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Detecting Changes in Vegetation Cover using NDVI (Normalized Difference Vegetation Index) in Al- Muthanna Governorate

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Abstract

The study was conducted on the vegetation cover of Al-Muthanna Governorate, located in southern Iraq, bordered to north by Najaf Governorate, to the east by Al-Qadisiyah Governorate, and to the west by the Kingdom of Saudi Arabia. study the dynamics of vegetation cover in Al-Muthanna Governorate using the natural difference index for plants (NDVI), to analyze changes in vegetation cover between 2015 and 2025. Landsat 8 satellite images, which include multiple spectral bands, were used to analyze the health of the vegetation cover and identify areas of change was the aim of the research. The images were analyzed after correcting meteorological and radiometric data.

The results showed that the vegetation cover in the region had improved slightly, with an increase in areas containing healthy vegetation cover and an increase in areas covered by shrubs 2025 compared to 2015.

A slight improvement in water distribution in the region was also observed, and the four-way classification of areas based on index values showed NDVI found that areas covered by non-vegetation were larger in 2015, while areas covered by healthy plants and shrubs increased in 2025. The classification also included four categories: Non-vegetated land, shrubs, healthy plants, and water.

By integrating this data with geographic information systems (GIS) Using GIS, maps were created showing the distribution of vegetation cover and identifying areas experiencing changes in vegetation cover. The study showed a slight improvement in vegetation cover in Al-Muthanna Governorate, with an increase in areas covered by shrubs and healthy plants between 2015 and 2025. An increase in water bodies was also observed, which may indicate improvements in water resource management and improved environmental and agricultural resource management strategies in the governorate.

Keywords: Vegetation Dynamics, Spatial Analysis, Environmental Monitoring, Change Detection, Dryland Resource Management.

Introduction

Plants are an essential part of the terrestrial ecosystem, playing an important role in the hydrosphere, biosphere, and atmosphere. Furthermore, plants influence the carbon sink in the carbon cycle and can reflect the state of the ecological environment. [1]

The depletion of vegetation covers across various ecosystems, including tropical forests contributes to climate change at different levels. As noted Plants also act as a natural feedback system controlling water, carbon, and energy between the ground and atmosphere. [2] Therefore, it is essential to understand regional environmental changes by detecting the changes and driving forces behind plant dynamics across time and space to and design proper conservation plans. Remote sensing is a key tool for monitoring vegetation cover on a large scale over time.

The analysis of long-range, large-scale remote sensing data produces diverse and rich information, this capability is largely driven by the proliferation of high-resolution satellites

and rapid advancements in quantitative remote sensing technologies. Consequently, Remote sensing has supports a wide array of ecological and environmental applications, including land cover classification, soil moisture measurement, forest species classification, quantification of plant water content, snow mapping, sea ice classification, and oceanographic studies. Multispectral remote sensing images carry important spectral and spatial properties of Different objects. [3] And from Among common sensing technologies, Count the normal difference index of the plant cover **(NDVI)** Detecting changes using LiDAR and high-resolution land cover data are among the most commonly used methods. NDVI is the simplest and most globally available method for assessing green vegetation cover compared to methods such as LIDAR and high-resolution imagery. [4]

this research will analyze changes in vegetation cover using **Normalized Difference Index of Plants (NDVI) in Al-Muthanna Governorate**. It is calculated NDVI based on the reflection of infrared and near-infrared

radiation captured by the satellite.

Landsat8 OLI.

Research objective:

1. Value account NDVI in the period between 2015 and 2025.
2. Identifying changes in the area of green vegetation covers in Al-Muthanna Governorate During the period between 2025 – 2015.

Normalized Differential Vegetation Index (NDVI)

Vegetation Cover Index (NDVI) A remote sensing tool for assessing vegetation growth This indicator measures the difference in reflection.in the Wavelength Near-infrared and red radiation Which Researchers and land managers were allowed to description Different characteristics of vegetation cover. NDVI values range between -1 and 1. High values indicate Because More vegetation growth and health. And for These indicators are widely popular due to their effectiveness in data analysis. The large from multiple images and superlative with technological advancements, it has become possible to calculate NDVI using multiple sources, such as satellites,

drones, and even the Floor equipment. Development NDVI This led to A qualitative leap in monitoring vegetation cover through monitoring them Changes over time. And one Using Geographic Information Systems (GIS), it is possible from Displaying NDVI data and monitoring changes over different time periods. This capability is crucial for analyzing how vegetation interacts with climate change, land use, and management. Satellite images can be analyzed over several years to assess the effects of the Operations Agricultural crops or monitoring the restoration of ecosystems after a for different changes [5]

And with the agricultural sector relying on the Vegetation Cover Index (NDVI) for monitoring growth Plants, The importance to This indicator clearly. the Scientists and researchers use the NDVI index in Irrigation, crop stress, and yield forecasting. The ability to monitor vegetation growth trends through the NDVI index is not limited to individuals, but also supports initiatives. The range wide in the field of precision agriculture and Sustainable land management. [6] And through exploring applications This Indicator in

assessing vegetation cover, it is possible to estimate Values This is especially true in agriculture, where real-time information about plants plays a role in decision-making and resource management.

and Assessments Index Essential for implementing timely interventions, such as disease control or optimal fertilizer use, which have a direct impact on agricultural productivity. That A clear understanding of how the vegetation cover index (NDVI) is calculated and its impact Monitoring crops is crucial to modern agricultural practices. Because Linking the vegetation cover index (NDVI) to methods Specifically, it enables farmers to make the most of it, leading to healthier crops and more efficient farming techniques. [6].

