



Spatial and temporal changes of vegetation cover in karbala using vegetation index difference

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Abstract

The research aims to calculate the spatial and temporal changes in the study area, where the analysis of satellite images from the Moon (Land Sat) that were taken for the years (1993, 2008, 2023) was relied upon. It is noted that the area of vegetation cover was in 1993 about (971.05) km², while the area of vegetation cover in 2008 became about (1012.6) km², but in 2023 it became about (1422.64) km². The research problem emerged what trends of change in the area of vegetation cover in the holy province of Karbala, spatially and temporally using RS. By comparing the area of vegetation cover in the period, we find that the area of variable vegetation cover is equal to 41 km². The area of vegetation increased in 2023, where it became 1422 km², where the area of agricultural land was 951 km², constituting a percentage of 67%, while the area of natural plant was 471 km², constituting a percentage of 33%, which means that there is a positive change of an area of about 480 km², that is, the area of agricultural land is increasing, while the area of natural plant is decreasing 230 km². The beginning was with the spread of modern agriculture in the Karbala Plateau, but at a slow pace at the beginning. In 2010, the signs of success appeared on the experience. Quick and serious steps began to take advantage of these areas of neglected desert land. It seems that modern agriculture using axial sprinklers was the main step in success until it reached its peak at the end of 2023, and the total area became about 1031.43 km². The use of remote sensing techniques is an important means of extracting sensitive and accurate information about the characteristics of any target on the surface of the earth and the emergency changes that occur to that target, as well as determining the extent of vegetation cover change in the research area caused by a variety of natural and human factors.

Keywords: Vegetation covers, RS, Human, Natural, Environment

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Introduction

Vegetation cover is one of the basic elements that contribute to the balance of the ecosystem on the planet. Vegetation cover extends to dense forests, grassy plains, desert areas, and wetlands, reflecting the diversity and richness of plant life. Plants play a pivotal role in oxygen production, food provision, and climate regulation, as well as being home to many living organisms. The technical progress, the development of computer technology and the flow of a huge amount of renewable information about vegetation through satellite data, the development of GIS software and remote sensing have made it possible to formulate solutions to achieve the best results for human well-being through the development and maintenance of vegetation through the use of these modern technologies, in order to obtain more accurate details about the classifications and changes of vegetation. Remote sensing technology provides the necessary information base through the optical values (Brightness Value) of electromagnetic energy representing the characteristics of vegetation. This information is very spatial and spectral resolution, because it records the reflected package of the image element (Pixel Bard). The higher the distinguishing accuracy, the more detailed the information is in terms of place and then a large amount of ground information.

First: The Research Problem

1. Are there trends in the change in the area of vegetation cover in the holy province of Karbala, spatially

and temporally (spatially) for the period (1993-2023)?

2. What are the reasons that led to the change of vegetation cover in the holy province of Karbala, spatially and temporally?

Research Hypothesis

1. There is a change in the areas of vegetation cover, as it was detected and its temporal and spatial changes were calculated for the period (1993-2023).
2. There are a number of reasons that led to the change of vegetation cover in the holy province of Karbala, spatially and temporally

Objective of the Research

1. The study aims to detect and know vegetation changes and calculate them temporally and spatially, whether negative or positive.
2. Distribution and analysis of vegetation in the holy province of Karbala.
3. Employing the use of remote sensing techniques and integrating them with GIS data and showing the potential of these techniques in detecting the problem and devising its hypotheses.
4. The role of spectral indicators and vegetation clues in measuring the cadastral trends of the vegetation of the Holy Karbala Governorate.

Fourth: Borders Research Area

It extends in the western central part of the Republic of Iraq in the central Euphrates region, and is astronomically located within one latitude between (8- 32°, 50- 32°) north, and longitudes (10- 43°, 19- 44°) east, and on the outskirts of

the eastern edge of the northern desert plateau of the western plateau, west of the Euphrates River bordered to the north and west by Anbar Governorate, to the east by Babil Governorate, and to the south by Najaf Governorate.

