

Suitability and Feasibility Assessment of Land Cover in Rawah District During the Wet Season (2004–2024)

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Abstract

This study evaluates the spatial suitability and land capability of land cover in Rawah District during the wet season from 2004 to 2024. Utilizing Remote Sensing (RS) and Geographic Information Systems (GIS) techniques, the research establishes a comprehensive framework based on a set of natural and anthropogenic criteria, including land use, soil characteristics, water resources, and climatic factors. These parameters were analyzed to delineate the levels of spatial suitability and land capability across both the wet and dry seasons. The findings reveal a pronounced spatial variation in suitability and capability to degrees throughout the district. Areas exhibiting high spatial suitability and land capability are predominantly concentrated near the Euphrates River and within the alluvial plains. Conversely, these levels decline significantly in zones remote from water sources and are heavily affected by aridity. Furthermore, GIS techniques proved instrumental in generating highly accurate spatial maps that track the spatiotemporal dynamics of the land cover. This integration delivers a rigorous scientific database essential for supporting environmental planning and fostering the sustainable utilization of natural resources in Rawah District, Al-Anbar Governorate.

Keywords: Spatial Suitability, Land Capability, Land Cover, Wet Season

Introduction

Land evaluation refers to estimating land efficiency and effectiveness when utilized for a specific purpose. This encompasses all methods and tools that demonstrate or predict the current and future productive capacity of the land. This process relies on conducting comprehensive studies, including the analysis of soil characteristics, prevailing climate, topography, vegetation cover, and other geographical features. Land evaluation is based on two fundamental concepts: (spatial suitability and land capability). The ultimate goal of this study is to enable optimal land exploitation while ensuring the conservation of its natural resources and protecting them from long-term degradation. In evaluating the land cover within the study area, this research relied on (qualitative evaluation), which entails assessing land viability and response to various uses, categorizing them into multiple levels, including very low, low, moderate, etc.

Research Problem

What is the nature of the spatial and temporal variation in the levels of spatial suitability and land capability of land cover in Rawa District during the period (2004–2024)? Furthermore, what is the impact of natural factors—namely soil, water, climate, and land use—on this variation?

Research Hypothesis

There is a distinct spatial and temporal variation in the levels of spatial suitability and land capability in the Rawa District during the period (2004–2024). This variation is directly linked to the availability of water resources, soil characteristics, climatic factors, and land use, leading to the concentration of areas with high spatial suitability and land capability near the Euphrates River, and their decline in more distant areas.

Research Methodology

The study adopted a (spatial analytical approach) utilizing Remote Sensing (RS) techniques and Geographic Information Systems (GIS). Data regarding land use, soil, water resources, and environmental indices were collected and processed. Subsequently, spatial analysis and overlay operations were performed to generate spatial suitability and land capability maps for the wet season during the years 2004 and 2024. The results were classified into varying categories (high, moderate, low, and very low) to interpret the spatial variation of land cover in Rawa District.

