



Temporal NDVI Trends and Productivity of Cereal Crops in Al-Anbar Governorate

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Abstract

The study area covered Al-Anbar governorate, specifically in the district of Ameriyat Al-Sumoud, Iraq, Plot 21/Al-Shamiya. The objective was to assess temporal variability using the normalized difference vegetation index (NDVI) and to evaluate the productivity potential of strategically cultivated cereal crops. A variation in the NDVI was observed based on the classification and interpretation of the index across the three reference years of 2005, 2015, and 2025. The results for the five NDVI classes showed the highest value for the "barren land" class in 2005 (71.44%), while the "severely degraded" (34.85%), "moderately degraded" (5.63%), "mildly degraded" (9.01%), and "not degraded" (9.81%) classes recorded their highest increases during 2025. The study indicates that vegetation class in 2025 was predominantly of high quality, covering 58.55% of the total study site area. Regarding land productivity potential, the "excellent" class increased in particular soil series, specifically DW85, DW46, and MW7, and represented 33.42% of the study area covering a total of 18,949.35 ha.

Keywords: NDVI, productive capacity, strategic crops, temporal variation

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Introduction

Anbar Governorate, particularly the Al-Shamiya region, is an arid area facing environmental and climatic challenges that impact the productivity of cultivated crops and, consequently, the degradation of large areas of these lands (10). Remote sensing, an effective tool for studying vegetation cover, reveals spatial and temporal variations in vegetation distribution and density with high accuracy. The use of spectral indices enables the assessment of soil fertility and enhances its productive efficiency (16). The normalized difference vegetation index (NDVI) is a major tool for evaluating the condition of vegetation cover, with a direct impact on agricultural productivity (7). (6) reported the use of satellite images captured by the Landsat

satellite to study changes in land use and vegetation cover in Kirkuk Governorate during 1987-2007, indicating changes in the percentage of vegetation cover and the type of land use over this period. The study emphasized that monitoring trends in vegetation cover, considered a successful method for tracking changes in land cover, yields beneficial results in interpreting and assessing changes in land use when satellite images of the region are available over several years.

The goal of land suitability analysis is to achieve sustainable and optimal use of natural resources (4, 9, and 18). Land evaluation studies also contribute to solving many of the problems facing Iraq, such as salinity, desertification, and water scarcity, by providing accurate scientific information that

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facilitate better agricultural, environmental, and management decisions. The most prominent of these is the optimal use of land and combating its degradation (17,28). According to (22), an effective crop production system requires proper planning and management of available land resources. The evaluation of land characteristics is essential for conducting agricultural activity (3).

A positive increase in vegetation status was observed in scattered areas of the Outvasn Plain and Barsin Depression physiographic units, primarily due to increased agricultural activities between 2008 and 2016, and to a lesser extent, the Depression, Old River Bed, and Oxbow Lake physiographic units, due to agricultural activities confined to specific areas. A study by (1) using software based on space data in Nineveh Governorate distinguished three degrees of degradation i.e., slight, medium, and severe, according to the desertification scale. In a study of some parts of the Kirkuk and Erbil plains (12), an apparent relative change was noted in the green agricultural areas through the use of the vegetation difference index, as its area reached 3,258 hectares (0.7%) in 2020 compared to 8,791 hectares (1.9%) in 2000.

A study by [14] on selected areas in Ramadi Island revealed variations in the productivity of soil series, which were divided into five categories depending on the specific factor and its intensity. The categories comprised excellent productivity (29.12% of the total area), good productivity (49.30%), and medium productivity (5.75%), while the two categories with poor and very poor

productivity comprised 13.92%. The study by [13] indicated that the integration of remote sensing techniques with multi-source indicators represents an effective tool for assessing land degradation. This enables the monitoring of effects resulting from human activities and climate change with high accuracy, making it a fundamental pillar in formulating sustainable management strategies aimed at protecting land resources and enhancing their long-term sustainability. Therefore, this study aims to demonstrate the geographical distribution, determine the temporal variation of plant cover types and areas, and evaluate their productive capacity for growing strategic crops.