The first topic: -Calculating vegetation cover in the holy province of Karbala using numerical data for the years (1978- 1993 - 2008 - 2023)

The numerical data were used to calculate the spatial and temporal changes of vegetation cover in the holy province of Karbala. The numerical data for the years (1978- 1993 - 2008 - 2023) were classified. Space data maps (2), (3), (4), (5) were produced for us. Through Table (1) and Figure (1), it is noted that the area of vegetation cover in the study area in the year (1978) amounted to 1005 km², where the area of agricultural land was (400) km², forming a percentage of (40%), and the area of the natural plant was (605) km², forming a percentage of (60%), and depending on the base year to know the temporal and spatial changes. It is noted that the area of vegetation cover decreased in (3,199) and became an area of (971)km², where the area of agricultural land reached

(420) km², and formed (43%), while the area of the natural plant reached (552)km², formed a percentage of (57%), meaning that there is a positive change of an area of about (20) km², which is an increase in the area of agricultural land, while the decrease in the area of the natural plant reached (-53)km². Where the changes from the period (1978-1993) were calculated, there was a clear increase in the area of agricultural land, and this applies exactly to the reality in that period, which increased the agricultural area of field crops to meet the local need of the market in the country, or more precisely, the neglected or fallow lands were reclaimed in those years before and after (1993). This increase was the result of reasons related to the economic blockade imposed on the country, which contributed greatly to the increase in agricultural land as a result of the support of the state in that research period because it was not imported from outside the country. The areas of agricultural land increased, or more precisely, the neglected or wastelands were reclaimed (Figures 1, 2, and 3, Table 1).