NDVI index using the formula $NIR - Red / NIR + Red$, NIR represents the reflection of near-infrared light, while Red represents the reflection of visible red light. And for This mathematical relationship has values ranging between -1 and 1. The values indicate healthier and denser vegetation cover. When it is high. and Data requirements must be

met. sample This includes using high-quality satellite or aerial images capable of capturing near-infrared and red wavelengths. That Sensor characteristics remote Crucially important to ensure the accuracy of NDVI calculations, it is necessary to These devices have the ability to detect minute changes in reflection to provide accurate results.

And Satellite platforms, such as Sentinel-2, It is considered Highly effective thanks to its high spatial accuracy and amount Multispectral, which Give Basic spectral bands for calculating the vegetation cover index (NDVI).

The situation Integrating the Natural Vegetation Index (NDVI) and program Geographic Information Systems (GIS) from Index for application. Geographic Information Systems (GIS) provide visualization and analysis. For Spatial data, which Allow for Mapping Vegetation Cover Index Values during Different regions. This integration It allows for researchers and Land Owners are used to make decisions based on the spatial distribution of vegetation cover, which makes Resource management

and conservation efforts Easy and effective [7]

study by [8] showed that integration of remote sensing data into a monitoring framework, then Monitoring crop patterns and changes over time, which enhances Getting to know The Hope is the factor affecting the vegetation cover. That Merging Vegetation Index (NDVI) data and Geographic Information Systems (GIS) Very easy Mapping different types of land cover, such as forests and wet lands and dry Urban. And decrease in vegetation cover index values in a particular area indicates deforestation or urban expansion. Specific Which It requires procedure lot from researching the causes of transformations and their potential effects.

[11] Defined that Geographic Information Systems (GIS) refers to programs for storing, managing, processing, and analyzing spatially-related data. and This type of data includes reference information, maps, and statistics [12]

The rapid spread of geographic information systems in academic institutions led to increase focus big Data management using this

technology. By the 1990s, geographic information systems (GIS) had undergone further development through the merge between it and remote sensing data Which allowed Introducing multiple variables into a spatial database (Erdas, 2003).

That The ability to create accurate maps during Large spatial scales have become a major focus of renewed research. Studies such as those by [15] confirm that human activities it has significant impact On the biosphere, putting pressure on ecosystems on spatial scales unprecedented in human history.

For Despite the numerous benefits of Geographic Information Systems (GIS) in obtaining information The Environmental Effectiveness Environmental monitoring mapping is possible, but the time, money, and expertise required to fully utilize this technology may Formed A challenge at the beginning. Numerous environmental inventories were conducted through field surveys; however, these surveys were. Take a long time and High cost Especially when studying large and remote sites, and when long-term

monitoring is linked to resource management [16].

That This methodology provides valuable insights into ecosystem integrity, making it a crucial resource for land management and conservation initiatives [17]

Other factors that affect NDVI measurements the Air interference, Weather conditions, such as clouds, fog, and air pollution, can block out light and alter visibility. Reflection, which leads to data inaccuracy. And it is possible that The effectiveness of the vegetation cover index (NDVI) varies among plant species due to their unique responses to environmental conditions. Similar This variation may lead to inconsistencies in NDVI index measurements. and This makes the Inside It is difficult to accurately compare NDVI results between the Sites the Different. Users should exercise caution when interpreting NDVI data, especially in areas with the Variable patterns that may introduce an element of uncertainty into the measurements [18].

Studies that examined the vegetation cover index have confirmed the importance of remote sensing

indicators., The various vegetation cover indicators are related in a way effective by analyzing the vegetation cover index, it is confirmed that a well-defined approach is essential. Specify for remote sensing analysis. In cases where traditional vegetation index analysis methods yield substandard results. Required is the case during periods flowering It has been proven that some indicators Give More data accuracy. Allow This flexibility allows researchers to better assess crop health and implement timely interventions to improve growing conditions [19]

Research is expected to delve deeper into more sophisticated indicators, such as those found in the spectrum. X-rays The red color enhances the accuracy of leaf length index estimates. It also. It is done Developing techniques that address variations in leaf growth stages and shape, Which It provides an understanding of dynamic changes in vegetation cover. Expanding remote sensing techniques to improve ecosystem monitoring and management paves the way for advances in vegetation cover analysis [19].

And when Analyzing satellite images captured at different time intervals enabled from Monitoring the Changes in NDVI values, and it Indicators of changes in plant health. Helped These time analyses help farmers identify periods that maybe It contains crops Exposed Stress resulting from different factors Such as dehydration or nutrient deficiencies. It allowed This Information Taking corrective measures, such as Improving methods Irrigation or the use of fertilizers, and Ultimately enhancing Crop productivity [20].

3–Materials and methods

3-1.