Materials and Methods

Location and selection of the study area

The study site in District 21/Al-Shamiya-Iraq within the administrative boundaries of Ameriyat al-Sumoud District, Anbar Governorate was selected due to its unique location in terms of agricultural exploitation and strategic crop production. It lies between longitudes 33°18'00" and 33°00'00" east and latitudes 33°00'00" and 43°39'00" north, and within the 169th row, 37th path, according to the Iraq Aerial Photograph Atlas and the Landsat 7.8 satellite path. The 56,700.63-ha area is bordered to the north by the districts of Fallujah and Ameriyat Al-Sumoud, to the east by the Euphrates River, to the west by Lake Habbaniyah and Lake Razzaza, and to the south by Al-Musayyab District (Figure 1). Geomorphological features, represented by a range between two rivers, were distinguished in the study area (11).

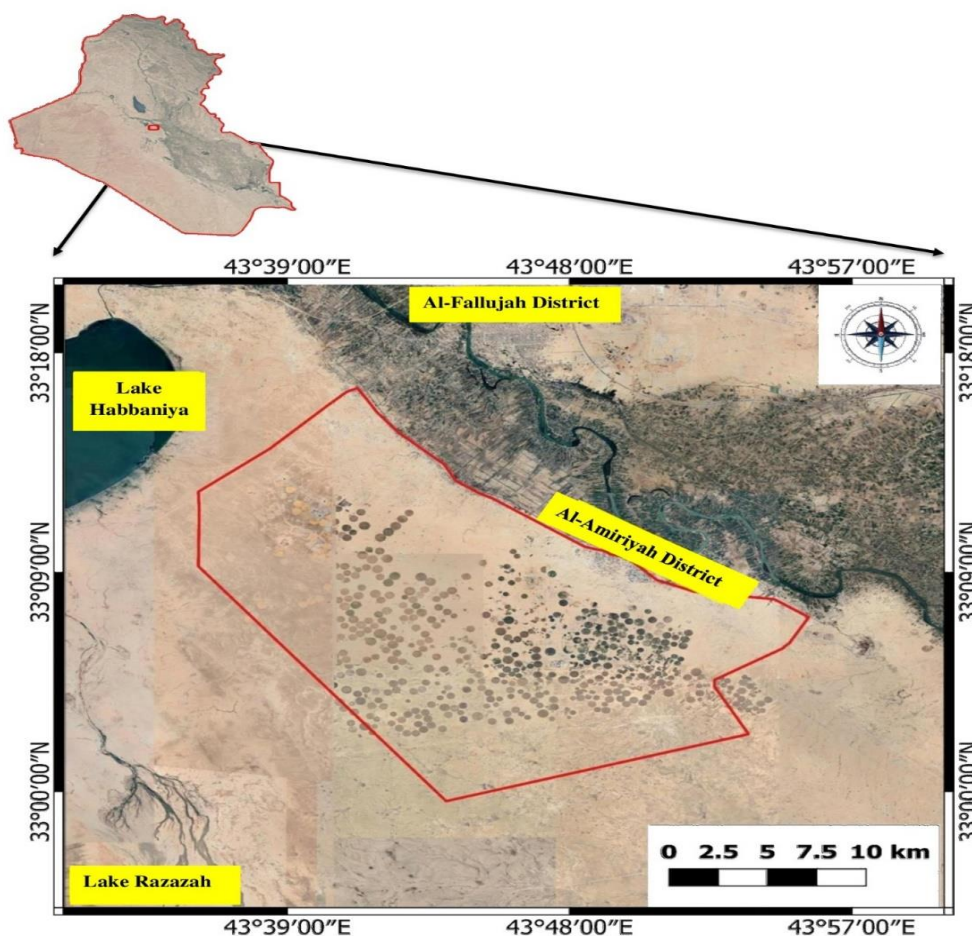


Figure 1. The study area within the map of Iraq

Climate

The climate of the study area is semi-arid, characterized by a long, hot, and dry summer and a cold, rainy winter. The humidity regime of the study area is classified as arid (aridic) due to the soil remaining dry for more than 90 days continuously (26), in addition to the differences between the average temperatures of the summer and winter months, which exceed 5 °C.