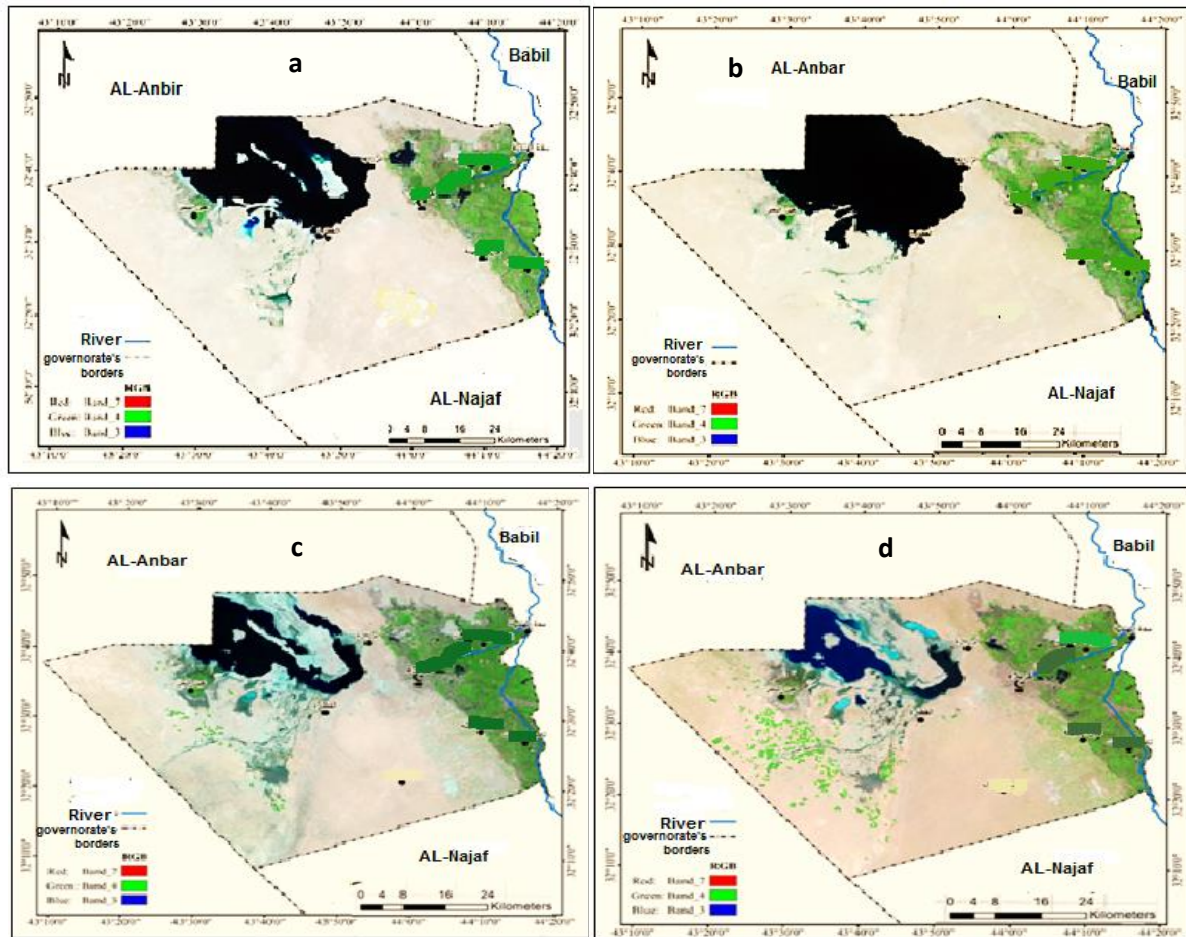


Figure 1: Satellite Visualization (a.1978; b.1993; c.2008; d.2023) by (ERDAS 9.3, ARC GIS 10.1)

Table 1: Spatial and temporal changes of vegetation cover in the holy governorate of Karbala for the period (1978, 2008, and 2023)

Dispute	Reveg.	Agricultural land area	%	Change	Natural plant area*	%	Change
78	1005	400	40	---	605	60	
3	971	420	43	20	552	57	53 ^{2*}
8	1012	471	66	52	241	34	311
2023	1422	951	67	480	471	33	230

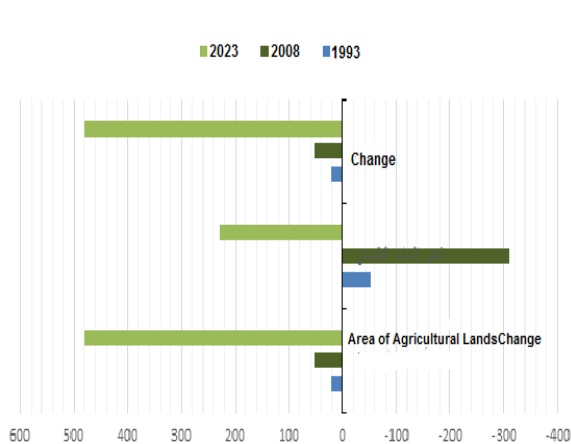


Figure 2: Spatial and temporal changes of vegetation cover in the holy province of Karbala for the period (1993, 2008, and 2023)

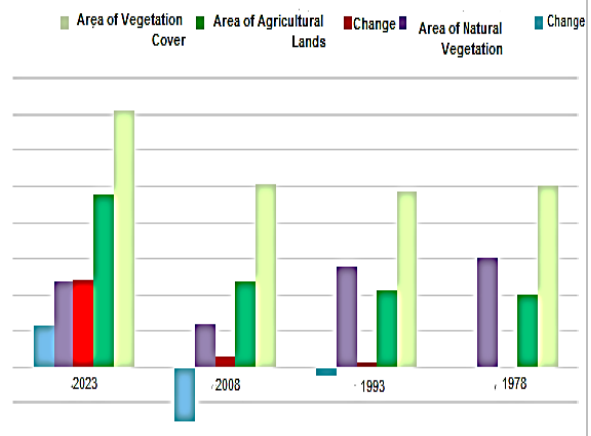


Figure 3: Calculate spatial and temporal changes of vegetation cover in Karbala governorate for the period (1978-1993- 2008-2023)

Modeling and classification of vegetation cover in the Holy Governorate of Karbala using the difference in vegetation cover index (NDVI) for the years (1993- 2008 - 2023)

The Natural Vegetation Index (NDVI) is an important indicator first proposed and used by (Rouse *et al.*, 1973) at the University of Texas Remote Sensing Center for Plant Diagnosis, Detection, Vitality Determination, Density, and Normal Distribution. It is also useful for mapping green spaces, characterizing the density and type of vegetation, as well as revealing plant health, activity, and diseases. It is a good indicator of the status and degree of desertification, and can distinguish between vegetation and bare soil. It measures changes in the spectral reflectance of living elements. The Natural Vegetation Index (NDVI) helps reduce external noise factors, such as topographic influences and sun angle variations. It can also be used to calculate transpiration and evapotranspiration coefficients, where active green plants absorb growth and vitality.

