Using Spectral Indices to Analyze Vegetation Cover Using Remote Sensing Techniques During Two Seasons in Al-Karmah District, Anbar Governorate

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Abstract

The purpose of this study was to observe the geological processes in two seasons at Al-Karmah District, which is located on the east of the governorate of Anbar and northeast of Fallujah. It is located between 44080 to 430360 east and 330260 to 330400 north with an area of about 1000 km (which is about 100, 000 hectares). The spatial and temporal changes within the study area were compared and analyzed using two satellite images that were taken on January 15, 2025 and July 18, 2025 with Landsat 8. The data collection tools were the NDVI and SAVI vegetation indices. Applicable in the method of remote sensing and the geographic information systems to measure vegetation cover and examine how its density varies over the two periods studied. The outcome indicated a significant difference in values of vegetation covers in the two seasons, with the value being higher in winter season than the summer season, which is explained by the fact that climatic conditions were enhanced, not to mention the closeness of certain areas to irrigation water bodies. The research also revealed that the regions that were found to be in climatic conditions arid and semi-arid experienced an overall reduction in the green cover and those lands which were developed with date palm orchards and evergreen trees were found to experience relative stability in the vegetation cover. It was also revealed by the study that remote sensing methods are efficient in measuring changes in the vegetation cover seasonally, biomass, which is relevant in supporting agricultural planning and sustainability of natural resources in arid and semi-arid regions.
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Keywords: Remote Sensing, Spectral Indices, Vegetation Cover, Seasonal Variation.

Introduction

The vegetation cover is one of the most essential aspects of the environment as it serves as an indicator of the environmental health and sustainability of the natural resources in any area. It relies on the intricate climate, soil and human land use interactions. Following the advancement of remote sensing technology and geographic information system (GIS) it is now possible to monitor the vegetation cover changes within a time span in a quantitative and accurate way through satellite data. These technologies use spectral indices which are dependent on the reflectance of radiations in certain wavelengths of electromagnetic spectrum to describe and identify the density and health of plants. They may be calibrated difference vegetation index (NDVI) and soil-adjusted vegetation cover index (SAVI) among others that are more frequently used in the recent literature. The NDVI index has been extensively employed to describe the state of vegetation since it is based on the contrast between the reflectance of the near-infrared (NIR) and the red (Red) bands, which reflect the presence of chlorophyll in plants and compares them to soil and non-vegetative features. The SAVI index, however, is modeled to correct soil effects on the NDVI values and as such, it is more fitted to the regions with minimal vegetation cover of the region or in cases where there are soil background effects. [4]. The latest research has shown how such indices can track and assess vegetation cover changes over varying periods of time, which has helped in improving the study of the dynamics of ecosystems as well as the reaction to climatic impacts and anthropogenic activities[6]. Recent studies have confirmed the efficiency of vegetation indices such as NDVI and SAVI in arid and semi-arid environments [10] As an example, NDVI and SAVI have been employed to measure and monitor vegetation density in other regions other than Iraq as in a study that established vegetation density by use of NDVI and SAVI using Landsat images, which showed the validity of these indices in describing vegetation cover. According to a study by [2], NDVI values may be affected by a number of environmental factors, including soil background, moisture, and the solar radiation angle, and showed that other vegetation indices like SAVI and EVI in addition to NDVI are important to provide a better description of vegetation cover status. Thus, the purpose of this study was to examine the vegetation cover, based on satellite data by retrieving NDVI and SAVI indices out of the remote sensor data, assessing the distribution and vigor of the vegetation cover in the study area, and comparing the precision and appropriateness of both indices to describe the vegetation cover.

Material and Methods

Study Area

The research location is the Al- Karma district of the governorate of Anbar. It is typified by a variety of land uses, agricultural lands and residential zones to semi arid regions, like the ones in central Iraq. The selection of Al-Karma district was based on the fact that it is a significant agribusiness district that is influenced by climatic conditions and human activities. It is situated between the 44080 and 430360 East and 330260 and 330400 North longitudes and latitudes respectively. On the north it borders on portions of the Fallujah district and local villages in northern Anbar; on the south on agricultural lands, the southern Anbar districts, and the Fallujah area; on the east on the Fallujah district and the Euphrates River; on the west on the western Anbar countryside to the intimacy of the borders. This renders it applicable in the analysis and study of vegetation cover by the use of remote sensing technology. Figure 1: serves as a picture of the area of study.