Research Objectives

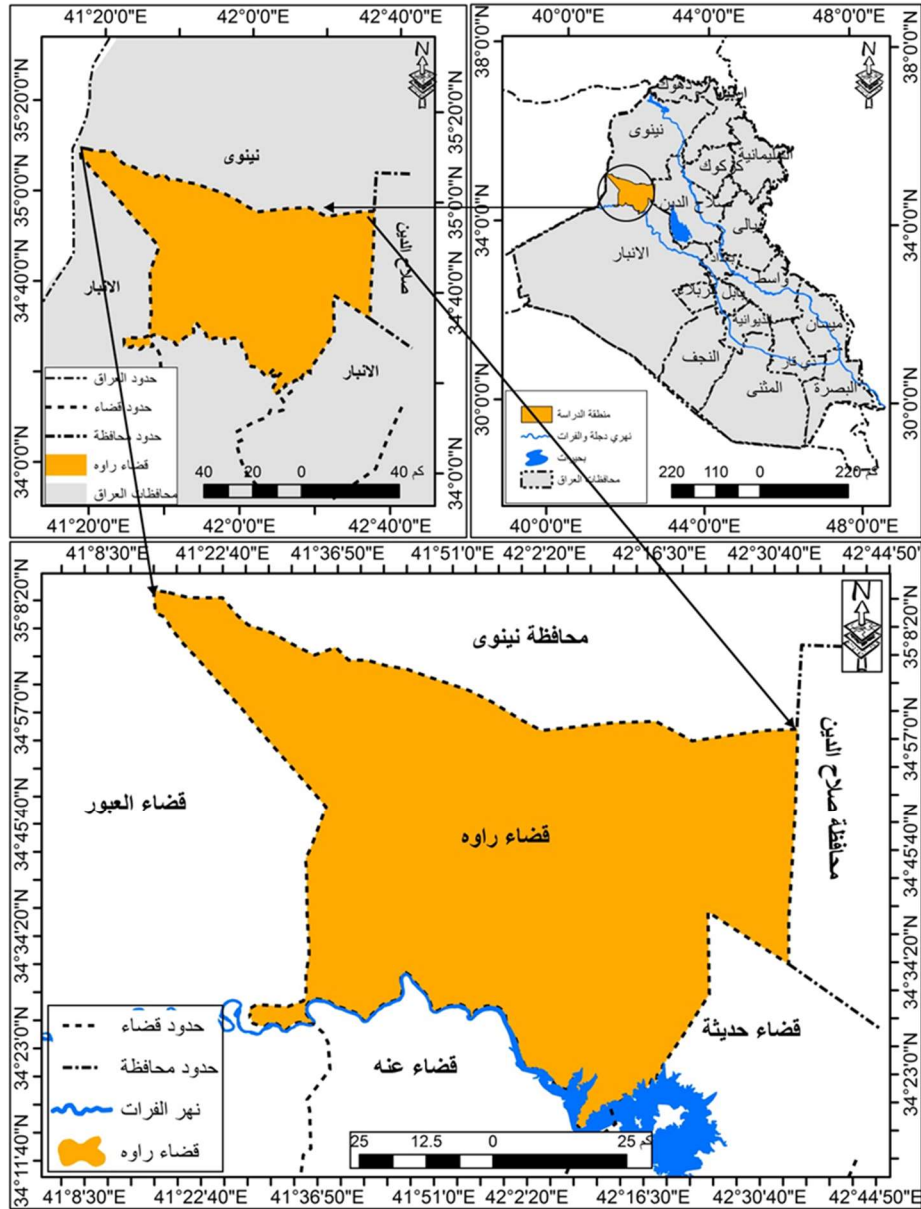
1. To evaluate the spatial suitability and land capability of land cover in Rawa District during the wet season for the period (2004–2024).
2. To analyze the impact of natural and human factors on the variations in suitability and capability.
3. To produce spatial maps illustrating the levels of spatial suitability and land capability using Geographic Information Systems (GIS).
4. To provide an information database that supports environmental planning and sustainable management of natural resources in Rawa District.

Location of the Study Area

The study area is located within the northern and northwestern parts of Al-Anbar Governorate. The administrative boundaries of Rawa District extend between latitudes $34^{\circ}15'30''$ and $35^{\circ}09'00''$ North, and longitudes $41^{\circ}17'35''$ and $42^{\circ}30'43''$ East.

Geographically, it is bordered by Nineveh Governorate to the north, the administrative boundaries of Ana and Al-Qaim districts to the south, and Al-Qaim district to the west. To the east, it is bordered by Haditha district and Salah Al-Din Governorate, as illustrated in Map (1). Furthermore, Rawa District is situated on the northern bank of the Euphrates River, covering a total area of $5,844.84 \text{ km}^2$.

Map (1): Location of the Study Area



Source

Republic of Iraq, Ministry of Water Resources, General Directorate of Surveying, Administrative Map of Iraq 2026, Scale (1:1,000,000); Administrative Map of Anbar 2026, Scale (1:500,000); and outputs of ArcMap 10.8 software.

Constructing the Spatial Suitability Map for Rawa District

Spatial suitability is a vital indicator used to determine the viability of the natural environment for various land uses, based on climatic elements, soil, water, and topography. Accordingly, a spatial suitability map was constructed based on land cover indices in Rawa District during the wet season for the period 2004–2024. The prevailing climatic conditions in Rawa District revealed a decline in rainfall, rising temperatures, and increased evaporation rates. These factors led to a regression in areas with dense vegetation cover and

an increase in desertification indicators within the study area. Furthermore, environmental suitability levels varied spatially according to the distribution of natural resources and surface characteristics within the district.