Study area:

Al-Muthanna Governorate is located in southern Iraq, bordered to the north by Najaf Governorate, to the east by Al-Qadisiyah Governorate, and to the west by the Kingdom of Saudi Arabia. Latitude: The region, located at 31.3100° N longitude and 45.2800° E longitude, has a hot, dry desert climate in the summer and relatively cold winters with long periods of drought. Al-Muthanna Governorate covers a vast area of approximately 51,000 square

kilometers, making it one of the largest governorates in Iraq.

What is the population of Al-Muthanna? The province has a population of 15 million (according to the latest census), with the highest concentration in the city of Samawah. Agriculture is one of the most important sources of income in the province, with residents relying heavily on crops such as wheat, barley, and vegetables. The province benefits from groundwater and the Euphrates River for irrigation.

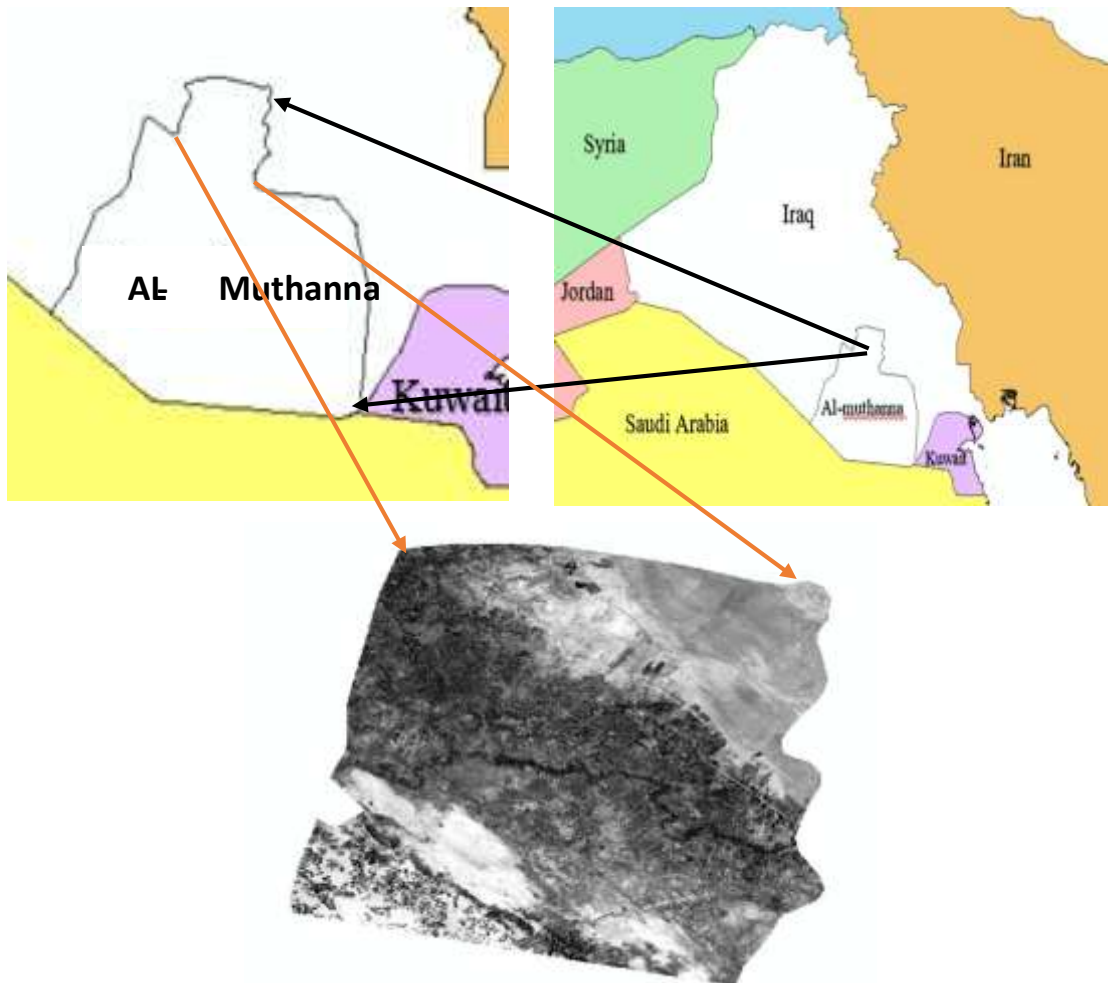
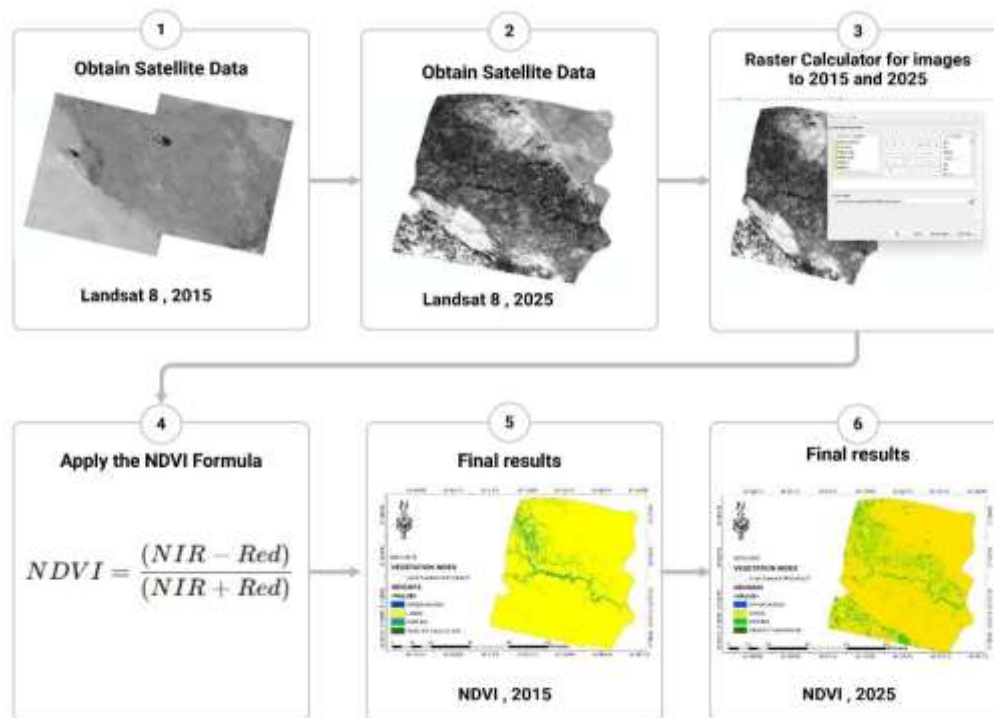