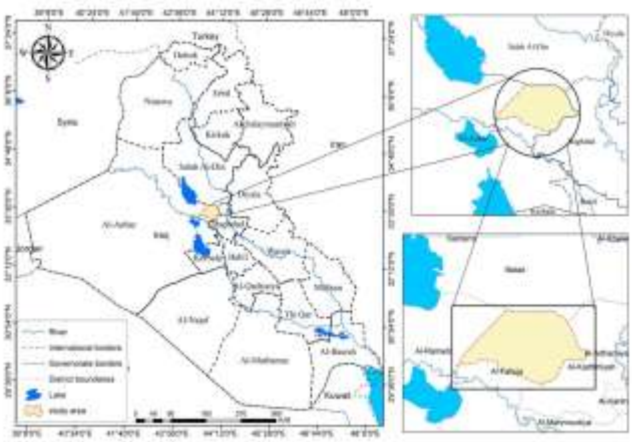

Figure 1: the study area

Climate of the Study Area

The climate in the study area is arid and semi-continental, hot, dry during summer, and cold and wet during winters, and there is a high change in day time and night time temperatures. The summer temperature is about 33-36 o C and the winter temperature is about 11 o C and the difference is 22 o C between the two. The rain falls are low (around 107.9 mm every year), which are concentrated in the period between October and May, and which does not occur during the summer. The location is also defined as having a low vegetation cover and evaporation rates in the summer period are high, with the evaporation rates being at about 30% of the annual evaporation taking place in the month of July and August. Wind erosion towards the northwest and south east through these climatic conditions results in the formation of soils and geological layers. Although the erosion is weak owing to low rainfall level, the erosion is intensified by high heat and evaporation over the windy seasons. Table 1 demonstrates the climatic conditions at the study area**.**

Table 1: Average climatic data for the study area for the years 1990-2019

Months	Ave.Monthly rainfall(mm)	Avr.Monthly Temp(c)	Avr.Mini.Temp (c)	Avr.Max.Temp. (c)	Evap.Rate (class A pan) mm	Ave.Relative % Humidity	Ave.monthly soil temp. (c) for adepth50cm
jan	22.9	9.6	4.5	14.7	51.5	76.1	3.6
Feb	16.8	13.45	8.5	18.4	87.0	64.9	14.5
Mar	15.5	15.7	9.4	22.0	124.0	58.4	14.7
Apr	15.4	22.4	15.5	29.3	199.8	50.6	25.9
May	5.9	27.4	20.4	34.4	286.2	42.1	25.6
Jun	0	31.7	23.8	39.6	386.2	33.9	30.8
Jul	0	33.7	25.2	42.2	429.6	31.2	34.5
Aug	0	33.1	24.8	41.4	405.9	33.2	35.1
Sep	0	29.7	21.2	38.2	324.8	39.7	32.2
Oct	9.2	24.2	16.4	32.0	212.6	51.2	27.4
Nov	18.1	16.7	10.5	22.9	110.5	64.7	22.3
Dec	23.1	11.3	5.6	17.0	77.1	76.5	16.0
Average		22.41	15.26	29.34	224.29	51.13	24.4
Total	126.9				2691.5		

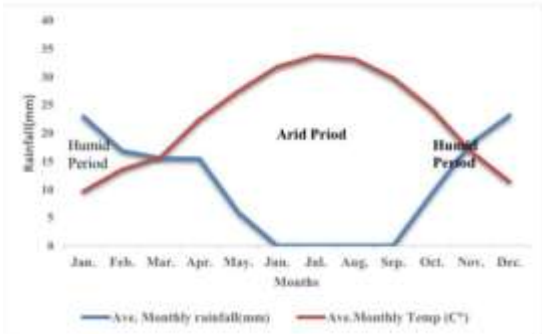

Figure 2 shows the relationship between average temperature and rainfall in the study area between 1990 and 2019

Natural vegetation and Agriculture.