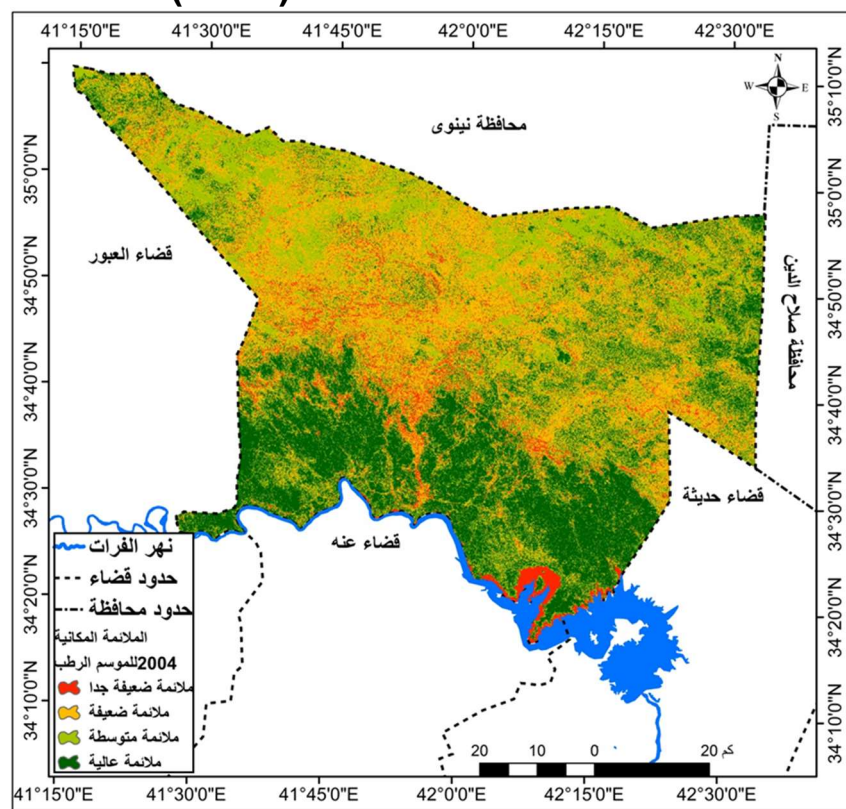
Constructing the Spatial Suitability Map for the Wet Season in Rawa District

Based on criteria including land use patterns, soil distribution, and available water sources, the study analyzed the environmental variation and its geographical distribution in Rawa District during the wet season for the period between 2004 and 2024, as detailed below:

Spatial Suitability for the Wet Season in Rawa District (2004)

According to Table (1) and Map (2), the study area during the 2004 wet season was classified into four categories based on a set of criteria. The most prominent criteria included natural vegetation, land use patterns, soil distribution, and the availability of water suitable for various uses, alongside environmental risk levels, categorized as follows:

Map (2): Spatial Suitability Levels for the Wet Season in Rawa District (2004)



Source

Based on spectral indices of data and outputs of ArcGIS 10.8 software.

Table (1): Spatial Suitability Levels for the Wet Season in Rawa District (2004)

No.		Area (km ²)	Percentage (%)
1	Very Low Suitability	396	6.73
2	Low Suitability	1794.60	30.70
3	Moderate Suitability	1824.58	31.22
4	High Suitability	1829.66	31.30
Total	5,844.84		100

Source

Based on Map (2) data.

1. Very Low Suitability

This category is distributed across narrow and critical zones, specifically along the southern fringes near Haditha Lake. This limited concentration in sensitive areas indicates the presence of harsh environmental obstacles—such as severe salinization or challenging cliff slopes—that entirely impede any utilization. Its minor spatial distribution does not diminish its severity; rather, it represents ecologically dead spots within the geographical domain. This level covers an area of 396.00 km², equivalent to 6.78% of the total district area.

2. Low Suitability

The distribution of this category takes a scattered or fragmented pattern amidst areas of moderate suitability. Its appearance in this manner indicates the presence of localized limiting factors, such as the existence of rocky plateaus, poor soil, or areas with highly dissected topography that prevent it from ascending to the moderate suitability class. This non-contiguous distribution implies that the constraints here are natural factors, irregularly distributed across the landscape. This level covers an area of approximately 1,794.60 km², accounting for 30.70% of the district's total area.

3. Moderate Suitability

This class is characteristically distributed across the northern and central zones of the district. These areas reflect a state of environmental equilibrium; although they lack direct access to permanent water bodies, they retain natural characteristics that qualify them to support specific patterns of seasonal vegetation cover, relying on rainfall during the wet season. The lands of this level are characterized as highly suitable for rain-fed agriculture, alongside their viability as natural rangelands. They are represented by sedimentary soils deposited in the valleys spanning Rawa District that drain toward the Euphrates River, meaning they mostly concentrate at valley mouths and slopes. Their proximity to the river enhances their significance, in addition to containing groundwater suitable for human consumption. These lands extend over an estimated area of about 1,824.58 km², constituting 31.22% of the total study area.