Figure (1) Map showing the study area of Al-Muthanna Governorate



Methodology

3-2 Data collection:

images were collected from the U.S. Geological Survey website (USGS) online ([/http://earthexplorer.usgs.gov](http://earthexplorer.usgs.gov)) to the location of the Samawah region identified in the route168 And the row38. Landsat 8 (OLI) images for 2015 and 2025, and the Thermal Imager (TIRS) for 2015 and 2025, both freely available data, were selected. Landsat 8 images contain nine spectral bands, with a spatial resolution of approximately 30 mRa for bands 1 to 7 and band 9,

and a resolution of 15 m for band 8 (the panchromatic band).

3-3 Image processing:

images were merged into multiple layers because they contain several bands, especially the band 11. To achieve this, layer merging was performed. to reduce the effects of the atmosphere on the image radiometric correction was applied. Dust, clouds, or other parts in the atmosphere refract reflected light. Based on the refraction that occurs, radiometric correction was performed using a radiometric calibration tool before

image analysis. Subsequently, atmospheric correction was performed to remove brightness errors recorded in the image due to atmospheric scattering (path

3-4 Normalized Difference Vegetation Index (NDVI)

NDVI is calculated by combining the reflection in the red band and near-infrared band (NIR) using Equation 1 [9]

Electromagnetic spectrum MS), a healthy plant has a low reflectance in the red range and a high reflectance in the near-infrared range.

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

- Band 4 Red (0.64 - 0.67 μm) 30 m.
- Band 5 Near-Infrared (0.85 - 0.88 μm) 30 m

NDVI is usually used to distinguish between vegetated

radiation) using the Flash correction tool. All procedures were performed using ENVI 5 software.

and non-vegetated areas and it shown to give a strong indication of vegetation [10]. Vegetation index values range from -1 to +1, with values between -1 and 0 indicating non-vegetated areas such as bare surfaces, water bodies, and built-up areas. However, vegetated areas are represented by values greater than 0.

The primary objective of this step is to preserve only vegetated areas and isolate non-vegetated areas such as built-up areas, paved roads, and bare soil. (See the following table.)¹. The NDVI values and the greenness level of the plants are classified.

Table (1) Index Classification Levels NDVI

Classification Ranges	The greenness level of the vegetation
-1<NDVI<-0.03	Non-vegetation area, open area, waterbody
-0.03<NDVI<0.15	Lands

