MONITORING DESERTIFICATION IN SOME REGIONS OF IRAQ USING GIS TECHNIQUES

Y. K. Al-Timimi
Assist. Prof.
Dept. of Atmospheric Sci. Coll. of Sci. Mustansiriyah University
yaseen.altimimi.atmsc@uomustansiriyah.edu.iq

ABSTRACT

Desertification is one of the phenomena that threatening the environmental, economic, and social systems. This study aims to evaluate and monitor desertification in the central parts of Iraq between the Tigris and Euphrates rivers through the use of remote sensing techniques and geographic information systems. The Normalized difference vegetation index NDVI and the crust index CI were used, which were applied to two of the Landsat ETM + and OLI satellite imagery during the years 1990 and 2019. The research results showed that the total area of the vegetation cover was 2620 km^2 in 1990, while there was a marked decrease in the area Vegetation cover 764 km^2 in 2019, accounting for 34.8% (medium desertification) and 10.2% (high desertification), respectively. Also, the results showed that sand dunes occupied an area of 767 km^2 in 1990, while the area of sand dunes increased to 1723 km^2 in 2019, with a rate of 10.2% (medium desertification) and 22.9% (severe desertification), respectively. It was noted that the overall rate of decrease in vegetation cover was 21.33 km^{2}year^{-1} while the overall rate of increase in ground erosion in the area is 10.99 km^{2}year^{-1}.

Keyword: desertification, monitoring, landsat, remote sensing, GIS

مراقبة التصحر في بعض مناطق العراق باستخدام تقنيات نظم المعلومات الجغرافية

ياسين كاظم التميمي
استاذ مساعد
قسم علوم الجو – كلية العلوم – الجامعة المستنصرية

المستخلص

تعد ظاهرة التصحر من الظواهر التي تهدد النظام البيئي والاقتصادي والاجتماعي, تهدف هذه الدراسة الى تقييم ومراقبة التصحر في الاجزاء الوسطى من العراق والواقعة بين نهري دجلة والفرات من خلال استخدام تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية. تم استخدام مؤشر الغطاء النباتي NDVI ومؤشر القشرة CI والتي طبقت لاثنين من صور القمر الصناعي لاندسات +ETM و OLI خلال السنوات 1990 و 2019. اظهرت نتائج البحث ان المساحة الكلية للغطاء النباتي كانت 2620 كيلو متر مربع في عام 1990, بينما كان هناك نقصان ملحوظ في مساحة الغطاء النباتي 764 كيلو متر في عام 2019 بما نسبته 34.8 %(تصحر متوسط) و10.2% (تصحر عالي) من المساحة الكلية لمنطقة الدراسة, على التوالي.ايضاً اظهرت النتائج ان الكثبان الرملية شغلت مساحة 767 كيلو متر مربع في عام 1990 , بينما ازدادت مساحة الكثبان الرملية الى 1723 كيلو متر مربع في عام 2019 بما نسبته 34. 10.2% (تصحر متوسط) و 22.9% (تصحر شديد) من المساحة الكلية لمنطقة الدراسة, على التوالي. لوحظ ان المعدل العام لنقصان الغطاء النباتي هو 21.33 كيلومتر مربع/ سنة، بينما المعدل العام لزيادة الانجراف الارضي قي المنطقة هو 10.99 كيلو متر مربع/سنة.

الكلمات المفتاحية: التصحر، المراقبة، لاندسات، التحسس النائي، نظم المعلومات الجغرافية.

