Detecting the Changes of AL-Hawizeh Marshland and Surrounding Areas Using GIS and Remote Sensing Techniques

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ABSTRACT

The marshes of Iraq, which lie in southern part, play an important role in the economic and natural equilibrium. In the last decades, the Iraqi marshes suffered from several changes especially the land cover changes, which effect on environmental and ecosystem of marshes.
In this research, AL-Hawizeh marsh was selected as a study area due to being a one of the largest and most important Iraqi Marshlands to deduce the occurred changes in last decades. This study aims to detect the changes of land cover using vegetation index (NDVI), water index (NDWI), and sand dune index (NDSDI), these are implemented for a study area represented by AL-Hawizeh marsh and surrounding areas for the four years of the period of 1990-2015 depending on GIS technique and multi-temporal satellite data.
During the last decade remotely sensed data have been widely used to monitoring Marshland. Satellite remote sensed data can also provide information on surrounding land cover and their change over the time. Four Landsat images were used for 1990 (Landsat TM), 2000 (Landsat ETM+), and 2013 in addition to 2015 (Landsat LDCM).
The findings of this study showed significant change in land cover, for example, the surface area of vegetation decreased about 43% during this selected period.

1. INTRODUCTION

Iraqi marshlands were known as the biggest wetlands in the Middle East and characterized by different environment such as lakes, rivers and vegetation covers in addition to its animal wealth like various types of fish and bird. Moreover, these marshlands were considered the main factor affecting on economic, social, and commercial production of the country, [1]. Geographic information systems (GIS) and remote sensing data are applicable tools for distribution monitoring of wetland area and spatial-temporal dynamic multiplicity, [7]. Remotely sensed data have been used to observe the terrestrial land-cover changes especially the quantitative and qualitative changes, [15]. In recent decades, significant changes occurred for the marshes, this necessitated many researchers to conduct studies regarding to monitoring and detecting these changes using (GIS) and high resolution images, where monitoring technique of natural phenomena became easier, more flexible and faster than it was in the past.

Recently, integration GIS and remote sensing data is widely used to examine the changes of land cover in term of pattern, size, and nature of land variations in different times. Where, detection of changes is helpful in various applications such as evaluation of deforestation, observation shifting cultivation, land use rating, examination of vegetation cover changes, detection of crop stress , assessment of damage, catastrophe monitoring, daily analysis of thermal properties in addition to other changes of environmental, [6,12]. Additionally, these changes may be employed for tracking economic and urban growth.

2. STUDY AREA

AL-Hawizeh marsh are considered the largest among the southern marshes of Iraq and locates to the straddling the border between Iran and Iraq. Where, the largest part of it are located on the Iraqi side of the Tigris River, east of the Amarah and north of the Basrah province (approximately 75-80%), and the remainder part of it in the Iranian side across international borders, which named Al-Azim marsh (fig.1). The dimensions of the Hawizeh marsh are approximately 80 km in North-South direction and 30 km in East-west direction covering an overall area with geographic coordinate's 31°00′ - 31°45′ to the North and 47°25'-47°50′ to the East. This overall area decreased to about 600 Km^2 in dry years where less rain, [3]. Moreover, There are villages and agricultural lands, which lie on the western edge of Hawizeh, these include many roads, dikes and water barriers such as Al-Musharah, Al-Kahla'a, and Al-Sheeb to the North-West, and Al-Khana (Dasim) and Al-Uzayr in the South-West extremity. It is worth to mentioning that Hawizeh marsh represents the first site of Ramsar in Iraq based on the Convention for Protecting Internationally Important Wetlands, which named as the Ramsar Convention, on 17/02/2008 (Ramsar, 2011), [5].

Fig. 1. 2D map of AL-Hawizeh case study (Google Maps ©).

3. MATERIALS AND METHODOLOGY

A. Utilization of remotely sensed data

Images of Multispectral Landsat were gathered for the period 1990 to 2015. Metadata of AL-Hawizeh marsh were obtained from each of Landsat 5 named Thematic Mapper (TM) in 1990, Landsat 7 known as Enhanced Thematic Mapper Plus (ETM+) for the year of 2000, and Landsat 8 which called Landsat Data Continuity Mission (LDCM) for the years 2013 and 2015. Thus, the main interest of this study is to detect the changes and monitoring of the marshlands by constructing the thematic layers, while the difference of spatial resolution between the variety Landsat used in this research was not take into consideration in this case.