0.15 < NDVI < 0.25	Shrubs
0.35 < NDVI < 1	Healthy vegetables

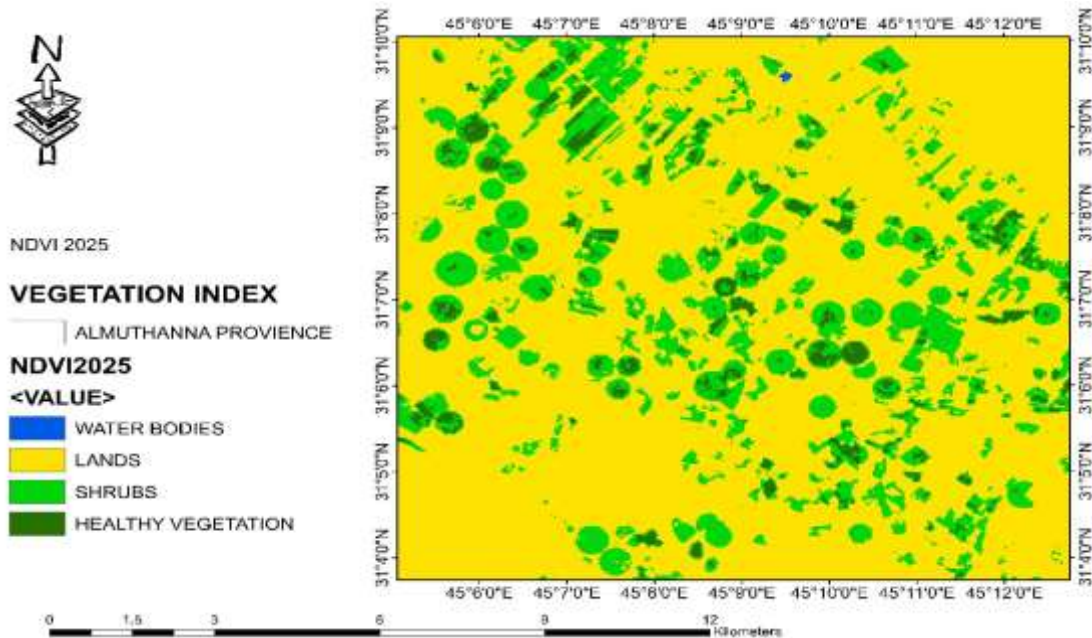


Figure (2). Application Map NDVI

Use Geographic Information Systems (GIS) software ArcGIS 10 is used for map production, specifically Spatial Analyst tools, to generate digital topographic maps for different years and identify patterns of topographic change using the Interpolation command within the Spatial Analyst group in the Toolbox.

As for calculating the areas, the number of The pixels in the satellite image and the area specified for the region are

determined by entering the equation $\text{count}/\text{sum} \times 100(\text{Count})$, through which the percentage of the total number of pixels is calculated, and then the areas for each of the classifications mentioned in the table of categories are determined by the equation $\text{Area pir} \times \text{surface}/100$, which represents the percentage of pixels multiplied by the area of the study polygon specified for this study.

4-Results and discussions

4-1 Normalized Difference Vegetation Index (NDVI) Calculation

Maps relating to the vegetation cover index were created (NDVI) for the years 2015 and 2025 in Al-Muthanna Governorate. The analysis results showed the following:

Table (2) (Classification limits NDVI) 2015

Symbol (Color)	Range	Label
Dark Blue	-0.316647112 - 0	WATER BODIES
Yellow	0 - 0.15	LANDS
Blue-Green	0.15 - 0.3	SHRUBS
Dark Green	0.3 - 0.549153149	HEALTHY VEGETATION

Each according to the subject classification and measurement the 2015 NDVI showed that Water Bodies were represented in blue, with negative values ranging from 0.316 to 0. Lands were represented in yellow, with values ranging from 0 to 0.15. Shrubs were represented in light green, with values ranging from 0.15 to 0.3. The final category was Healthy Vegetation, represented in dark green, with values ranging from 0.3 to 0.549.

Table (3) (2025 classification limits) NDVI

Symbol (Color)	Range	Label
Blue	-0.195416868 - 0	WATER BODIES
Yellow	0 - 0.15	LANDS
Light Green	0.15 - 0.3	SHRUBS
Dark Green	0.3 - 0.476337194	HEALTHY VEGETATION

While the ranking results showed The NDVI for 2025 shows the same distribution between values and symbols, but with a slight change in the extreme values of the categories. This indicates the validity of applying spectral reflectivity and data extraction, as the Water Bodies (in blue) remained in the same range between 0 and negative, while the Lands in yellow, goes between 0 and 0.15. The Shrubs results were

represented by light green between 0.15 and 0.3. Finally, Healthy Vegetation (dark green) ranged between 0.3 and 0.476.