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INTRODUCTION

The international community has become aware of the desertification problem and has taken action towards it. In 1977, during the United Nations Conference on Desertification (UNCOD) in Nairobi, Kenya, the desertification problem was discussed as an issue worldwide for the first time, and an Action Plan to Combat Desertification (PACD) was prepared. In 1992, at the United Nations Conference on Environment and Development (UNCOD) held in Rio de Janeiro, Brazil, both the Earth Summit and Agenda 21 called on the United Nations General Assembly to form a committee of member governments to prepare an integrated legal mechanism to address the problem of desertification. Desertification means land degradation in arid and semi-arid regions and in dry and sub-humid areas that results from various factors, including climate changes and human activities (3),(16),(18). This does not mean closing the debate to develop the definition, as it is proposed at the level of the United Nations and the competent authorities, and this is due to the fact that the study of desertification is relatively new as the first scientific text bearing this designation appeared about 50 years ago. The first map of desertification was completed by the subsidiary bodies of the United Nations was In 1977, this coincided with the convening of the United Nations Desertification Conference in Nairobi, Kenya (13),(17). In fact, desertification is the process of destroying or destroying the vital energy of the earth, which can eventually lead to conditions similar to desert conditions, which is a manifestation of the widespread deterioration of the ecosystems that leads to the shrinking of the vital energy of the earth represented in plant and animal production and from there the effect in sustaining human existence. There are many stages in the desertification process, but whatever their form, the final stage will be complete desert with vital productivity reaching zero.Iraq lies in the arid and semi-arid region is exposed to desertification problems, especially in the middle and southern parts of Iraq, which are estimated to be about one million hectares (8),(19). Desertification phenomenon is considered one of the dangerous international environmental phenomena, becouse 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. The causes of desertification in the Iraq have been identified as meteorological, pedological, geological and agricultural problems. Losses in soil fertility , movement of the desert environment, population migration, and great losses in human and material resources are the main outcome(21). Many researchers have studied this phenomenon such as, Ayad and Wuhan studied the monitoring desertification in Shaanxi province, China. The results showed that the study area has severe desertification with desertification area accounting for 88.9% of the whole area in 1999 (6). Hadeel and others studied the sensitivity of desertification in Basrah city, the results revealed that the severe desertification were located in the western southern parts of the region (7). Pashaei and others studied the desertification Vulnerability Index in Iran, the results showed that about 22% or the study area was classified as medium vulnerability of desertification, while 60% were classified as highly vulnerable to desertification. (15). Abdul Razzak and othes used the remote sensing data in Karbala Governorate, the results reveal that the region of study has severe desertification because the area has suffered from erosion, urban growth, and poverty of water resources (20). Dulliami studied the Monitoring of desertification in the Baiji region, the results reached the prevalence of degrees of severe and very severe deterioration in sand dunes, while degrees of low and moderate deterioration were relatively less (5). The aim of this study is to evaluate and monitor desertification in the central parts of Iraq between the Tigris and Euphrates rivers through the use of remote sensing techniques and geographic information systems, using vegetation index and the CI crust index.

MATERIALS AND METHODS

Study area

Iraq is a large Mesopotamian alluvial plain, Consisting of the Tigris and the Euphrates rivers (11). The study area is lie between the Tigris and the Euphrates rivers, in Wasit and

Babel governorates, which includes the Al-Suwaira, Al-Mahawil , and Al-Musayab district. It is located in the sedimentary plain in Iraq. The study area was chosen because the region contains agricultural lands on both sides of the Two Rivers, which is one of the agricultural fertile lands in Iraq. see Figure1.