NDVI is used to determine the density of vegetation on any patch of land. Researchers observe the waves of visible sunlight and near-infrared radiation reflected by plants, and then the value of NDVI is calculated from the visible light and near-infrared radiation reflected by plants. The one on the left absorbs most of the visible light that falls on it, reflects much of the near-infrared light and is healthy in shape. The vegetation on the right reflects visible light more clearly and less light than near-infrared and its shape is

unhealthy. NDVI values are calculated between (-1.0) - (+1.0). Negative values indicate the absence of plants, while positive values indicate the presence and density of plants, and are calculated through space data (Al-Hamidawi, 2022).

There is no doubt that the conversion of raw satellite data into NDVI values gives an approximate measurement of the type and density of vegetation and its condition in the study area. Thus, the natural variables, surface slope, lighting, temperature and rainfall can be linked with each other and with the values of the vegetation index to reach the changes that affect it and what are their causes?

In addition, further analyses can be conducted to distinguish the health of plants in place, and the density and prosperity of vegetation cover can be revealed and the extent of temporal changes in vegetation cover values for the period (1993-2008- 2023).

Values can be derived from the following equation: -

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

where (Red) = red beam and (NIR) = near infrared

$$NDVI = \frac{(B4 - B3)}{(B4 + B3)} \quad \text{Landsat - 7ETM}$$

$$NDVI = \frac{(B5 - B4)}{(B5 + B3)} \quad \text{Landsat - 8OLI}$$

Calculation of spatial and temporal changes (NDVI) for the years (1993 - 2008 - 2023)

The values of (NDVI) were calculated through maps (6), (7)and(8) and then divided into six categories for each of the years (1993- 2008 - 2023), as it is

noted that the vegetation cover index (NDVI) for the first category (there is no vegetation cover at all) for the wet season was about (2937) km², the shape of (70%) was the least area during this year, while its area increased to become in (2008) about (3166.88) km² and the shape of (69%), while the lowest area was in (2023) and its value became (2750.7) km² and the shape of (58%), which means an increase in the value of the non-good category, especially in (2008).

The values of (NDVI) were calculated for the years (1993- 2008 - 2023), as it is noted that the vegetation cover index (NDVI) for the first category of (no vegetation cover at all) for the dry season was in (1993) about (2989.13) km², the figure of (71%) was the least area during these years, while its area increased to become in (2008) about (3173.87) km² and the figure of (69%), while it was the least area in (2023) and became (2760.7) km² and formed (59%), which means an increase in the value of the bad category, especially in (2008).

As for the value of the second category between (very weak vegetation cover) for the wet season in (1993) about (300) km² and the form of (7%), but in (2008) the area of this category increased to (326.44) km² constituting (7%), as well as its value increased in (2023) to (562.55) km² constituting

(12%), and this indicates that the plant biomass index (NDVI) has increased in 2008-2023.

While the value of the second category between (very weak vegetation cover) for the dry season in (1993) was about (340) km² constituting (8%), while in (2008) the area of this category increased to (365) km² constituting (8%), while its value increased more in (2023) to (668) km² constituting (14%), which indicates that the plant biomass index (NDVI) has increased in 2008-2023.

As for the third value of the category that was within (weak vegetation cover) for the wet season, its value in (1993) was about (324) km², constituting (8%), and its value in (2008) became about (339) km², constituting (7%), while it decreased in (2023), so its value became (301) km² (7%), which means that the NDVI of this category is constantly decreasing.

While the third value of the category that was within (weak vegetation cover) for the dry season, its value in (1993) was about (300) km², constituting (7%), and its value in (2008) became (369) km², constituting (8%), while it decreased in (2023), so its value became (322) km², constituting (7%), which means that the vegetation index (NDVI), meaning that this category is constantly increasing Table 2.