4. High Suitability

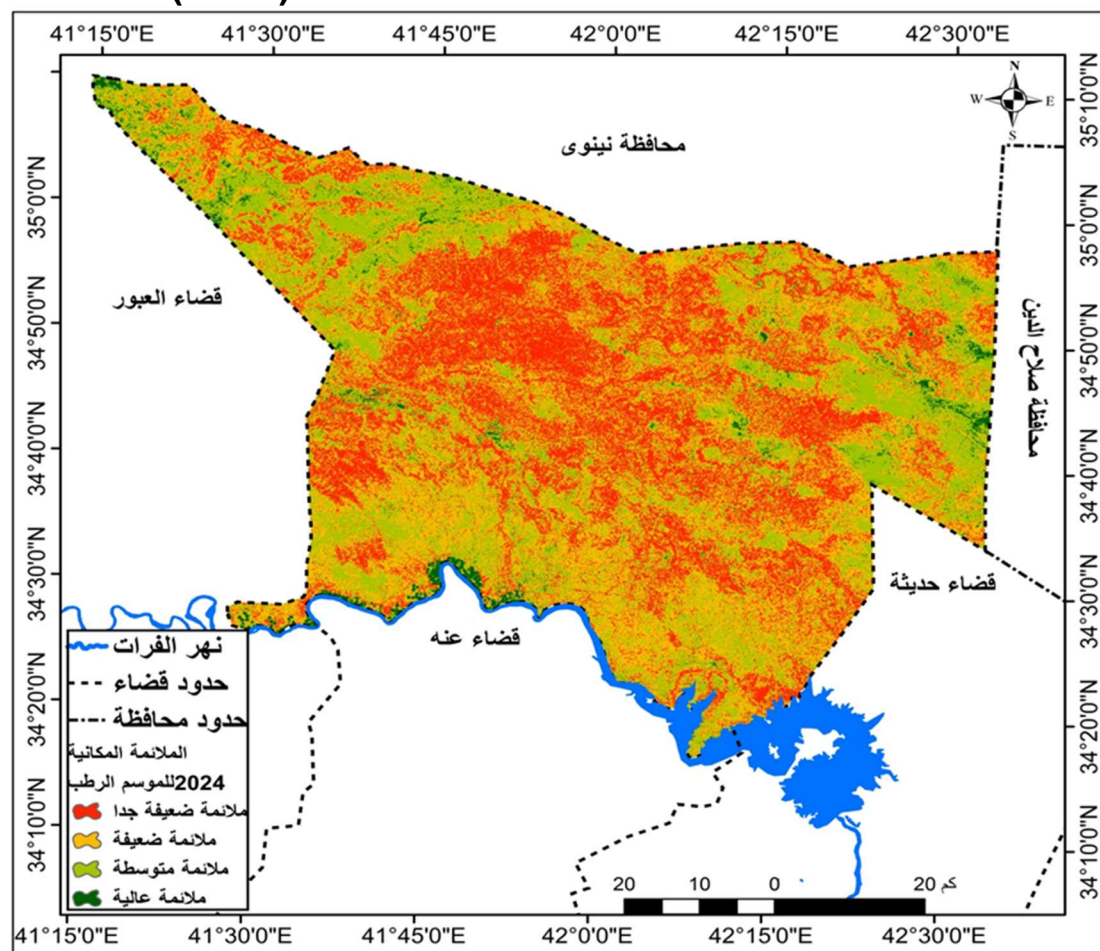
This zone appears clearly in the southern parts adjacent to the Euphrates River course. The results indicate that proximity to water resources represents the decisive factor in elevating suitability efficiency, as these

areas provide ideal conditions for supporting vegetation cover and human activities. This aligns with hydrological models that link water availability to ecological balance. This level represents floodplain areas and lands near riverbanks, as well as alluvial soils resulting from torrents and floods. These soils are characterized by high fertility compared to other soil types. This category covers the largest area in the district, estimated at approximately 1,829.66 km², which is equivalent to 31.30% of the total area of the district.

Spatial Suitability for the Wet Season in Rawa District (2024)

According to the spatial and statistical analysis illustrated in Table (2) and Map (3), the study area during the 2004 wet season was classified into four distinct categories. The classification process was based on key environmental and developmental determinants, most notably natural vegetation, land cover patterns, land use types, the suitability of available water resources for various consumption sectors, and the varying degrees of environmental risks in the region, categorized as follows:

Map (3): Spatial Suitability Levels for the Wet Season in Rawa District (2024)



Source

Based on spectral indices data and outputs of ArcGIS 10.8 software.