Remote Sensing Data

A satellite image was obtained from the Landsat 7 and 8 satellites. The extracted image was merged by performing geometric corrections on the sensor's spectral bands (ETM+) and then entered into ERDAS Imagine 9.3 software to obtain a single image of the spectral bands (1, 2, 3, 4, 5, 6, 7) with a

spatial resolution of 28 m. Using the mapping results of the indices applied in the study area for each year, areas with variation rates in these indices were extracted, and the land productivity of the area was estimated for some strategic crops. Soil degradation was studied using geospatial techniques, with three different years (2005, 2015, and 2025) selected for the study area, specifically in March. For this purpose, six sites were randomly selected to examine cultivated fields within the study area. Study samples were obtained, air-dried, and then passed through a 2 mm sieve for physical measurements, such as texture, apparent and true density, porosity, soil depth, and chemical analyses, including measurements of calcium carbonate, gypsum, pH, cation exchange capacity, and ECe.

Normalized Difference Vegetation Index (NDVI)

The NDVI index, which is equivalent to the simple ratio index proposed by (20) and derived from the ratio of the difference between the near-infrared (NIR) and red-light

bands to their sum, was calculated, as shown in Equation 1. Reflectance values from the satellite images of the Landsat 7 ETM+ sensor were used. A comparison was made to determine the changes in vegetation cover values that occurred during the study years.

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

Where:

B: Band

B4: Fourth spectral band

B5: Fifth spectral band

NIR: Infrared

RED: Red

Table 1 (23) on the classification of vegetation density and its degree of

degradation offers a deeper understanding of vegetation cover state within the study area.

Table 1. Ranges for the NDVI

NDVI value range	Vegetation Density	Degree of Deterioration
Negative values	Barren	Very severe or barren
0.0 - 0.19	Sparse	Severe
0.2 - 0.49	Medium	Moderate
0.5 - 0.79	Good	Mild
0.8 - 1.0	Very dense	None

Vegetation Quality Index (VQI)

This index was calculated based on several criteria and sub-indices, as shown in Table 2, and using the following equation:

$$VQI = (Plant\ cover \times Erosion\ protection \times Drought\ resistance)^{1/3} \quad (2)$$

Where:

Plant cover: The value of the vegetation cover index

Erosion protection: The value of the erosion index

Drought resistance: The value of the drought resistance index

Plant cover calculated based on the soil map units and the area occupied by the plant cover relative to its area, as in the equation:

$$\% \text{ plant cover} = \frac{\text{area of vegetation cover}}{\text{area of soil mapping unit}} \times 100 \quad (3)$$

A value of NDVI of less than 0.1 was adopted to represent the line separating agricultural and non-agricultural lands, as shown in (4). Fallow soils are represented by 0-0.1. (23) indicating that the value of natural difference in vegetation, which ranges between 0.1 and 0.2, represents the lowest value in vegetation cover. As for secondary indicators

such as the erosion and the drought conditions comparison indices, in addition to the environmental conditions that characterize Iraq, especially the study area, some characteristics and indicators were added that represent saline and abandoned lands. The calculations are presented in Tables 2 - 5.

Table 2. Types, description, and ranges of vegetation coverage index values

Class	Description	Plant Cover (%)	Index Value
1	High	> 40	1
2	Low	10-40	1.8
3	Very low	< 10	2

Table 3. Types, descriptions, and ranges of erosion index values

Class	Description	Vegetation Type	Index Value
1	High	Evergreen perennial crops (olives)	1
2	Moderate high	Deciduous perennial crops (almond orchards)	1.2
3	Moderate	Annual crops (cereals) & annual grasslands	1.4
4	Low	Bare & saline lands	1.6