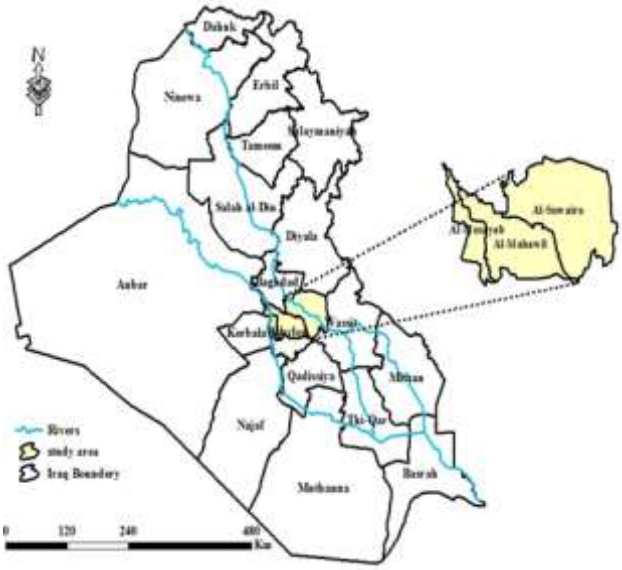

Figure 1. map of the study areas location

Iraq can be dividied into three climatic regions depending on the rainfall parameter : Arid and Semi-Arid Zone where annual rainfall above 400 mm, Steppes Zone where annual precipitation of 200-400 mm, and Desert Zone where annual rainfall less than 200 mm, the spatial distribution of annual mean rainfall in the study area ranges between 50-100 mm (9). The temperature reaches the highest value for the months of August and July and reached 36 C, and the lowest value in January and December and reached 9 ^{o}C , in the study area the mean temperature ranges between (20- 25) ^{o}C (11).The mean annual of wind speed was range from 3.5- 4.5 m/sec (1). The two images of Landsat which her Path was 168 and Row was 37 have been downloaded from the U.S. Geological Survey server. The first image was Landsat 5 thematic mapper acquired on April 1990, while the second image was Landsat 8 the operational land imager OLI required on April 2019 for a period of 29 years (1990-2019). The preprocessing of the images included geometric corrections. The two Landsat images were projection UTM zone N 38. All indices are derived from the Landsat satellite imagery downloaded from the USGS website (www.earthexplorer.com). The two images of Landsat which her Path was 168 and Row was 37 have been used in this study and downloaded from the U.S. Geological Survey server. The first image was Landsat 5 thematic mapper acquired on 24 April 1990, while the second image was Landsat 8 the operational land imager OLI required on 21 March 2019 for a period of 29 years (1990-2019). The preprocessing of the images included geometric corrections. The two Landsat images were projection UTM zone N 38. All indices are derived from the Landsat satellite imagery downloaded from the USGS website (www.earthexplorer.com). These indicators are:

The Normalized difference vegetation index (NDVI)

The Normalized difference vegetation index, known as NDVI, is one of the most widely used spectral indicators in the field of satellite image analysis, vegetation study, fire and desertification, and other natural phenomena . NDVI can be defiend as a ratio between the red (R) and near-infrared (NIR) values (14);

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}}$$

Crust Index (CI)

Crust Index, known as CI, is used to recognize the soil having sand deposition. Soil having sand deposition will appear dark as compared to the other soil types due the absence of organic matter in it. This index can be used on any satellite imagery having Blue (400-500 nm) and Red (500- 600 nm) band. The value of CI ranges from 0 to +2.This guide represents the difference between the third and first bundles on their sum subtracted from one. As it is the highest in the first package, and it is characterized by monitoring the thin layer that forms on the surface of the soil or sand dunes, and hence is considered one of the important indicators in expressing the movement and activity of sand dunes(10). The form of spectral crust index can be given by:

$$\mathrm{CI} = 1 - \left(\frac{\mathrm{RED} - \mathrm{BLUE}}{\mathrm{RED} + \mathrm{BLUE}}\right)$$

Crust index and NDVI algorithms were applied to images. The vegetation cover, drifting sand images were interpreted and statistically analyzed to produce desertification severity maps based on the vegetation cover and extent of drifting sand.

Table 1. Indices of factors used in assessment of land desertification (4).

Indicator	Severity Level				Weight
	Severe	High	Medium	Low	
Vegetation Cover	< 10	10 - 25	25 - 40	> 40	0.40
Drifiting Sand Cover	> 65	15 - 65	5 - 15	< 5	0.25

RESULTS AND DISCUSSION

Normalized Difference Vegetation Index (NDVI) and Crust Index (CI) were derived from Landsat images for the years 1990 and 2019. Figure 2 A and B, illustrate the map of vegetation cover derived from NDVI index over the study area between 1990 and 2019, while Table 2, reveals the related statistics which include, the amount of area for each region, the percentage of all regions. The NDVI results showed that in Al-Suwaira and Al-Mahawil district were the biggest decline by 30.57% and 27.74% in the vegetation cover area. covering 34.8% of the area, vegetation cover is designated as a medium degraded land in 1990, while it decreased to 10.2% in the year 2019 and designated as high degraded land. Desertification (vegetation degradation) was at a medium level in Al-Suwaira in1990, while it was at a high level in 2019. In Al-Mahawil, desertification was at a medium level in 1990, while it rose tohigh level in 2019. The high level has dominated Al-Musayab city during the study period.