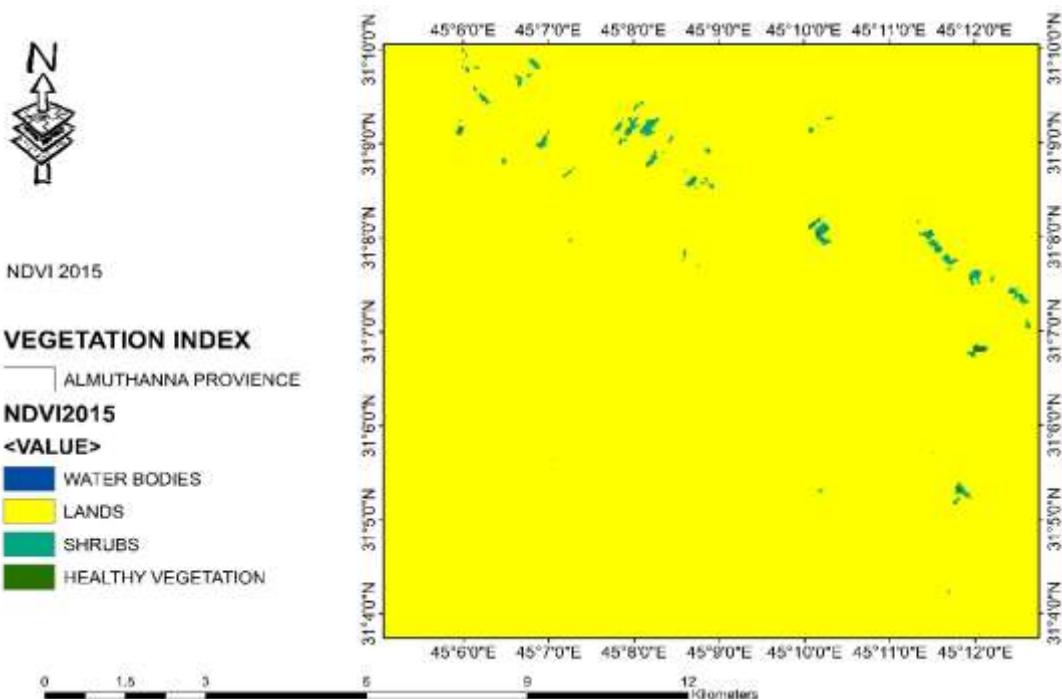
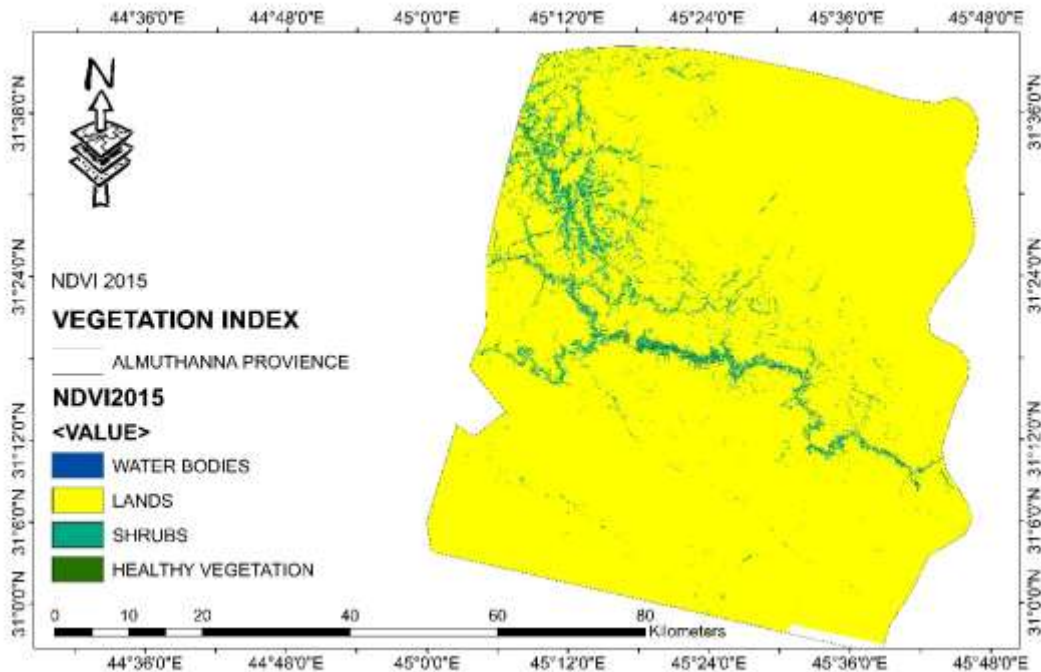


Figure (3) NDVI for 2015

We observe from general maps 2015 It contains the NDVI vegetation distribution where yellow dominates most areas (indicating land) with some blue lines indicating water (along rivers and water bodies).

While the maps of the year 2025 shows a slight change, with light green (shrubs) and dark green (healthy plants) appearing in some areas, indicating an increase in healthy vegetation cover compared to 2015.