Table 4. Types, description, and duration of drought resistance index values

Class	Description	Vegetation Type	Index Value
1	Very high	Conifers, deciduous, olives	1
2	High	Perennial agricultural trees (vines almond orchards)	1.2
3	Moderate	Perennial grasslands	1.4
4	Low	Annual crops & annual grasslands	1.6
5	Very low	Bare & saline lands	1.8

Table 5. Types, descriptions, and ranges of values of the vegetation cover quality index

Class	Description	Vegetation Type	Index Value
1	Very high	Conifer & deciduous olives	1
2	High	Perennial agricultural trees (vines almond orchards)	1.2
3	Moderate	Perennial grasslands	1.4
4	Low	Annual crops & annual grasslands	1.6
5	Very low	Bare & saline lands	1.8

Productivity Index

The productivity index is based on the equation proposed by (25, 19), as follows:

$$X = Pmax * \sqrt{\frac{y1}{100} * \frac{y2}{100} * \frac{y3}{100} * \frac{y4}{100} * \frac{y5}{100} * \frac{y6}{100} * \frac{y7}{100} \dots \frac{yn}{100}} \dots \dots (4)$$

Where:

- y1: Lime content
- y2: Soil texture
- y3: Salinity
- y4: Soil depth
- y5: Gypsum content
- y6: Drainage status
- Pmax = 100

-0.175 to 0.618, while for 2015 and 2025 they were between -0.363 to 0.456 and -0.236 and 0.547, respectively. Table 6 shows some stability in the NDVI between the study area locations. NDVI values <0.1 were adopted to represent non-vegetation land features, such as barren lands, water bodies, and residential areas, while values >0.1 represent vegetation cover, according to (23). The map for this guide was classified into five land cover categories.

Results and Discussion

Normalized Difference Vegetation Index (NDVI)

Figures 2 - 4 illustrate the NDVI in the study area for 2005, 2015, and 2025. The results indicated variation in the type and area of vegetation cover, as seen in the index values. In 2005, the NDVI values ranged from

The results of this classification showed barren areas for the years 2005, 2015, and 2025 at 71.44%, 63.05%, and 49.17%, respectively. The vegetation difference maps in Figures 7 – 9, show an apparent increase in green

agricultural areas. Barren areas comprised 40,509.45 ha, representing 71.44% of the total area, in 2005, but decreased to 35,751.15 ha (63.05%) in 2015 and to 27,879.12 ha (49.17%) in 2025. This is due to the

development of administrative systems, the increase in agricultural operations, and the adoption of agricultural rotation measures in the region during the study years.