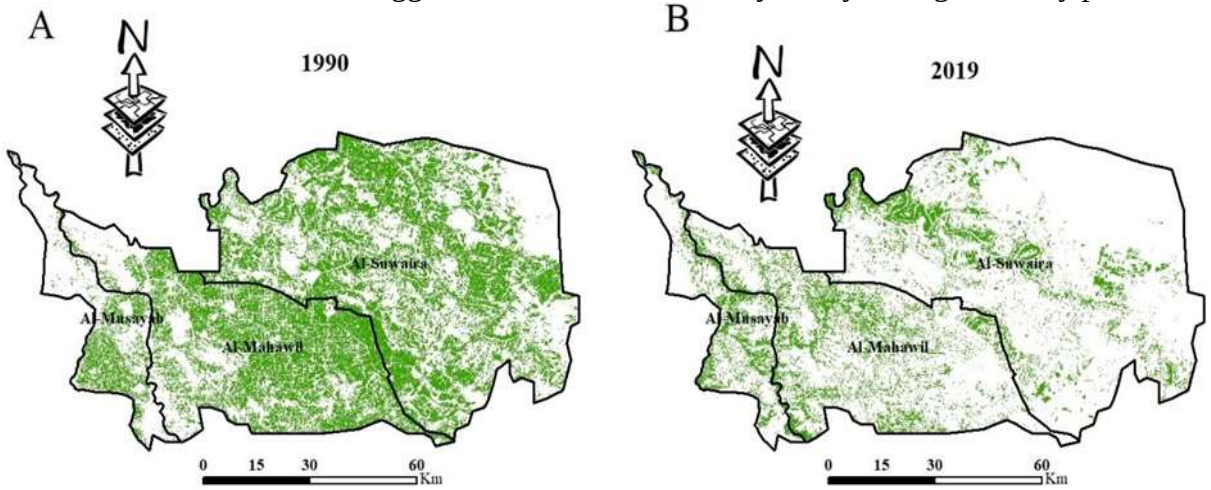

Figure 1. A Vegetation cover of the study area in 1990, B Vegetation cover of the study area in 2019

Table 2. Area and percentage of vegetation cover in three regions for years 1990 and 2019

Study site	Area of Region (km2)	Area of NDVI (km2)1990	Area of NDVI (%)1990	Area of NDVI (km^2)2019	Area of NDVI (%)2019
Al-Suwaira	4341	1524	35.11	341	7.86
Al-Mahawil	2388	950	39.79	288	12.05
Al-Musayab	794	145	18.29	135	17.03
Total	7523	2619	34.8	764	10.2

The results showed the maximum value of vegetation decrease rate in three regions was in Al-Suwaira 32 km^2 $year^{-1}$, while Al-Musayab city had the minimum value of rate 0.34 km^2 $year^{-1}$. The whole average of the vegetation cover decrease rate in the study area was 21.33 km^2 $year^{-1}$. The results showed that total vegetation cover in the entire study area was 2620 km2 34.8% in the year 1990, while it decreased to 764 km2 10.2% in the year 2019. There was a remarkable dwindling in the vegetative cover in the study area during the span of 29 years from 1990 to 2010.

Table 3. Amount and rate of vegetation cover for the years 1990 and 2019

Study site	Amount of change (km^2)	Rate of Change (km^2/year)
Al-Suwaira	1183.4	32
Al-Mahawil	662.5	22.84
Al-Musayab	10	0.34
Average	618.63	21.33

CI index was applied on the TM and OLI images to extract the sandy soil information for the study area. Figure 3. A and B and Table 4, show that the sand dunes and drifting sand have covered 10.2% of the area, are designated as a medium degraded land in the year of 1990, while the value of level has increased to 22.9% in 2019, and designated as high degraded land. The result showed that the drifting sand cover percentage in Al-Suwaira, Al-Mahawil and Al-Musayab 13.79%, 3.87% and 9.55% in 1990 to 32%, 8.29% and 17.03% in 2019 respectively.