Table 2: Vegetation covers areas in Karbala Governorate (1993-2008-2023) according to (NDVI) levels

NDVI Levels	Vegetation	1,2/ 1993		7.8/993		1,2/ 2008		7.8/2008		1,2/ 2023		7,8/ 2023	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
Range:	There is no vegetation at all	2937	70	13	71	88	69	87	69	2750	58	2760	59
300 meters	0.1 Vegetation	300	7	340	8	326.	7	365	8	552	12	668	14
	0.2 Vegetation	324	8	300	7	339	7	369	8	301	7	322	7
	0.3 Vegetation	87	5	202.	5	255.5	6	264.	6	201	4	209	4
	0.4 Dense vegetation (planted or natural)	420.68	10	350	9	479.92	11	394.	9	900	19	749	16
0.4more than	Vegetation	4848	0	7.311	0	9.13	0	10.91	0	13.68	0	8.7	0
	Total	15	100	231	100	87	100	99	100	4718	100	4718	100

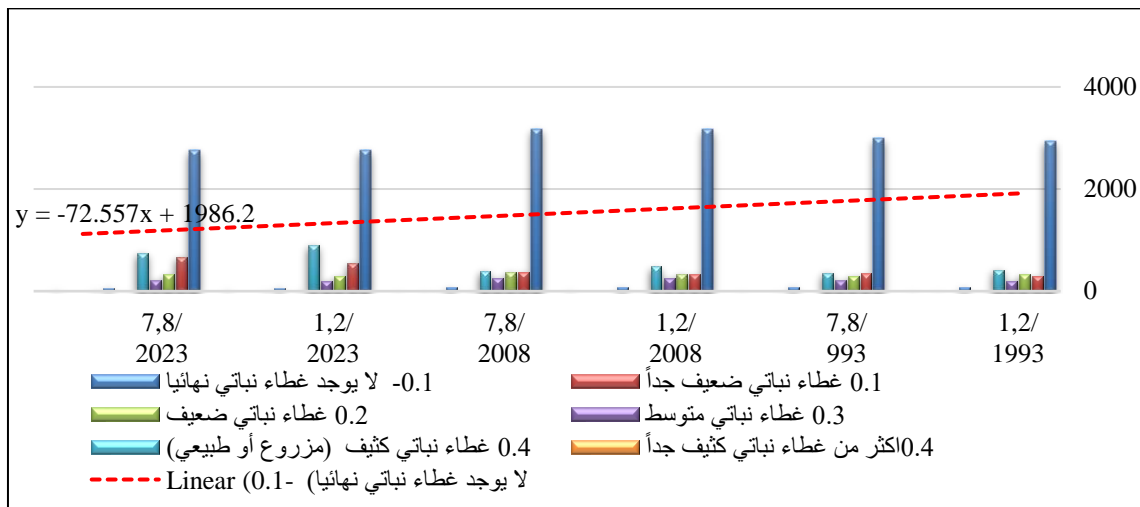
**Figure 4: Vegetation covers areas in Karbala Governorate (1993-2008-2023) according to NDVI levels.**

Figure 4 As for the fourth category, which falls within (medium vegetation cover) for the wet season, the value of this category in (1993) was (200.87) km², this value increased in (2008) to (255.5) km², while in (2023) it decreased to (201) km², and this means that the NDVI is constantly increasing in this category, and this means that there is a continuous improvement within this category over these thirty years, and this is a good indicator during these years.

As for the fourth category, which falls within (medium vegetation cover) for the dry season, the value of this category in (1993) was (202.96)km², this value increased in (2008) to (264.14)km², while in (2023) it

decreased to (209)km², and this means that the vegetation index (NDVI) is constantly increasing in this category, and this means that there is a continuous improvement within this category over these thirty years, and this is a good indicator during these years.

The fifth category, which is (dense plant cover (planted or natural) for the wet season, had a low value in (1993) of about (420.68) km², but its value increased in (2008) to (479.92) km², while it increased significantly. Its value in (2023) was about (900.99). This means that the index of the plant peel or plant biomass (NDVI) is increasing in the period (1993-2023). This indicates that the plant density is high, especially

in 2023. This indicates that this category is higher because of taking care of the specific value of the plant by providing fertilizers, pesticides and water.