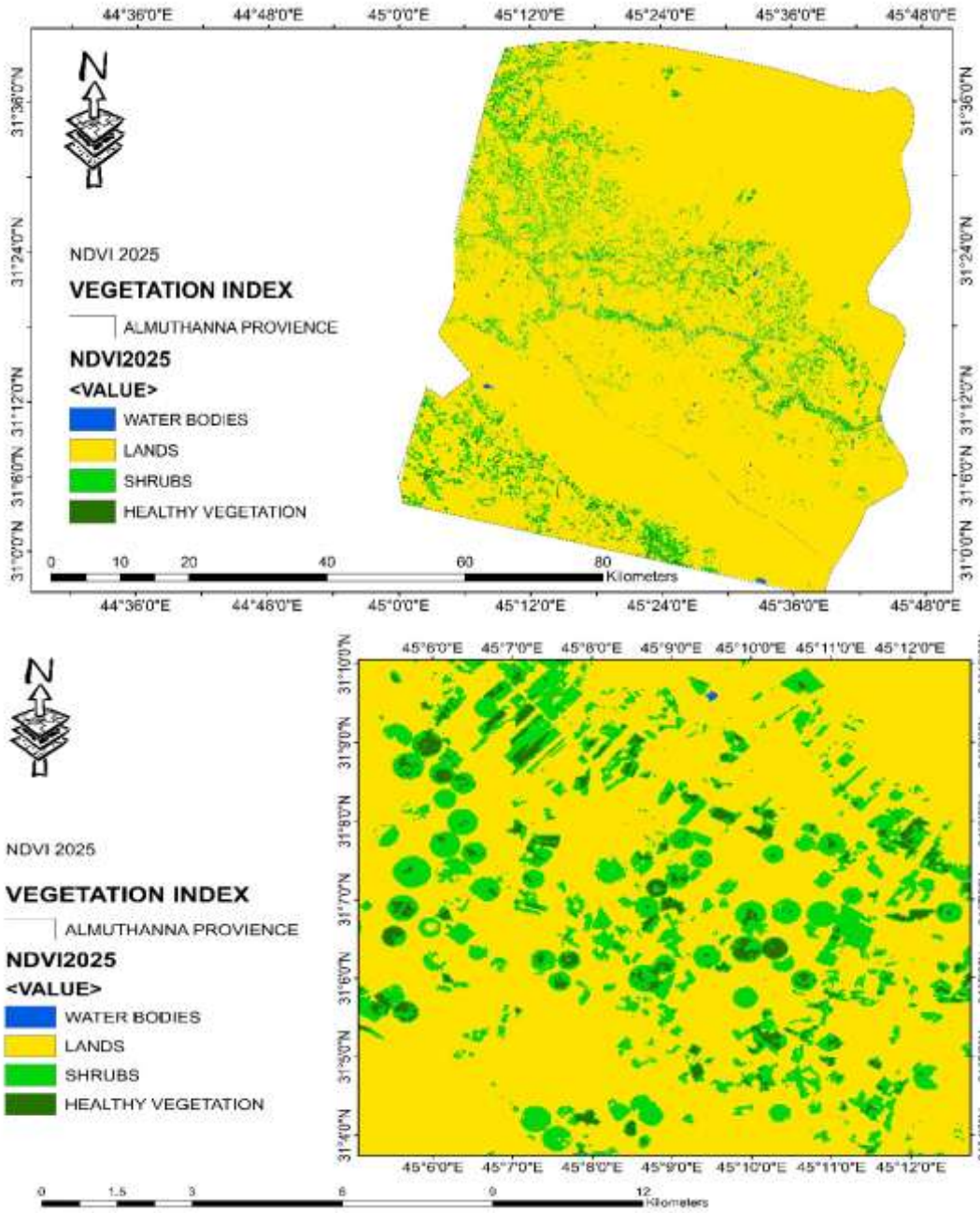


Figure (4) NDVI for 2025

These differences between the maps reflect the potential for improved vegetation cover in some areas over time, with an increase in shrubs and healthy plants at the expense of the surrounding land. The region was classified into four main categories based on the vegetation cover index. NDVI) for the year 2015, and this classification resulted in the following data:

Table (4) Area 2015 NDVI

AREA	PERCENTEGE	Count	Value	OBJECTID
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AREA	PERCENTEGE	Count	Value	OBJECTID
9.238673	0.195957	10226	1	1
4481.900876	95.06333	49608	2	2
211.389972	4.483686	23398	3	3
12.117966	0.257028	13413	4	4

Water represented a very small part of the area, with the area allocated for water being approximately 9.24 km², or just 0.2% of the total area. This indicates the presence of some bodies of water in the region, such as rivers or lakes, but they occupy a small area. Land, on the other hand, constituted the largest part of the region in 2015. This area represents about 95% of the total area, covering 4,481.9 km². These areas include uncultivated land or land with little vegetation cover.

While the Shrubs constituted approximately 4.5% of the area, covering approximately 211.39 km², was designated for healthy vegetation. This category represents areas with moderate vegetation cover, such as shrubs or small plants. Healthy vegetation comprised less than 1% of the area, covering approximately 12.12 km². These areas represent healthy and dense vegetation, such as large trees or plants that grow vigorously and healthily.

As for the year 2025, some changes occurred in the distribution of vegetation cover in the region. The results showed a change in the areas of the four selected classifications.

Table (5) Area 2025 NDVI

T

AREA	PIR	Count	Value	OBJECTID
18	0.379536	19846	1	1
4267	90.507307	47326	2	2
386	8.196102	42857	3	3
43	0.917055	47953	4	4

r area increased slightly in 2025 compared to 2015, reaching approximately 18 km², equivalent to 0.38% of the total area. This slight change in area suggests that water bodies may have been expanded or that there have been improvements in water distribution within the region.

Land still occupies the largest share of the area, but there is a slight decrease in the percentage compared to last year. In 2015, the land area was 4,287 km², representing 90.51% of the total area. This minor shrinkage indicates an increase in other types of vegetation, specifically shrubs, which axiom a significant rise compared to 2015. In 2025, the area dedicated to shrubs reached approximately 386 km², equivalent to 8.2% of the total area. This increase suggests greater growth in intermediate plants, such as shrubs, and an improvement in biodiversity. The latest classification of healthy plants has also increased significantly in the year by 2025, its area would reach 43 km², equivalent to 0.92% of the total area. Although this increase is small, it indicates an improvement in the health of the vegetation cover and an expansion of areas containing healthy plants.

