible with EMI results. This relatively supports the finding of increasing degradation processes, and thus sand encroachment in the study area during the addressed periods. Sand encroachment from west to east was evidently observed during a field survey in 2011.

The statistical analysis of the classified images indicates that sand area decreased from 1976 to 1990, from 1990 to 2001, and then increased from 2001 to 2011. This is mainly attributed to the fact that sand encroachment increases following the wind direction. The change rate of sand dunes during the period 1976 to 1990 is – 3.19 Km^2 $year^{-1}$, 1990 to 2001 is – 7.37 Km^2 $year^{-1}$, and 2001 to 2011 is 8.78 Km^2 $year^{-1}$. These results indicate that sand encroachment rate was rapidly increasing during the last years.

The comparison between the change in vegetation or agricultural land and sand dunes in the study area shows very high increase in sand soil and decrease in vegetation cover during the addressed periods. This indicates that the area had been subjected to desertification processes with special regard to wind erosion and denudation of vegetation cover as desertification indicators.

Undoubtedly, sandstorms over the west part pollute the environment and affect human health and agricultural production, as sand-storms disrupt the physiological functions of plants, especially during pollination and florescence. Sandstorms blow from the sand dune fields of the western area, their incidence have increased during the last years.

Another forcing factor for desertification in the study area is the waterlogged area; the classification of land cover explains that the waterlogged area appeared in 2001 and increased in2011.Where it increased from about (20.69) Km^2 in year 2001 to become about (27.28) Km^2 in year 2011 with change rate about 0.65 Km^2 $year^{-1}$.

As a consequence of the consumptive use of irrigation water and the lack of drainage systems, coupled with high ground water rates and rise of water levels for drainage system that passes through the region; this led to the appearance of waterlogged areas in the region.

Water logging is considered as indicator of desertification, where it reduces the fertility of the soil and its ability for production may be led to infertility and transform it from a productive land into fallow land.

Another factor affecting desertification in the study area is the water resources. The statistical analysis of the classified images indicates that water area increased from 1976 to 1990, from 1990 to 2001, and then decreased from 2001 to 2011. The change rate of water during the period 1976 to 1990 is 0.03 Km^2 $year^{-1}$, 1990 to 2001 is 0.08 Km^2 $year^{-1}$ and 2001 to 2011 is – 0.16 Km^2 $year^{-1}$.

In recent years, the proportion of rain during the rainfall season (from November to March) was about 30% and decreased levels of the main river water by more than 50% and the estimated farmland sharply damaged due to the drought was 44%.

Also this area suffers from the rapid growth of population and this led to expansion of urban area towards agricultural land. When, haphazard urban sprawled on agricultural land to increase the growth of population and the fragment the orchards to be sold as civilian lands. And this problem led to decrease the areas of agricultural land. The results which extracted from Land cover maps refer to increase the urban area through the period from year 1976 to 2011. The change rate of urban area during the period 1976 to 1990 is 0.03 Km^2 $year^{-1}$, 1990 to 2001 is 0.09 Km^2 $year^{-1}$ and 2001 to 2011 is 0.38 Km^2 $year^{-1}$.

Another cause of desertification in the study area is the incorrect management for the land, natural resources and water, this led to increase the proportion of decertified land. Summed up it can be said:

1- Overgrazing in certain pastoral areas led to the deterioration of vegetation cover and desertified of large areas such as the forests of old green belt on the road to Karbala – Najaf, and in northwest of the study area.
2- Uprooting trees and shrubs in agricultural areas led to accelerate the desertification process and this has occurred in the Al-Jadwal Algarbi in study Area and the surrounding agricultural areas.
3- Ignorance among farmers of modern irrigation technique and have to control diseases of plants and cultivation of improved varieties.
4- There is a set of natural factors relating to the nature of the climate, ecosystems and the geology and in weather conditions they lead to:
   1. Lack of rainfall in the recent successive years.
   2. High temperatures in the summer, accompanied by an increase in the rate of evaporation.

These factors apply together on the lands of study area, where poor of annual rainfall causes lack of moisture in soil, which is considered as one of the most important reasons to speed up desertification.

It is concluded that the relationships between man, vegetation, soil, animal, and climate, are the determinant factors for the dynamics of desertification.

CONCLUSIONS

As result of this study, the following conclusions are obtained:

- Application of multi-temporal Landsat (MSS, TM , ETM+), and SPOT remote sensing data offer an effective opportunity for mapping desertification processes in the study area as well as in arid and semi-arid lands at relatively low cost.

- The topographic nature and physiographic position, in addition to the climatic variation have made the area vulnerable to the serious problems of environmental degradation and severity of desertification.
- The relationships between human, vegetation, soil, and climate are determinant factors for dynamics of desertification in the study area.
- The indicators of desertification considered in this study are as follows: Vegetation cover degradation, wind erosion, urban expansion and water erosion.
- The NDVI, EMI, NDWI have proved effective techniques in mapping the land cover changes in the study area where, EMI is a useful index to generate an easy and practical method for analyzing and mapping the vulnerability of soil to wind erosion. NDWI is also a useful index to generate an easy and practical method for analyzing and mapping the water bodies and the vulnerability of soil to water erosion.
- Supervised classification used for land cover, identifies six main land cover classified map, and used it to determin the change in land cover in the study area.
- Based on the visual interpretation of the change map for the period 1976, 1990, 2001 and 2011, statistical analysis, in addition to information obtained during field observations, ancillary data and relevant literature, it's clear that a significant land cover changes has taken place during the addressed periods: positive changes from 1976 to 2001 and the negative changes from 2001 to 2011.
- The study area suffers from severe desertification because it has suffered from erosion by wind and sand dunes, erosion by water, vegetation cover degradation, urban expansion, and lack of water resources especially in it is western part.

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