B. Image visualization and processing using GIS tools

1. Image view and preprocessing

The images regarding the study area were imported to GIS software and visualized based on false color composite. Consequently, Landsat images were corrected based on georeference procedure using four control points, which Obtained from previous surveys in the ministry of water resources, distributed in the study region.

2. Normalized Difference Vegetation Index

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator of plants (greenness). NDVI index is adopted to analyze remote sensing data and evaluate whether the observed target contains green vegetation or not using the visible and near-infrared bands of the light spectrum, [10,11]. Where, the variety targets of land are different in absorbing and reflecting the visible and infrared bands of the electromagnetic spectrum, this give more flexible to detect them. NDVI is widely used for several applications such as vegetative studies, estimation of crop yields, and pasture performance in addition to rangeland carrying capacities among others. In this study, GIS spatial analyze tool and raster calculator were used to compute the NDVI index as separated shapefile depending on the near-infrared and the red bands for AL-Hawizeh image using the following NDVI equation, [4,14]:

$$NDVI = \frac{NIR-RED}{NIR+RED} \quad (1)$$

where NIR refers to the near infrared band value and RED stands to the red band value.

3. Normalized Difference Water Index

In this study, the normalized difference water index (NDWI) was applied to detect the change of water situation in the region of study. The NDWI index is derived based on similar principles to NDVI index by reversing the equation of NDVI and using the green band instead of the red as in Eq,2, which utilized to suppress the vegetation and enhance the features of the open water, [9,13]:

$$NDVI = \frac{GREEN-NIR}{GREEN+NIR} \quad (2)$$

4. Sand Dune Index

In addition to vegetation and water index, The sand dune index (NDSDI) was taken into consideration in this study to detect and identify the accumulations sites of the sand dune regarding the study area. Additionally, the main purpose of this index is the differentiating between sand dune accumulations, and the other types of soils such as bare soil. The NDSI index depends on the difference values between the RED and the SWIR spectral bands as the following equation, [8]:

$$NDSDI = \frac{RED-SWIR}{RED+SWIR} \quad (3)$$

where SWIR refers to the short wavelength infrared band value

5. Images reclassification procedure Generally, classification of image may be applied for several classes using GIS tools such as water, farm land, body, rangelands, sand surface, sand dune and others, [2]. Regarding this study, classification procedure was applied depending on the values of the index computation in previous steps (NDVI, NDWI and SI). Thus, only three classes (vegetation water and soil) were assessed after extracting them in separated shape files. Additionally, the main summary of the workflow for the monitoring changes of AL-Hawizeh marsh that implemented in this study can be seen in Fig.2.