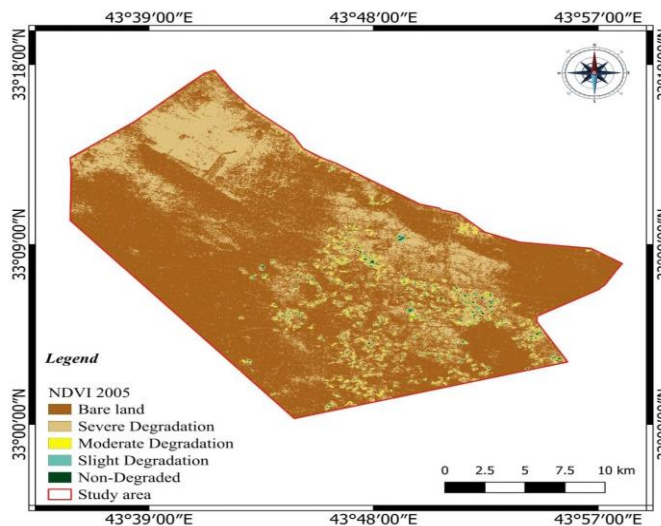


Figure 2. Normalized difference vegetation index map, 2005

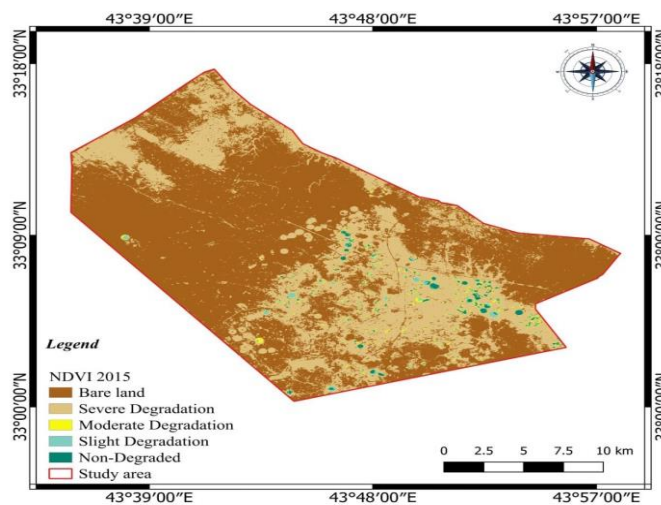


Figure 3. Normalized difference vegetation index map, 2015

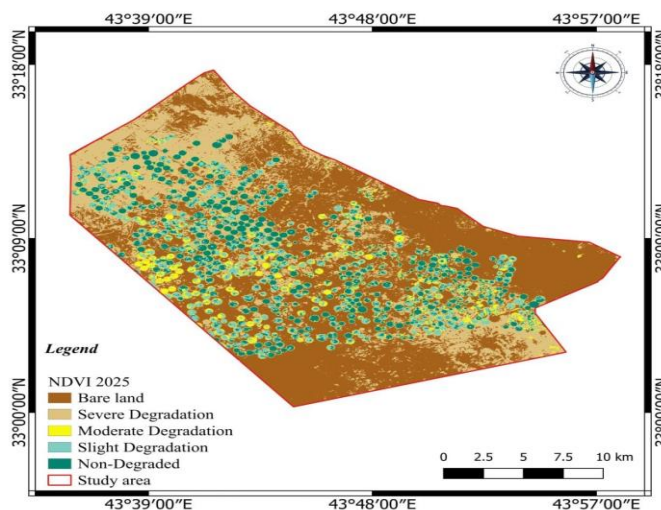


Figure 4. Normalized difference vegetation index map, 2025

Table 6. Areas and ratios of NDVI for 2005, 2015, and 2025

Class	2005		2015		2025		Difference	
	Area ha.	%	Area ha.	%	Area ha.	%	Area ha.	%
Barren	40509.45	71.44	35751.15	63.05	27879.12	49.17	-23120.82	-40.78
Severely degraded	14799.96	26.1	14958.09	26.38	19761.84	34.85	-19919.97	-35.13
Moderately degraded	817.65	1.44	425.11	0.75	3194.75	5.63	-2802.21	-4.94
Mildly degraded	387.93	0.7	416.38	0.73	5107.72	9.01	-5136.17	-9.04
Not degraded	185.64	0.32	346.15	0.62	5560.95	9.81	-5721.46	-10.11
Total	56700.63	100	56700.63	100	56700.63	100	-56700.63	-100

The second category (severe deterioration) reached its highest value in 2025, accounting for 34.85% of the study area, or 19,761.84 ha. The moderate deterioration category occupied the largest area, at 5.63%, in 2025, followed by 2005 at 1.44%, and the lowest at 0.75% in 2015. This is due to the abandonment of lands during military operations in the study area. Mild deterioration areas registered a higher percentage in 2025 than in 2015 and 2005, increasing from 0.70 to 9.01%, while land that did not degrade increased from 0.32% in 2005 to 9.81% in 2025.

Nevertheless, the fact that agricultural lands are not used for agriculture does not prevent their degradation as there were high levels of salinity in some of the study areas, in addition to the lack or scarcity of natural vegetation in

most locations. These areas, identified through screen digitizing using satellite images, showed evidence of engineering or agricultural activity. This finding is consistent with the results reported by (7,8).