The site was already under rainfed farming with wheat and barley that was filled by well surface irrigations that replaced the shortage of rainfall during winter. Summer crops and vegetables like watermelon, cantaloupe, and onions were cultivated in summer because the medium and coarse soils with light texture favored the vegetable crops. Nevertheless, poor irrigation management, saline well water, and surface irrigation caused land degradation and reduced productivity that meant farmers had to move out of land. This was added by the harsh economic times and security challenges brought about by recurrent wars. The climate of the area is severe and dry (with a small amount of rain, high temperatures, and evaporation), preventing the flourishing of natural plants. There is a prohibition of vegetation on the winter months and the water catchments regions with only drought resistant species existing during the summer. Significant vegetation in the region is Haloxylon salicornicum, Centaurea sinaica, Alhagi maurorum and Malva spp. This vegetation cover is very sparse and in the places there is often semi arid weather since there is no rainfall and was hit by drought and there is now little remnants of the plants in the surrounding areas.

Geology of the Study Area.

The Karma district is a region in the Anbar Governorate, western Iraq that is situated on the eastern side of the marshes and valleys of the Euphrates. It belongs to the Quaternary sedimentary basins and its formation is mainly composed of sand, silt and clay with the clay portion taking 50-70 percent of the whole sediment. These soils are usually submerged and have a poor drainage system. Ground water level rises in proportion with the distance between the riverbed and the ground with a high level of salinity as a result of low elevation of the riverbanks. This causes evaporation of water stored above them by high temperatures, thus leaving salt concentration on the surface. These soils may be poor or moderate with regards to drainage without efficient drainage systems or without reclamation. It also has a high value of lime, and it varies between 21% and 26% (as mentioned by [3]

Laboratory Procedures

Preparation of Samples to be used in Laboratory Measurements.

Various measurements were done on the study area randomly. Air drying and pounding of the soil samples were done by a wooden mallet. A 2 mm sieve was used to sieve them and place in plastic containers to prepare them in the laboratory. Bulk density was established by isolating some of the soil particles that were not dispersed.

Physical analysis of soil.

Soil particle size distribution: The densitometer method applied to soil samples in the study area was used in estimating the size distribution of the soils in the area as outlined by [5].

Soil bulk density (Pd): Bulk density of the soil was determined by paraffin wax coating method as per method provided by [5].

Chemical Analysis of Soil.

Electrical Conductivity (EC): According to [11], Electrical conductivity meter was used to measure the electrical conductivity of the saturated paste extract of soil.

Soil pH: The soil pH was also determined by using a pH meter, as indicated in [11].

Organic Matter: Organic Matter of the soil was also estimated by the wet digestion method as indicated in application of the black and walkley method, as explained in [7].

Cation Exchange Capacity (CEC): Cation exchange capacity of the soil was determined with the sodium acetate replacement technique at pH 8.2 where sodium ion was replaced by an ammonium ion as per the procedure in [7]. Soil gypsum level: The level of soil gypsum was determined by acetone precipitation as indicated in [14].

The content of soil calcium carbonate (lime) was tidyed with 1 N sodium hydroxide with the addition of 1 N hydrochloric acid, followed by the addition of phenonphthalein as an indicator as written in [7]. Sodium Adsorption Ratio (SAR): Sodium adsorption ratio (SAR) was computed using the following equation as reported in [14]. SAR = Na/ sqrt(Ca +Mg). Exchangeable Sodium Percentage (ESP): Exchangeable sodium percentage (ESP) was determined using the following equation: ESP = **100(-0.0126 + 0.01475SAR)/ 1 (-0.0126 + 0.01475SAR).**

Table 2: shows the physical and chemical properties of the study area.

ECe dS m-1	PH	O.M gm Kg-1	CEC Cmol(+)	Gypsum gm Kg-1	CaCO3 gm Kg-1	SAR	%ESP
5.7	7.72	1.1	31.50	13	276.0	4.9	4.6
Size distribution of soil fractions gm.Kg-1			Texture		Balk Density Mgm.kg-1		
clay	Silt	sand	SiCL		1.44		
293	531	176					

Office Work

Preparation and Composition of Satellite images.