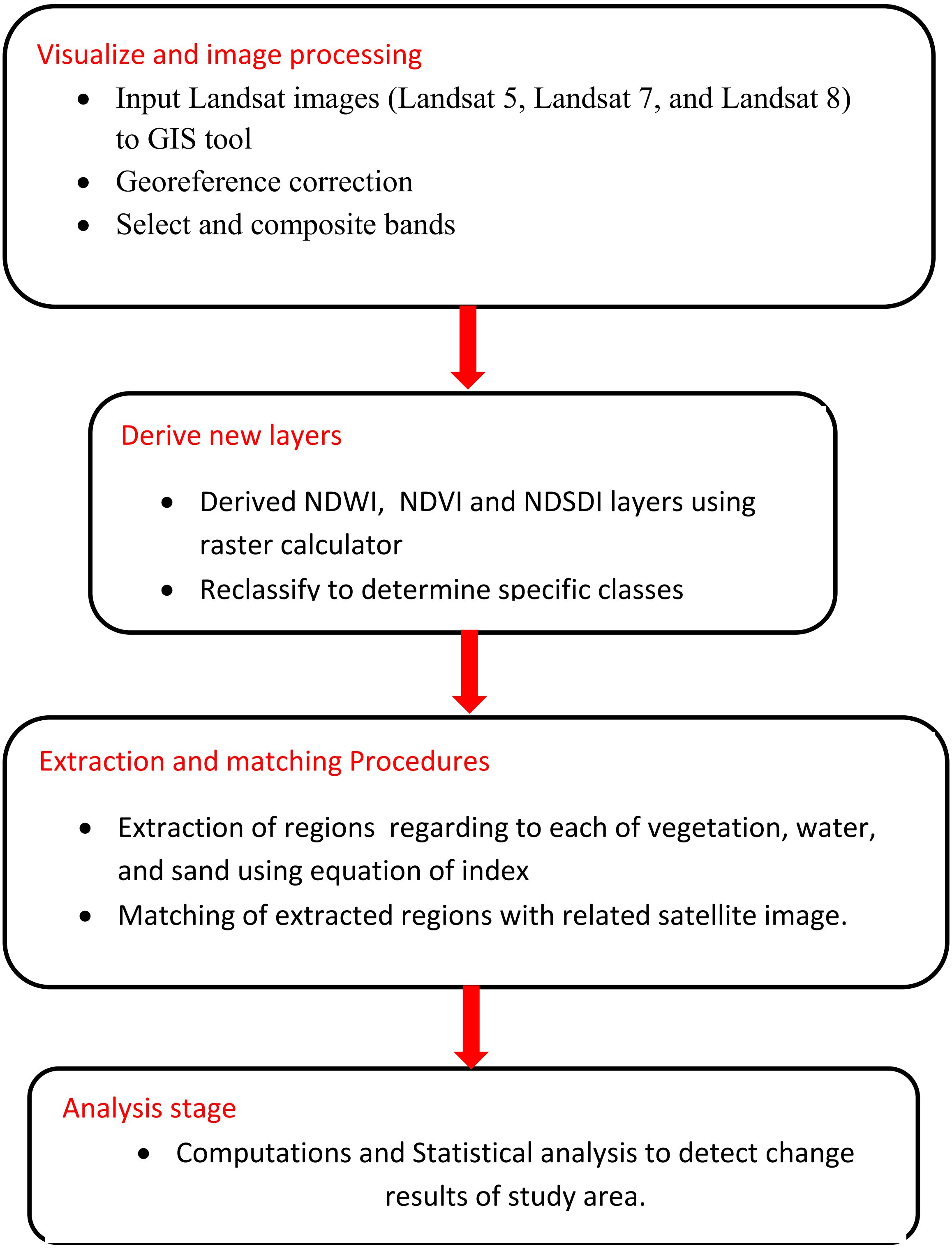

Fig. 2. The workflow diagram for the monitoring changes of the study region

4. Results and Discussions

Regarding this study, the surface area of Hawizeh marsh was computed using the polygon tool to select the study region for the period which was determined in this study (1990-2015).

The variation of the computed area was listed in Table 1 and summarized in Fig3.

Table 1. The surface area of Hawizeh marsh for all the study years.

Image date	Hawizeh marsh (Km2)
March 1990	1794
March 2000	1018
April 2013	1180
March 2015	1157

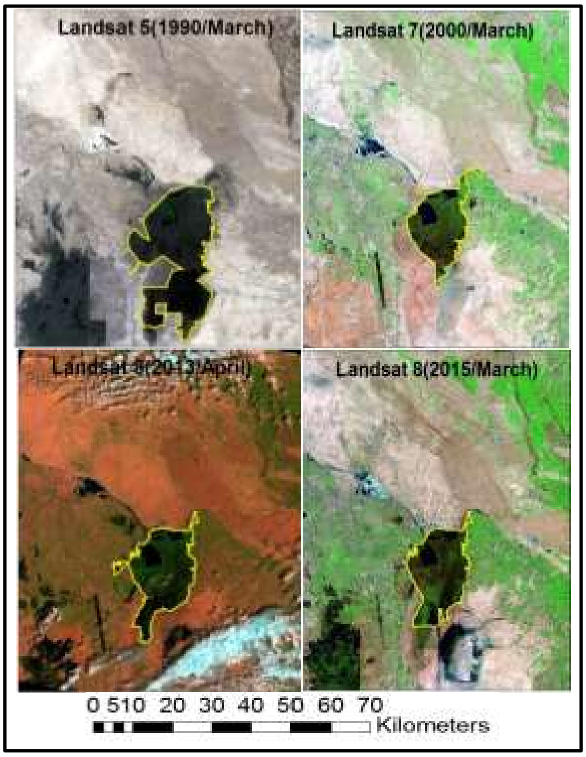

Fig. 3. Explain the changes of the surface area for the selected period

Additionally, the surface area for both of Hawizeh marsh and surrounding areas were reclassified and analyzed based on the following:

A. Results of vegetation area changes

The vegetation area was isolated using the vegetation Index (NDVI) of the satellite image (Eq.1) and separated it in individual layer. This study showed significantly reduced in vegetation area of Al-Hawizeh marsh for the periods 2000, 2013 and 2015 (after the year of 1990) by about 50 %. Where, the changes of whole area are illustrated in Table 2 and Fig.4. Moreover, the ancillary details to separate and compute the vegetation area for a certain year (2015 for example) are explained in Fig. 5.