Vegetation Quality Index

Table 7 and Figures 5 – 7 show that the vegetation quality index was high in 2025, covering 33,198.22 ha or 58.55% of the total area. However, it was low in 2005 and 2015, covering 2,976.78 and 9,400.96 ha, representing 5.25% and 16.58%, respectively. This variation in the area between the two types was due to temporal fluctuations from human administrative processes, as well as natural conditions affected by erosion. The increase in this index for 2025 is due to the

noticeable increase in land exploitation for agricultural purposes in various areas of the study area, as well as the adoption of modern

irrigation systems in agricultural operations. These results were consistent with those reported by (24).

Table 7. Temporal variations in the areas of the vegetation cover index categories for 2005, 2015, and 2025

Class	2005		2015		2025		Difference	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
High	2976.78	5.25	9400.96	16.58	33198.22	58.55	-39622.4	-69.88
Moderate	0	0	0	0	0	0	0	0
Low	53723.85	94.75	47299.67	83.42	23502.41	41.45	-17078.23	-30.12
Total	56700.63	100.00	56700.63	100.00	56700.63	100.00	-56700.63	-100.00

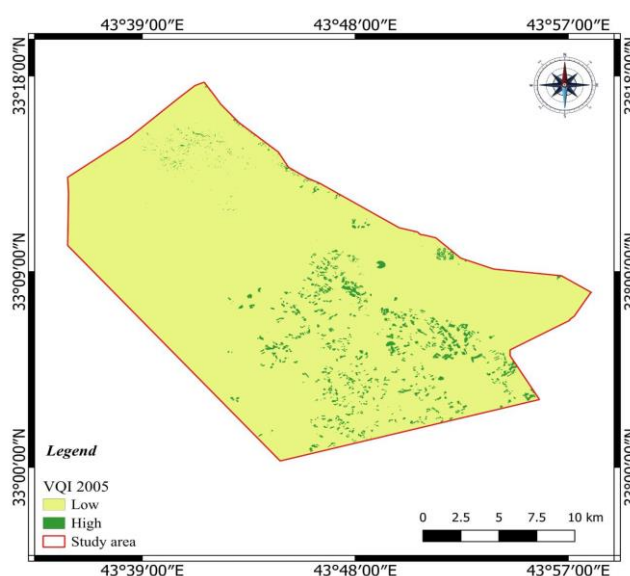


Figure 5. Vegetation quality index map, 2005

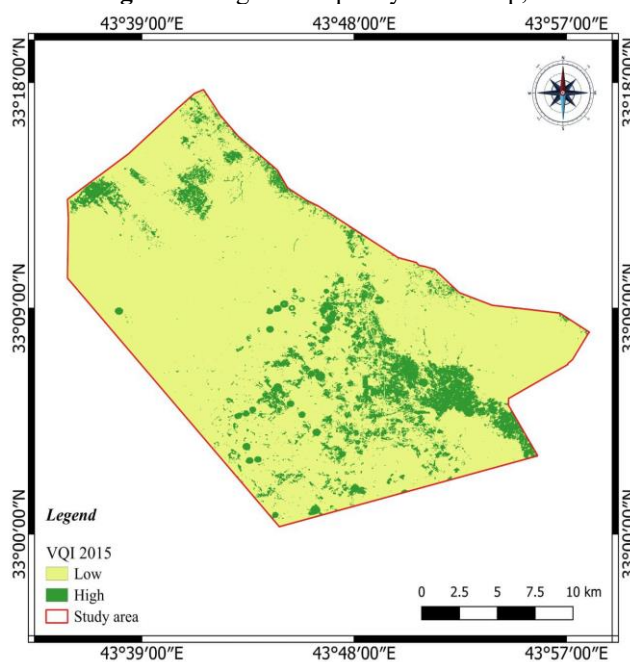
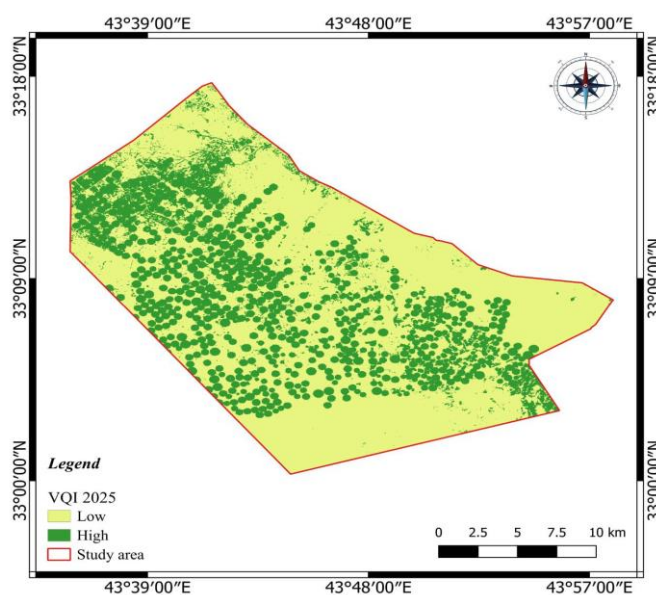