The official site of the United States Geological Survey (Landsat-8 satellite) (Global Visualization Viewer) provided satellite images of the trajectory 169 and row 37. The photos were taken in the year 2025, that is, on 15 th January, 2025 and July 18, 2025, covering summer and winter seasons. The original image was then cut to establish the boundaries of study area accurately. Landsat satellite and its ETM sensor in a span of eight spectral bands have an area in the range of 185 x 185 kilometers. The spatial resolution of band 1 to 7 is 28.5 x 28.5 meters, band 8 is 14.28 x 14.28 meters and band T is 60 x 60 meters. The spectral indices were calculated according to the Landsat Surface Reflectance product guide [15]. The early photographs were unpolished and squashed, with all the spectral frequencies. The compressed images were then broken down into single TIFF images per spectral band and lastly all the bands were combined into one IMG image using ERDAS Ver. 9.2 but without the thermal and panchromatic bands.

Intelligence Analysis of Satellite Imagery.

The image elements are classified with regard to the spatial and temporal association of the surrounding environment, to determine the surface components of the study area, by categorising the image elements first. Two broad classifications are possible:

UnsupervisedClassification:

Unsupervised classification is the classification of similar things in the visual field. It is based on dedicated software without the involvement of an expert or analyst. The software then just examines the results of the classification and then divides them into rows according to the convergence and the similarity of the numerical data. The resulting categories are sorted and amalgamated and the resultant categories are referred to as spectral categories. Visual field spectral characteristics are original grouped into rows. Subsequently, maps and field studies follow, which are based on the prior knowledge to match the spectral categories with the land cover. This technique applies in regions where there are no primary information and field data [17]. Unsupervised classification has found a huge application of course in agricultural research [1].

Supervised Classification:

This was done through ERDAS and ArcMap GIS software under supervision and a field survey after survey was carried out. This was founded on previous familiarity with all the terrain element and land usage in the region, which was the foundation in choosing the particular satellite imagery unit under the program (so-called training areas). The computer was then used to retrieve the spectral signature of the sample. This was coupled with classification process as explained by [9].

Database Creation Using GIS

A database was developed with the help of GIS software that associates the spatial data with the metadata, and evaluates the vegetation status of the study area with the help of two main indices:

1 .Natural Vegetation Index (NDVI):

This index makes use of the near-infrared and infrared radiations to evaluate vegetation density. Good vegetation areas reflect near-infrared radiation and absorb red light whereas poor or degraded areas do the opposite. The NDVI scores vary between -1 to +1 with +1 being the tall and healthy vegetation, and below depicting vegetation degradation.

$NDVI = (NIR - Red) / (NIR + Red)$

The NDVI value classification was adopted based on [9].

-1 – 0 Water / Barren areas

0 – 0.2Bare soil / Very sparse vegetation

0.2 – 0.4 Sparse vegetation

0.4 – 0.6 Moderate vegetation

0.6 – 1 Dense vegetation

2 .Soil-Adjusted Vegetation Index (SAVI):

This index is better applicable in gauging vegetation in regions with bare ground or sparsity of vegetation since it minimizes the contribution of soil reflectivity to the spectral measurements.

The SAVI index is calculated according to the equation proposed [12].

SAVI = (NIR - RED) / (NIR + RED + L* (1 + L(

L being a factor of soil correction, and the value of a generally 0.5 is used to optimize the index. The SAVI classification was adopted with reference to the original study by (Qi et al., 1994), which developed the index to reduce the effect of soil reflectance in arid and semi-arid regions.

Results and Discussion

Figure (3,4), which compares satellite images and the NDVI index, indicates that there is evident variation in area, density and distribution of vegetation cover of Al-Karma district over various durations of time. The wet months and thus the relative high values of vegetation cover were captured in wet months like the one in the picture was taken on January 15, 2025, during the winter season, since the rain rates were good. On the other hand, the level of vegetation cover was lower in the dry months as observed in the picture captured on July 18, 2025, when it was summer, because of the high temperatures and little rainfall, and other human activities such as urban developments, fires and overgrazing. The NDVI index demonstrated its suitability in the tracking of the spatial and temporal variations in vegetation cover in the Al-Karma district and the environmental degradation. Plants thrive well during the rainy season because of the lack of moisture stress, and other stresses like salinity and lack of water besides the low quality of irrigation water in the dry season. It results in increased variations in the development of natural or cultivated vegetation than the period where water is rather available (rainwater)[13].