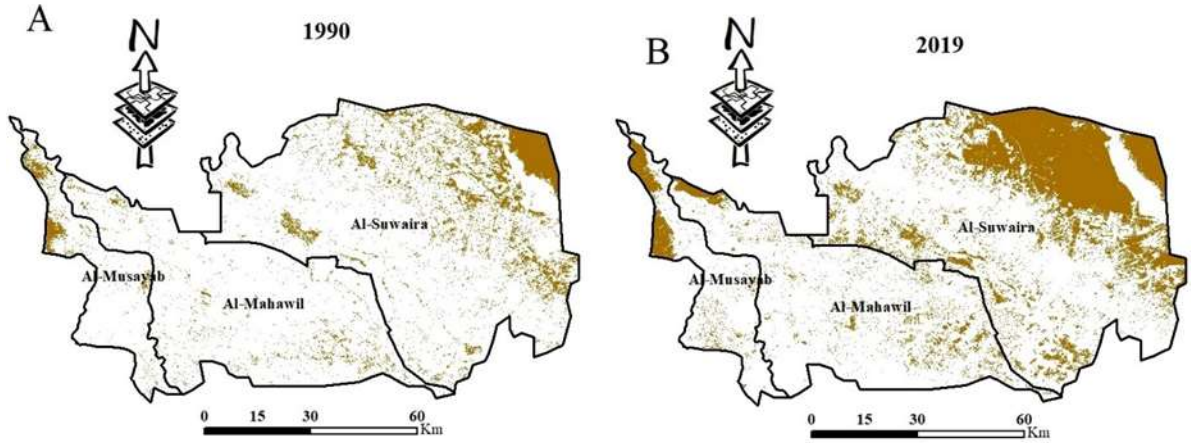

Figure 2. A Sand drifting of the study area in 1990, B Sand drifting of the study area in 2019

The sand drifting derived from CI index showed that Al-Suwaira has the biggest increase by 32%, while Al-Musayab has 17.03% in the sand drifting.Desertification (sand drifting degradation) was at a medium level in Al-Suwaira and Al-Musayab district in1990, while it was at a high level in 2019. In Al-Mahawil, desertification was at a low level in 1990, while it rose to medium level in 2019. Table 5. shows that the results the drifting sand areas in 2019 are larger than those in 1990, the highest and the lowest rate of change were 27.3km^2 year^{-1} and 2.05 km^2 year^{-1}in Al-Suwaira and Al-Musayab region, respectively. The overall average of the land drifting increase rate in the study area was 10.99 km^2 year $^{-1}$.

Table 4. Amount and rate of of sand drifting for the years 1990 and 2019

Study site	Amount of change (km^2)	Rate of Change (km^2/year)
Al-Suwaira	**790.4**	**27.3**
Al-Mahawil	**105.7**	**3.64**
Al-Musayab	**59.5**	**2.05**
Average	**318.53**	**10.99**

CONCLUSION

Using Remote sensing and GIS techniques are very necessary for managing the natural resources. In this study, the thematic Mapper (TM), and Operational Land Imager (OLI) images have been used for the detection of desertification changes. In this study, the trend of desertification was increasing during the period. The results of NDVI revealed that total vegetation cover was 2620 km2 in the year 1990, while it decreased to 764 km2 in the year 2019. The desertified areas accounting for 24 % of the total area, while the overall average of the vegetation cover decrease rate 21.33 km^2 year^{-1}. The drifting sand coverage had rather extended toward the cultivated lands areas. the drifting sand areas in 2019 are larger than those in 1990. The overall average of the land drifting increase rate in the study area was 10.99 km^2 year $^{-1}$. The decrease in vegetation cover can be attributed to the poverty of irrigation water and water resources during droughts, as well as the massive urban sprawl in the study area and the surrounding provinces. The decrease in vegetation cover in the studied area is due to the decrease in the amount of rain during the study period. Then, the decrease in rainfall amounts led to a significant decrease in the surface and groundwater resources of the study area such as rivers, lakes and groundwater, and thus the soil moisture content.