The fifth category, which is (dense plant cover (planted or natural) for the dry season, had a low value of (1993) (350.83) km², but its value increased in (2008) to (394.07) km², while its value in (2023) to (749.88). This means that the index of the plant peel or plant biomass (NDVI) is increasing in the period (1993- 2023). This indicates that plant density is high, especially in 2023. This indicates that this category is higher because of taking care of the qualitative value of the plant by providing fertilizers, pesticides and water.

The sixth category, which is (very dense vegetation cover) for the wet season, had a small value in (1993) (7.48) km², but its value increased in (2008) to (9.13) km², while its value in

(2023) to (13.68). This means that the plant peer index or plant biomass (NDVI) is increasing in the period (1993- 2023). This indicates that the plant density is high, especially in 2023. This indicates that this category is higher because of taking care of the specific value of the plant by providing fertilizers, pesticides and water.

The sixth category, which is (very dense vegetation cover) for the dry season, had a low value of (1993) (7.31) km², but its value increased in (2008) to (10.91) km², while its value in (2023) became (8.7). This means that the plant peel index or plant biomass (NDVI) is increasing in the period (1993-2008). This indicates that the plant density is high, especially in 2023. This indicates that this category is higher because of taking care of the specific value of the plant by providing fertilizers, pesticides and water (Figures 5 and 6).

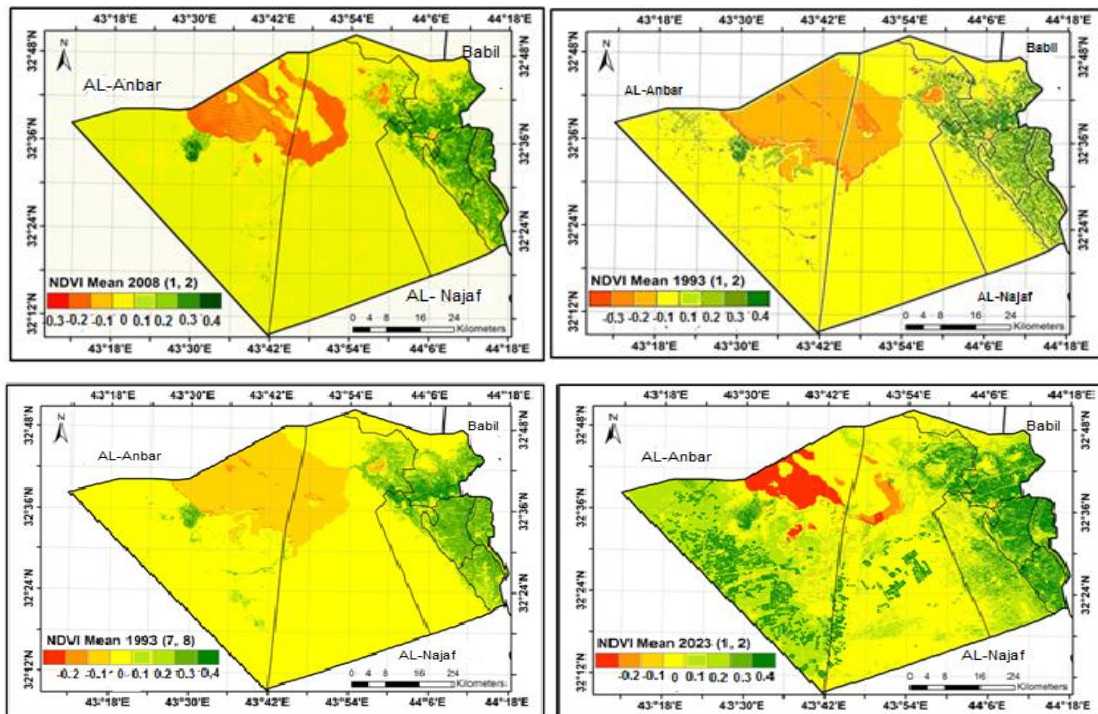


Figure 5: Vegetation classifications in Karbala Governorate in (1993; 2008; 2023) according to NDVI levels for the wet season.