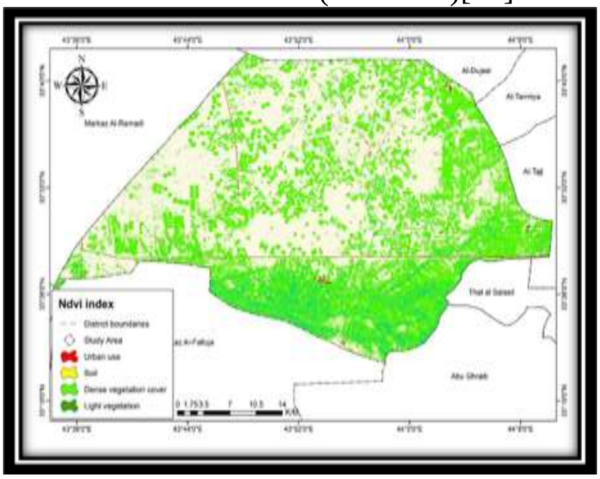

Figure 3 shows the NDVI for the summer season.

Table 3 Area and Percentage NDVI for the Summer Season

NDVI for the summer season		
Name	Area -h	Perc%
Urban use	5.64	0.47
Soil	874.3	72.21
Dense vegetation cover	272.69	22.52
Light vegetation cover	58.19	4.81

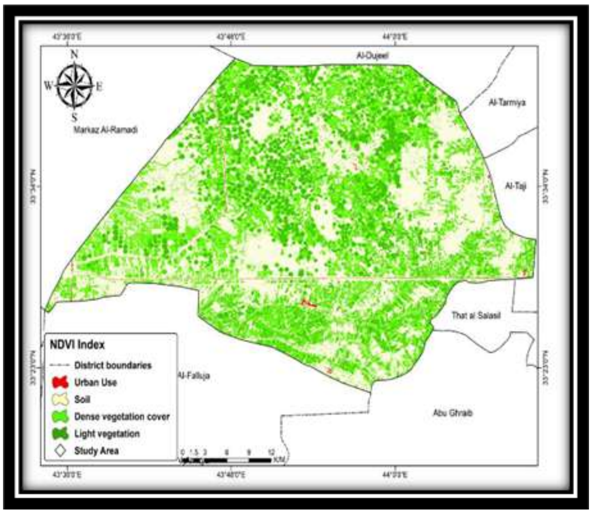

Figure 4: shows the NDVI for the winter season.

Table 4 Area and Percentage NDVI for the Winter Season

NDVI for the winter season.		
Name	Area -h	Perc%
Urban use	4.65	0.38
Soil	625.58	51.67
Dense vegetation cover	386.42	31.91
Light vegetation cover	194.17	16.04

The results of the study ascribe the change in the quantity of biomass in the winter season to enhanced increase in vegetative growth in winter and spring seasons and the broadening variety of natural or cultivated plants in the winter season. This results in an increase in the homogenization of vegetation cover. It can be noted that the vegetation distribution during the summer season is not the same as it is at the end of the winter season. The results of the study confirmed this since Figure (5,6) indicates that the vegetation cover values during the winter season were greater compared to the summer season. This is because the growth of plants is different in both seasons and the character of land use and the quantity of fresh material that is deposited to the surface of soil in each season as was verified by the findings of various researchers [8]. The SAVI index resulted in the obvious alteration of the density and distribution of vegetation cover that are affected both by climatic conditions and human activities. The index was high due to the better conditions of winter seasons and more rainfall which contributed to growth of crops and pasture plants. During summer period, there was a decline in the values of SAVI because of the high temperatures, low rainfall and greater evaporations, and this adversely affected the activity of the plants, particularly in non-irrigated areas. The fact that the SAVI index is effective in eliminating the impact of soil background when compared to NDVI indicates that it is a precise instrument to use in the monitoring of vegetation change in arid areas. These findings are consistent with recent studies conducted in arid regions which demonstrated that SAVI provides more reliable vegetation estimates compared to NDVI in sparse vegetation conditions [18]. The results are the sum total of seasonal climatic factors. The growth of human beings requires the use of sustainable methods of management of vegetation cover to slow down desertification[16].