REFERENCES

1. Adeeb ,H. Q. and Y. K. Al-Timimi,. "GIS techniques for mapping of wind speed over Iraq", Iraqi Journal of Agricultural Sciences. Vol.50, no.6, pp1621-1629, 2019

2. Arnold, E. UNEP, 1992. World atlas of desertification, London

3. Binns, T., 1990. Is desertification a myth? Journal article Geography 75:106–113

4. Black, G.R., 1965. Methods of soil analysis. Part 1. Agronomy. Madison: American Society of Agronomy, 9: 379–390

5. Dulliami, A., 2015. Using Normalized Difference Vegetation Index (NDVI) and some of vegetation Indicators for the Monitoring Desertification and Sand dunes in the Baiji/ Iraq. Tikrit Journal of Pure Science.20 (1).

6. Fadhil , A.,2004.Assessing and Monitoring the Desertification in the Northern Part of Shaanxi Province, China, Using Geoinformation Technology, Ayad Mohammed Al-Quraishi,Conference: International CEOS Workshop on Rapid Response Information Systems, 5-6 May 2004 Wuhan, China, At Wuhan

7. Hadeel, A., Mushtak, T., 2010.Application of remote sensing and GIS in the study of environmental sensitivity to desertification: a case study in Basrah Province, southern part of Iraq. Application of the geomat. 2:101–112

8. Jabbar, M.T.,2001. Soil loss by wind erosion for three different textured soil treated with polyacrylamide and crude oil, Iraq. J China Univ Geosci 2:113–116

9. Jawad, T. K. O. T. Al-Taai, and Y. K.Al-Timimi , 2018. Evaluation of drought in iraq using dsi. by remote sensing.Iraqi Journal of Agricultural Sciences. 49(6):1132-1145

10. Karnieli, A. 1997. Development and implementation of spectral crust index over dune sand,.int.Journal of Remote sensing., 18,1207-1220

11. Khudhairy A., and Al-Timimi,Y. K. ,2018. Spatial and Temporal Temperature trends on Iraq during 1980-2015, Journal of Physics: Conference Series (JPCS).1003,1

12. Kosmas, C., Ferrara, A., Briasouli, H., and Imeson, A.,1999. Methodology for mapping environmentally sensitive areas (ESAs) to desertifi-cation. Mediterranean desertification and land use (MEDALUS),European Union 18882, pp 31–47

13. Nicholson, S.E., Tucker, C.J., 1998. Desertification, drought and surface vegetation: an example from the West African Sahel. Bull Am Meteorol Soc 79(5):815–829

14. Pashaei, M., Rashki, A., 2017.An Integrated Desertification Vulnerability Index for Khorasan Razavi, Iran. Natural Resources and Conservation 5(3): 44-55

15. Rouse, J. W., R. W. Haas, J. A. Schell, D. W. Deering, and J. C. Harlan, 1974. Monitoring the vernal advancement and retrogradation (Greenwave effect) of natural vegetation.NASA/GSFCT Type III Final report, Greenbelt, MD, USA

16. Thomas, D.,1997. Science and the desertification debate. Journalof Arid Environ 37:599–608

17. Thornes, J.B., 1995. Mediterranean desertification and the vegetation cover. In: Fantechi R, Peter D, Balabanis P, Rubio JL (eds) EUR 15415 desertification in a European context: physical and socio-economic aspects. Office for Official Publications of the European Communities, Brussels, pp 169–194

18. UNCCD. 1994. United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa. New York

19. UNEP .2001. The Mesopotamian marshlands: the demise of an ecosystem. Early Warning and Technical Assessment Report, UNEP/DEWA/TR.01–3

20. Ziboon , A., Imzahim , A., and Alaa , G.,2015. study and analysis of desertification phenomenon in karbala governorate by remote sensing data and GIS. Iraqi Bulletin of Geology and Mining .11(1):143 −156

21. Ziboon, A.,R., 2008. The determination of Desertification phenomenon in Karbala Using Remote Sensing Techniques. Engineering and Technology Journal.26(11).