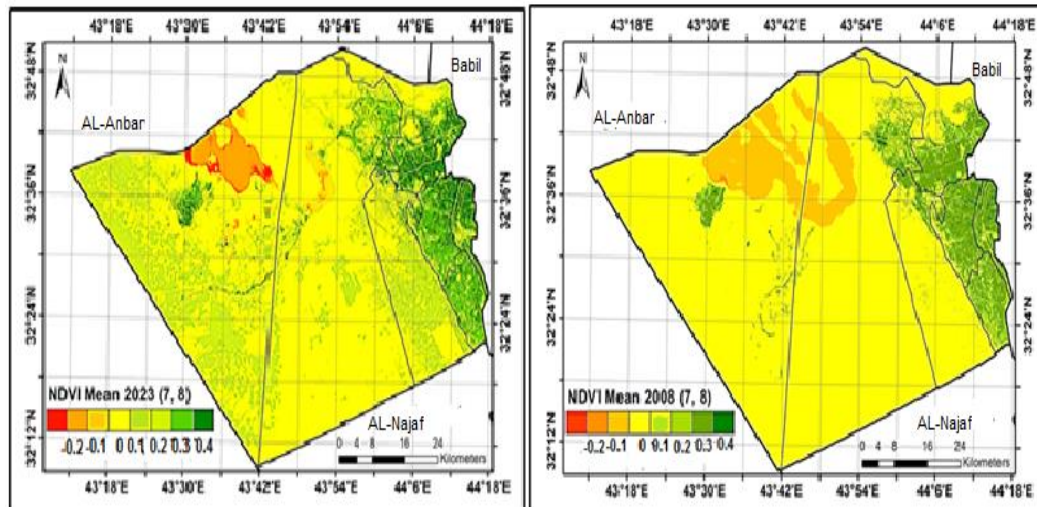


Figure 6: Vegetation classifications in Karbala Governorate in (2008 and 2023) according to NDVI levels for the dry season

Reasons for the change in vegetation cover areas in Karbala Governorate (1993-2008-2023)

While in the year (8,200), it is noted that the area of vegetation cover increased, where it became (1012) km², where the area of agricultural land (471) km², accounted for (66%), and the reason for this increase is due to the increase in the areas of agricultural land in the study area through the establishment of projects

- **Nakheel Al-Husseiniya Plant Project:** This project is located in Awn sub-district, west of Al-Husseiniya district, in the northeastern part of the governorate. Basically, its location was a small nursery to multiply some crops and sell them in the local market. However, the Horticulture Department of the Ministry of Agriculture proposed in (2004) to turn it into an important strategic project for the cultivation and breeding of palm mothers. The goal of transforming the small nursery into a large and vital project was to

multiply the mothers of the Iraqi palm varieties with bequests because of their economic and food importance. The total area of the project is about (67) dunums (Almudhafar, Jawad and Almayahi, 2024; Almudhafar, Almayahi and Jawad, 2020).

- **The Nakheel Al-Razzazah Unit Project** the Directorate of Agriculture in Karbala Governorate completed the Nakheel Al-Razzazah Unit Project in the year (2005). It is located within the desert plateau area near Al-Razzazah Lake in Al-Hurr District. This project was established with a research aim to multiply palm mothers of multiple varieties, as well as an environmental goal that serves as a wind source, stabilize the soil, preserve it from erosion, and plant large areas of desert land overlooking Al-Razzazah Lake to transform the desert land into a green oasis. The project area amounted to about (128) dunums.
- **Basateen Development Project:** Basateen Development Project is

located in the holy province of Karbala in the desert area in the northwest of the district of Karbala Center. The project was established in (2006) owned by the Directorate of Agriculture of Karbala, as it was established with the aim of piloting research to prove the validity of desert land for agriculture by planting it with palm trees and fruits (peaches, apples, apricots, koja, figs and sidr. The project area is about (5) dunums