Table 2. The surface area of vegetation for all the study years.

Image date	Surface area of vegetation (km2)	
	Hawizeh marsh	Surrounding areas
March 1990	959.353	3327.873
March 2000	333.421	4167.186
April 2013	711.567	12716.261
March 2015	346.477	13150.568

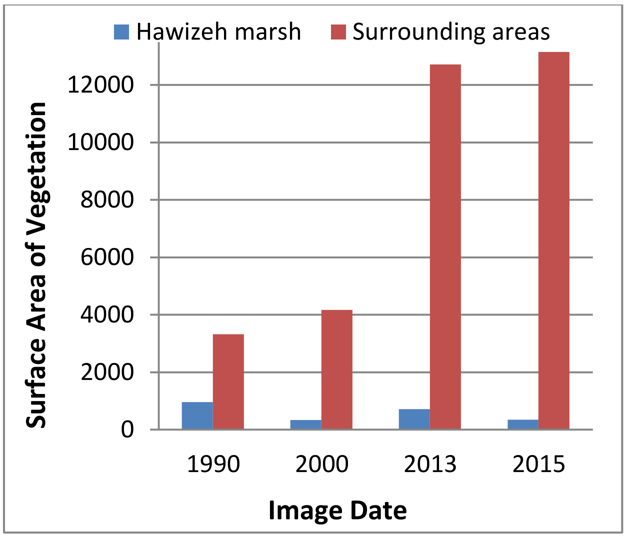

Fig. 4. Explanatory chart of the vegetation area change in different time

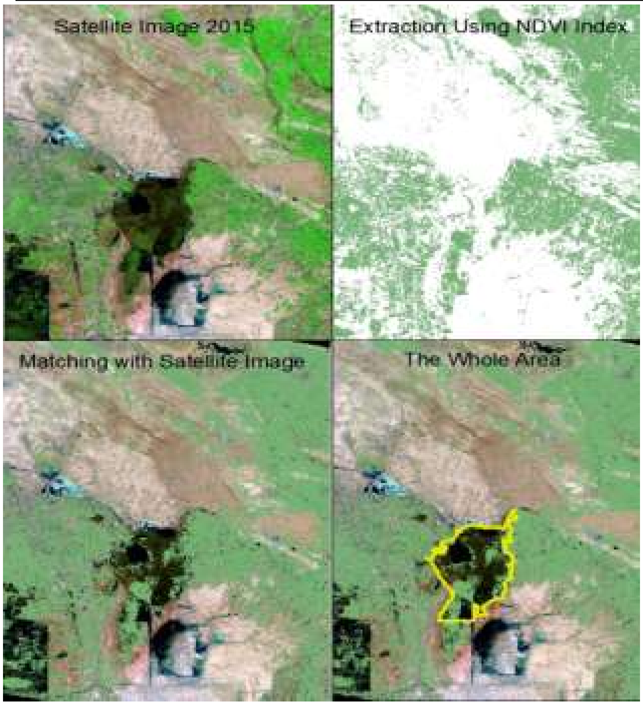

Fig. 5. The main steps to separate and compute the vegetation area (satellite image of 2015)

B. Results of water area changes

The surface area of water using NDWI index was separated in specific layer in addition to vegetation layer then computed it for all the period, which determined in this research. The finding of this study showed significant decreasing in the water area of the Hawizeh marsh after the year of 1990 by about 41%. Additionally, the changes of surrounding area are summarized in Table 3 and Fig.6.

Table 3. The surface area of water for all the study years.