Figure 6. Vegetation quality index map, 2015**Figure 7.** Vegetation quality index map, 2025

Productivity Index

The soil series varied in their productivity according to several categories based on the type and intensity of the range. These included series with excellent productivity, distributed over a range of 64 to 100. This category of soils occupied 18,949.35 ha, representing 33.42% of the total area, and were distributed among the DW46, MW7, and DW85 soil series. These soil series were characterized by low salinity, and low gypsum and carbonate contents, due to their depth and good drainage. The absence of constraints characterizes these soils, which are suitable for growing all crops and require simple management processes based on their climatic suitability.

The second category, characterized as good productivity, occupied 2,622.04 ha and accounted for 46.25% of the total study area. The DW76 soil series, distributed over a range of 34-64, represented the index range of this category. This is attributed to the high percentage of carbonates and the presence of one or more determinants in the class, which is of good productivity and suitable for most crops. According to climatic suitability and the quality of irrigation water, the third-class soil series of medium quality was distributed in the 19-34 range. They covered 2046.893 ha or

3.61% of the total area, and included the DW44 soil series because of its determinants, which are high calcium carbonates in addition to high salinity. This makes it medium determinants suitable for certain types of crops and gives good production depending on the management method employed.

The fourth type, characterized by poor productivity, included the DW87 series, which occupied 9,480,345 ha, representing 16.72% of the total area. The range of evidence for this type is 7-19 series. These soils have high gypsum content, in addition to high soil salinity, which is a key factor in determining the selection of crop types and the appropriate management methods for the region. It is noted that this soil type is characterized by the presence of many determinants that make it unsuitable for many crops and requires the overlap of exploitation of this series.

It also requires appropriate management processes and the reclamation of saline lands to increase the productivity of these lands, provide good water source, and prevent the degradation processes so that this area is not lost as productive land Table 8 and Figure 8. The absence of the fifth type (not good) in the study area is due to the adoption of special management processes represented by the use of sprinkler irrigation systems when planting

crops according to climatic suitability. This finding is consistent with those reported in (5, 25, 27).

Table 8. Classification of soil series according to the productivity index

Class	Series	Index Range	Class Type	Area (ha)	Percentage
1	Dw85, Dw46, Mw7	64 - 100	Excellent	36651.54	64.64
2	Dw76	34 - 64	Good	8521.85	15.03
3	Dw78	19 - 34	Moderate	9480.345	16.72
4	Dw44	7 - 19	Poor	2046.893	3.61
5		0-7	Very Poor	0	0
Total				56700.63	100