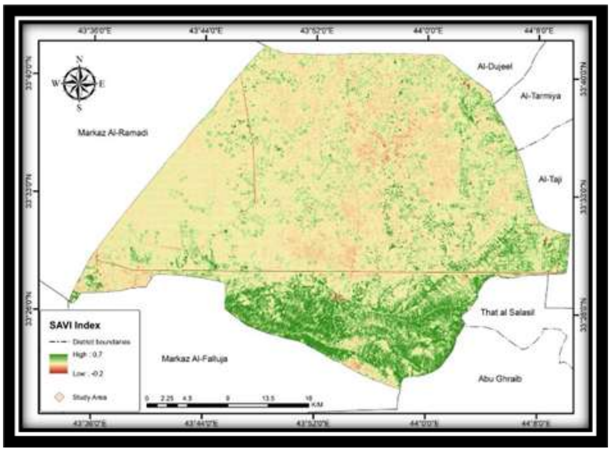

Figure 5: illustrates SAVI for the summer season.

Table 5 Area and Percentage SAVI for the Summer Season

SAVI for the summer season.		
Name	Area -h	Perc%
Low vegetation density	1062.01	87.71
High vegetation density	148.81	12.29

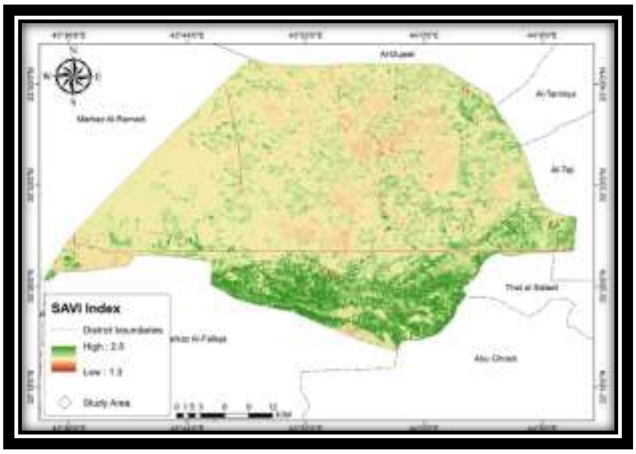

Figure 6: illustrates SAVI for the winter season.

Table 6 Area and Percentage SAVI for the winter Season

SAVI for the winter season.		
Name	Area -h	Perc%
Low vegetation density	1064.64	87.93
High vegetation density	146.18	12.07

The numbers indicate that vegetation cover in the Al-Karmah region was prevalent and high in both seasons around water sources whilst it was not the same in areas far away water sources. The vegetation cover is thick and spread well, and palm groves and trees of fruits are common. Moreover, there are increased water distributions in several regions as opposed to the ones that are far away along the river Tigris. Also, the land use has changed to the cultivation of various crops, besides horticultural crops within the area.

Conclusions

.The outcome of vegetation cover indicated that there was a clear temporal and spatial difference in the two seasons. Increasing values were related to the closeness of the soil to the water sources of irrigation and the development of both natural and cultivated plants. Most of the study areas were found to have low values of vegetation cover because they were found in arid and semi-arid climatic zones with minimal vegetation cover. The satellite images showed the distribution of the green cover to be much different between the winter and summer seasons with the green cover being more intense and extensive during winter season than it was in the summer season. The evergreen trees and date palm orchards appeared to have fairly stable vegetation cover all year round, with little seasonal addition of soil organic matter The research proved the usefulness of the remote sensing methods in tracking of the seasonal vegetation cover variations and the biomass that is why it is effective in the planning of agriculture and sustainable use of water sourcesDue to the nature of the study area, which is characterized as arid and semi-arid with vast areas of exposed soil, the SAVI index is more accurate and closer to representing reality compared to NDVI. This is because it incorporates a soil adjustment factor (L=0.5), which reduces the influence of the soil background reflectance on vegetation cover values

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