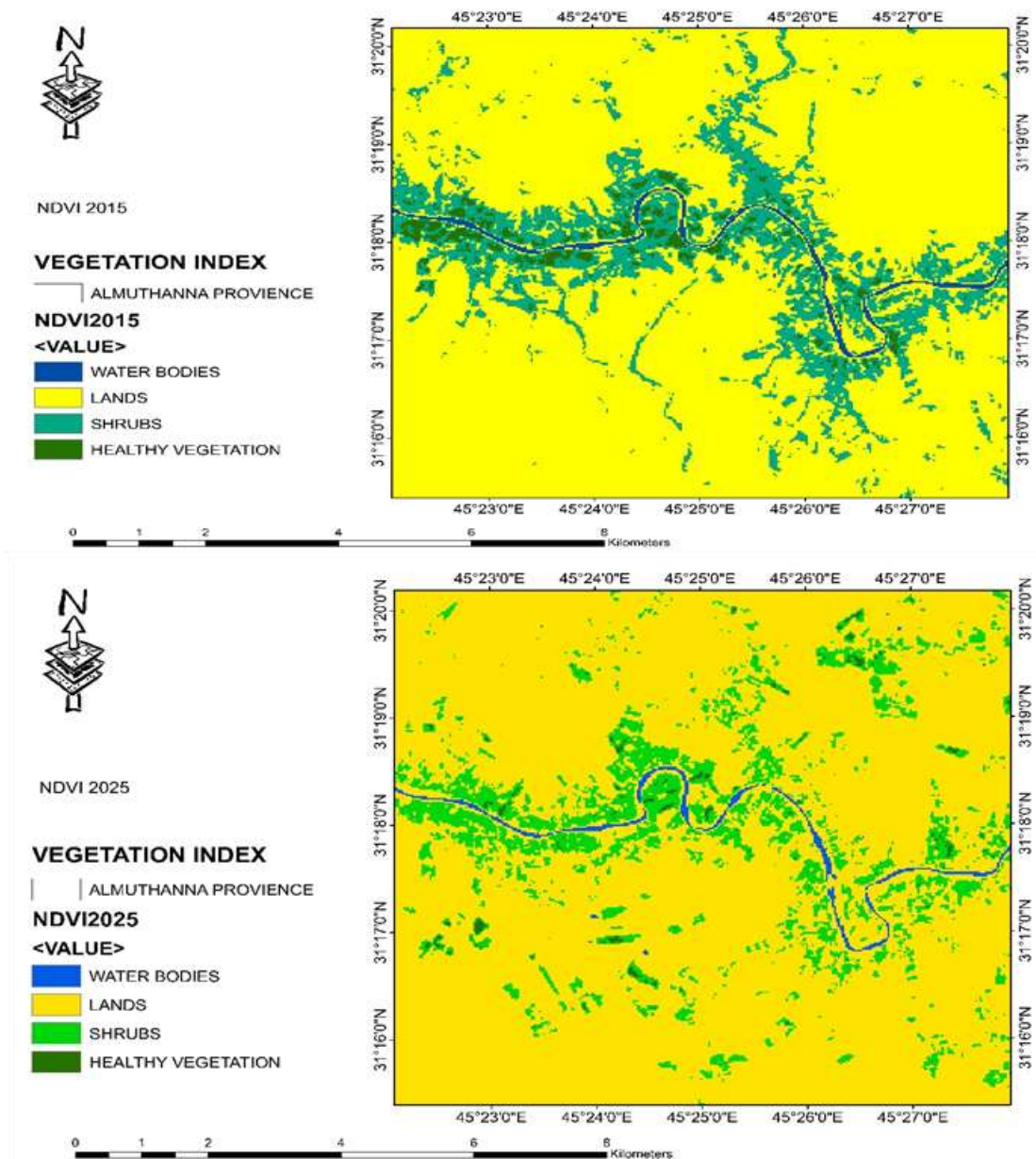


Figure (5) Comparison map between the results of 2015 and 2025

Comparing the results of the year in 2015 and 2025, we observe that in 2015, land was the dominant element in the region, with very little water. Shrubs and healthy plants were also very few compared to the land. However, in general 2025, there was a marked improvement in shrub and healthy plant cover compared to 2015. While arable land still constituted

5-1 Conclusions

Based on these results obtained from the study, the following can be concluded:

- 1- The region experienced a slight improvement in vegetation cover between the years 2015 and 2025, with an increase in the areas of shrubberies and healthy plants.
- 2- The percentage of the Shrubs increased from 4.5% to 8.2% of the total area, while healthy plants increased from 0.92% to 1.2%.
- 3- The importance of using geographic information systems in building a database specific to the region, especially the vegetation cover.
- 4- The proportion of non-vegetated land decreased from 95% to 90.51% between 2015 and 2025, indicating an improvement in the distribution of vegetation cover.
- 5- Water bodies represent a small percentage 0.2% (in the two years, indicating stability in the water in the region).

the majority of the area, the increase in shrubs and healthy plants indicated an improvement in environmental conditions, reflecting the potential for agricultural or vegetation improvement projects in the region. The slight increase in water availability may also indicate improved water resource management.

5-2 Recommendations.

- 1- Using remote sensing data to directly detect vegetation cover using the spectral ratio model and LMW, NDWI, and others, in addition to the FLAASH model, are used because of their high ability to collect the reflected light spectrum with very high accuracy, thus easily determining ground properties, as well as saving time and effort.
- 2- Utilizing the integration of remote sensing technologies and geographic information systems software Modern GIS in location-based information analysis, due to the superior ability of this technology to analyze, display, and present information accurately and quickly compared to conventional methods.
- 3- The study recommends developing projects to restore vegetation cover in areas that have experienced a decline in plant areas, such as uncovered land and plants.

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