- Al-Husseiniya District Project This project is located in Al-Husseiniya District in the northeastern side of Karbala Governorate. It was established in (2007) with a land area of (16) dunums. The project is one of the important projects implemented by the Directorate of Agriculture of Karbala, and belongs to it. The map (10) was implemented on a patch with the aim of guiding research as it was established to know the best modern methods and techniques that help farmers reduce the cost and obtain the best quality varieties of dates and American pomegranate trees and grapes. The project occupies agricultural lands that have been rehabilitated and cultivated, as its land was previously occupied by old and abandoned destroyed houses (Almudhafar, Mohsen and Almayahi, 2023; Guda *et al.*, 2020; Alduhaidahawi *et al.*, 2019).
- Karbala Oil Refinery:
The oil refinery is located in Karbala Governorate, south of the governorate near the strategic crude oil pipeline, that is, halfway

between the cities of Karbala and Najaf, on the Karbala-Najaf plateau. Its location places it among many other sites and uses, including (covered agricultural houses, and Karbala Airport). The foundation stone of the refinery was laid in (2007), on an area of (16) km² that was operated in (2022).

- Karbala Gas Station:

Karbala Gas Power Station is located in the desert area of Karbala Province District, 20 km south of its headquarters, on an area of 200 dunums. Opened in 2012, the plant is one of the most polluting industrial activities.

The plant waste varies between liquid and solid, in addition to the gaseous waste resulting from the continuous combustion of fuel to generate electricity. Until 2021, the waste of the liquid plant amounted to about (3000) liters per month, while its percentage during the maintenance period and the suspension of one of the operating units amounted to (1500) liters per month. These residues come from washing the plant units and their accompanying elements and chemical compounds, which may contaminate the soil, while solid residues from empty engine oil barrels in the plant amounted to about (120) barrels per month. These barrels often touch the surface of the ground at the plant site, causing a serious environmental impact on the ground due to the fact that these barrels contain residues of spent fuel, in

addition to oils spilled after accidents at the plant.

- **Karbala International Airport:**

The airport is geographically located between the cities of Najaf and Karbala, about (32) km southeast of the city of Karbala. The astronomer is located within the latitude: 32°21'58" N and longitude: 44°11'37" E. The total area of the project is (45) km². It is one of the largest investment projects. The length of the main runway is about (4.5) km, which is the longest in the country. The date of lying the foundation stone and working on it is (2017).



Figure 7: Karbala Airport location, Karbala refinery site and Karbala gas station location

In light of the findings of the study, it is clear that the holy province of Karbala is going through an important agricultural transformation that reflects human interaction with the environment through the use of modern technologies in agriculture and land reclamation. The NDVI has demonstrated that efforts by agricultural and government institutions have resulted in a clear increase in cultivated areas, especially in previously neglected desert areas Figure 7.

Conclusions

- The results of the analysis of satellite visualizations and digital data showed that the governorate of Karbala witnessed clear spatial and temporal changes in vegetation cover between the years (1978-2023), represented by an increase in the area of agricultural land compared to the decline in the area of natural plants in some areas.
- It was found that the period between and2023 was the most improved 2008 in vegetation cover indicators (NDVI), as a result of the expansion of government and investment agricultural projects such as Nakheel Al Husseinia, Al Razzazah and .Orchard Development projects
- Positive human factors such as agricultural reclamation using modern irrigation techniques, and the adoption of agriculture in the Western Plateau contributed to raising the plant biomass index and improving the quality of vegetation cover.
- Industrial activities such as the Karbala refinery, the gas power plant, and the Karbala International Airport were clear environmental stressors, as they contributed to the reduction of natural vegetation in their direct scope.
- The NDVI values showed that dense and very dense vegetation categories increased in 2023 compared to previous years, reflecting the success of government efforts to transform desert lands into productive .agricultural areas
- Vegetation indicators vary between wet and dry seasons, with values rising in the wet season due to

increased rainfall and improved environmental conditions, while decreasing in the dry season due to water stress.

- Relying on remote sensing and GIS technologies has proven highly effective in detecting environmental shifts with temporal and spatial accuracy, enhancing its role in supporting agricultural development decisions and sustainable environmental planning.
- The positive change in vegetation area over recent decades indicates a relatively positive environmental shift in the province, but it is not without future risks unless supportive environmental policies continue.

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