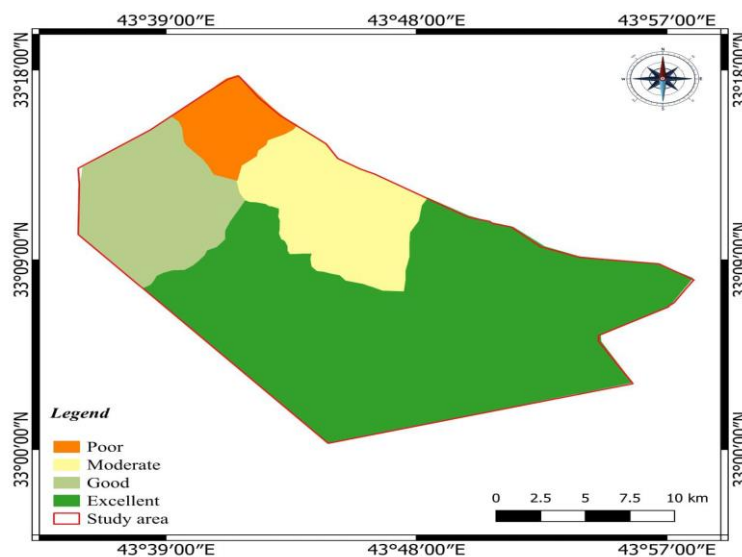


Figure . Productivity guide map of the study area

Conclusion

The use of spectral indices has proven to be an effective tool in assessing soil degradation and vegetation dynamics in arid and semi-arid environments. The observed temporal changes in vegetation cover, particularly the improvements noted in 2025, reflect the positive impact of modern irrigation systems and agricultural expansion. The NDVI values demonstrated clear spatial and temporal variability, aligning closely with field conditions and soil productivity indicators.

The significant increase of 33.42% in the productivity index, especially in soil series such as MW7, DW46, and DW85, highlights the critical role of the physical and chemical properties of soils, such as low salinity, sufficient depth, and good drainage, in supporting sustainable agriculture. In contrast,

soils with high salinity, gypsum, or calcium carbonate content (e.g., DW87 and DW44) exhibited lower productivity levels.

These findings emphasize the importance of site-specific soil management strategies. Areas with favorable soil conditions should be prioritized for agricultural development, while degraded areas require targeted reclamation efforts. The key takeaway from this study is that integrating spectral indicators with soil classification can guide decision-makers in optimizing land use planning and implementing sustainable soil management practices in fragile ecosystems.

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التغيرات الزمنية لمؤشر الاختلاف الغطاء النباتي وإنتاجية (محاصيل الحبوب) في محافظة الأنبار

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الخلاصة

اختيرت منطقة الدراسة ضمن محافظة الأنبار قضاء عامرية الصمود مقاطعة ٢١/الشامية الواقعة بين خطي طول (33°18'00" و 33°00'00") شرقاً ودائرتي عرض (44°57'00" و 43°39'00") شمالاً وبمساحة بلغت (٥٦,٧٠٠.٦٣ هكتار). لبيان التغيرات الزمنية باستخدام دليل NDVI والقابلية الإنتاجية للمحاصيل الاستراتيجية المزروعة. لوحظ تغيرات لمؤشر الغطاء النباتي حسب تقييم وصف الدليل وللسنوات الثلاثة (٢٠٠٥ و ٢٠١٥ و ٢٠٢٥) والتي اعتمدت فيها على خمسة اصناف. اذ تبين النتائج ان اعلى قيمة لهذا الدليل سجل عند صنف اراضي الجرداء خلال ٢٠٠٥ (71.44%). اما صنف التدهور الشديد (34.85%) وصنف التدهور المعتدل (5.63%) وصنف التدهور الخفيف (9.01%) وصنف الغير متدهورة (9.81%) قد بلغت اعلى زيادة له خلال ٢٠٢٥ تشير الدراسة الى ان صنف نوعية الغطاء النباتي كانت ضمن الصنف العالي النوعية في عام ٢٠٢٥ بنسبة ٥٨.٥٥ % من المساحة الكلية لمنطقة الدراسة اما من حيث قابلية الانتاجية للأراضي نلاحظ زيادة الصنف الممتاز لبعض سلاسل منطقة الدراسة وهي (٨٥DW و ٤٦DW و ٧MW) بنسبة ٣٣.٤٢% وبمساحة ١٨٩٤٩.٣٥ هكتار.

كلمات مفتاحية: التغيرات الزمنية، القابلية الإنتاجية، المحاصيل الاستراتيجية، دليل الإختلاف في الغطاء النباتي.

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