Image date	Surface area (km2) Hawizeh marsh	Surface area (km2) Surrounding areas
March 1990	715.537	756.055
March 2000	563.035	2468.345
April 2013	349.601	696.360
March 2015	415.055	1187.516

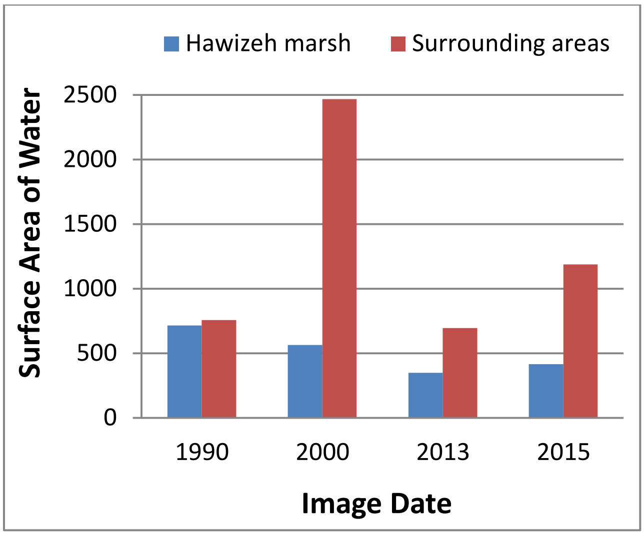

Fig. 6. Explanatory chart of the water area change in different time

The methodology steps to compute the NDWI index and separate the water area are explained in Fig.7 regarding the satellite image of 2015 for an example. This methodology steps are the same for all the determined years in this study.

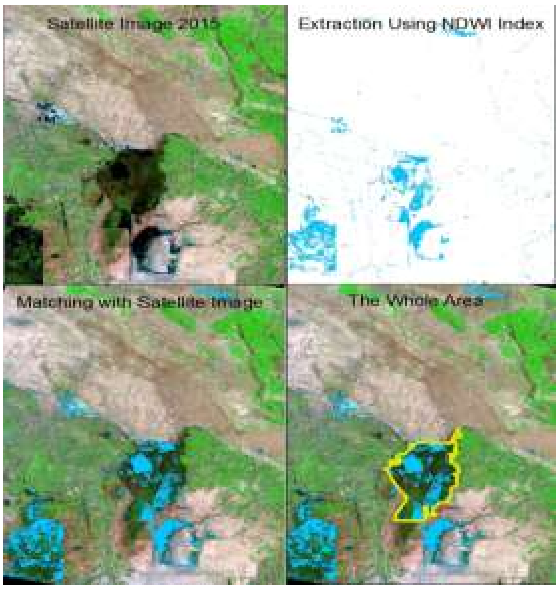

Fig. 7. The main steps to separate and compute the water area (satellite image of 2015)

C. Results of sandy area changes

The sand dune index (NDSDI) is applied in this study for detect and identify the accumulations sites of the sand dune regarding the study area. The changes of sand area related to the Hawizeh marsh and surrounding areas are listed in Table 4. In this study, it can be noted the huge increase of the sand area for the selected period 1990-2015 as shown in Fig.8.

Table 4. The surface area of sand for all the study years.

Image date	Surface area (km2)	
	Hawizeh marsh	Surrounding areas
March 1990	2.512	10916.176
March 2000	28.496	14856.954
April 2013	66.833	19364.038
March 2015	408.192	32242.253

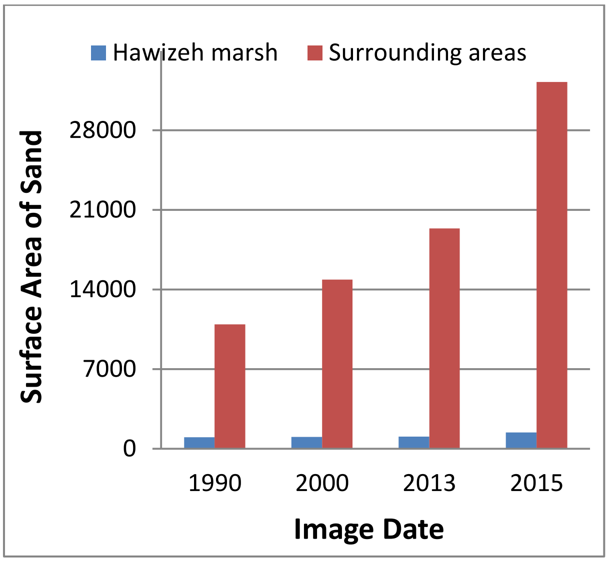

Fig. 8. Explanatory chart of the sand area change in different time

As in previous cases relating to this study, it can be summarized and shown the main steps to compute and separate the sand area, which regarding to the satellite image of the certain year (2015 for example), in Fig.9.

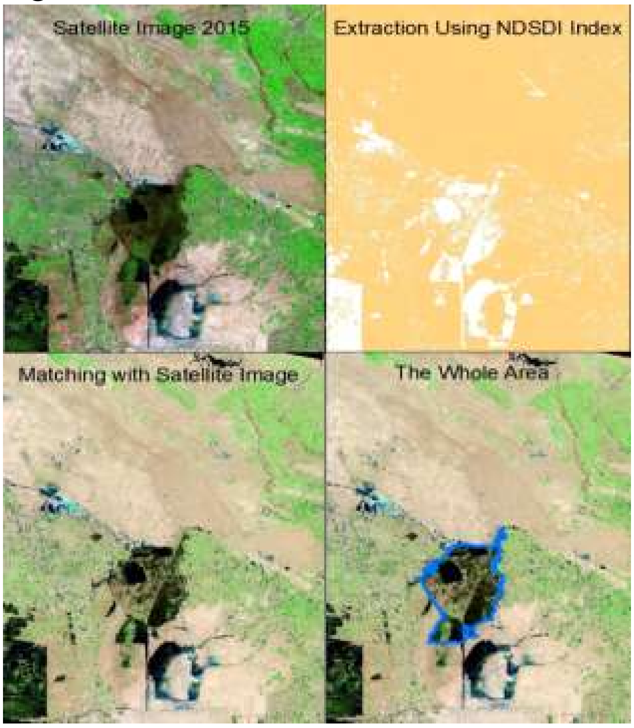

Fig. 9. The main steps to separate and compute the sand area (satellite image of 2015)

Conclusion

- This study reviews the mechanism of change detection regarding the selected land area in addition to present related results.
- The surface area of vegetation reduced by about 50 %, the water area of the Hawizeh marsh decreased after the year of 1990 by about 41% and there is a huge increase in the sand area.
- The results shown a significant decrease in both of vegetation and water area of AL-Hawizeh marsh after the year of 1990. On the contrary, the sand area increased

dramatically. Thus, gave a clear indication of the seriousness of changes in the area of Iraqi marshlands.

- The integration between remote sensing and GIS are important technologies for temporal analysis which is not possible to attempt through conventional mapping techniques. Change detection is made possible by these technologies in less time, at low cost and with better accuracy.

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الكشف عن التغييرات الحاصلة في هور الحويزة والمناطق المحيطة بها بأستخدام تقنيات نظم المعلومات الجغرافية و التحسس النائي

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الخلاصة

تسهم الاهوار العراقية المتمركزة في جنوبي البلاد في تحقيق التوازن الاقتصادي والطبيعي للمنطقة. وقد تعرضت هده الأهوار خلال العقود الماضية الى العديد من التغييرات خصوصا تغيرات الغطاء النباتي، والتي تؤثر على البيئة بشكل عام والنظام البيئي للاهوار بشكل خاص. تم اختيار هور الحويزه كمنطقة دراسة للاستدلال على التغييرات التي حدثت في العقود الأخيرة نظرا لكونه واحد من أكبر وأهم الأهوار العراقية. وتهدف هذه الدراسة إلى الكشف عن التغييرات في الغطاء الأرضي باستخدام مؤشر الغطاء النباتي(NDVI) ، ومؤشر الماء (NDWI)، ومؤشر الكثبان الرملية(NDSDI) .

حيث اعتمدت هده المؤشرات المدكورة انفا" لدراسة تغيرات الغطاء الارضي المتعلقة بمنطقة الدراسة (هور الحويزة) والمناطق المحيطة بها للفترة 1990-2015 اعتمادا على تقنية نظم المعلومات الجغرافية وبيانات الأقمار الصناعية المتعددة الازمنة.

خلال العقود الماضية تم استخدام بيانات الاستشعار عن بعد على نطاق واسع لمراقبة الأهوار. حيث يمكن توفير معلومات عن التغيرات الحاصلة في الغطاء الارضي للمنطقة والمناطق المحيطة بها على مر الزمن. في هذه الدراسة، تم استخدام أربع صور لاندسات المأخودة في كل من سنة 1990 (لاندسات TM) وسنة 2000 (لاندسات+ ETM) وسنة 2013 بالإضافة إلى سنة 2015 (لاندساتLDCM).

أشارت نتائج هذه الدراسة إلى تغيير كبير في الغطاء الأرضي، ، حيث بلغت نسبة التغيير في مساحة الغطاء النباتي (على سبيل المثال) الى مايقارب ال 43٪ خلال هذه الفترة المختارة.

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