Table (2): Spatial Suitability Levels for the Wet Season in Rawa District (2024)

No.		Area (km ²)	Percentage (%)
1	Very Low Suitability	1802.67	30.84
2	Low Suitability	2127.97	36.41
3	Moderate Suitability	1783.57	30.51
4	High Suitability	130.63	2.24
Total	5844.84		100

Source

Based on Map (3) data.

1. Very Low Suitability

This category represents the geographical area illustrated in red on the map, distributed extensively across the central and northern parts of the district. These areas are characterized as harsh environments dominated by barren lands with high spectral reflectance values, coupled with an almost complete scarcity of water and vegetation resources. These lands pose a major developmental challenge, reflecting the absolute dominance of desertification and severe geomorphological conditions that limit any human or natural utilization. This category covers an area of 1,802.67 \ km², equivalent to 30.84% of the total district area.

2. Low Suitability

This category occupies vast areas, appearing as the primary cover surrounding the district centers and areas of higher suitability. These regions suffer from degradation in the physical and chemical characteristics of the soil, in addition to limited natural vegetation cover, rendering them unsuitable for conventional economic activities without intensive interventions. These areas highlight the expansion of marginal lands that lack the essential requisites for sustainability under arid climatic conditions. Its area reached approximately 2,127.97 km², equivalent to 36.41% of the district area, making it the largest spatial category in the district.

3. Moderate Suitability

The lands of this level are characterized as highly suitable for rain-fed agriculture, alongside their viability as natural rangelands. They are represented by sedimentary soils deposited in the valleys spanning Rawa District that drain toward the Euphrates River, meaning they mostly concentrate at valley mouths and slopes. Their proximity to the river enhances their significance, in addition to containing groundwater suitable for human consumption. These lands extend over an estimated area of about 1,783.57 km², constituting 30.51% of the total study area.

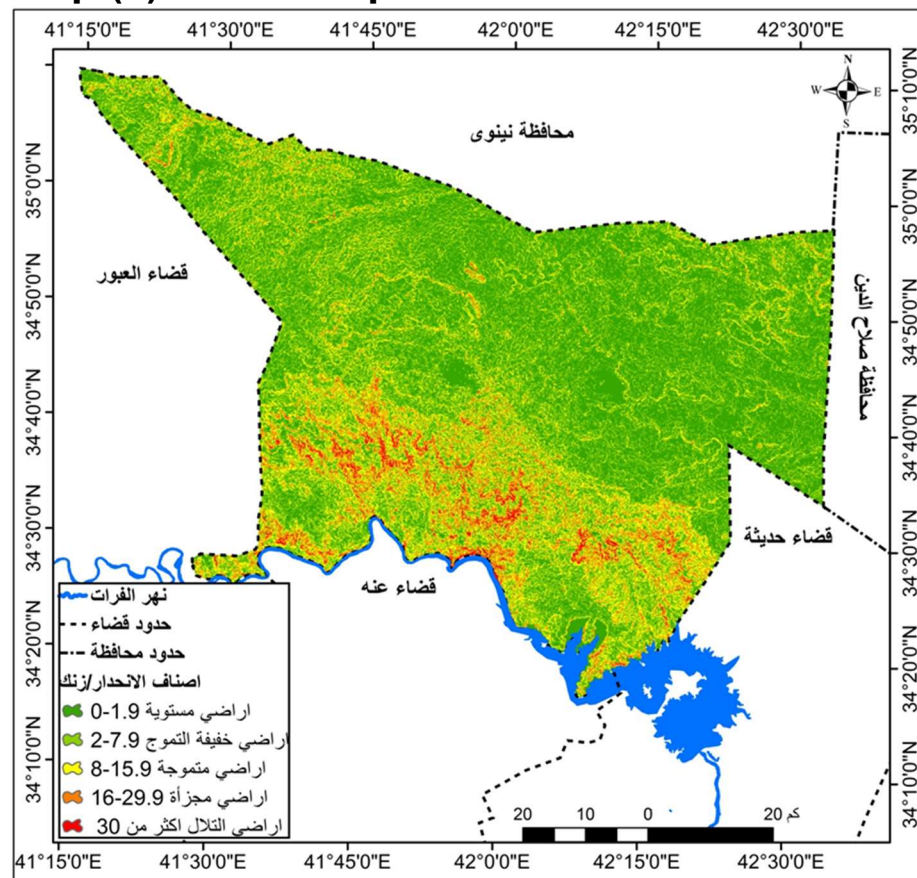
4. High Suitability

This category is concentrated within a narrow and limited zone extending along the southern fringe of the district, specifically along the course of the Euphrates River. This level represents floodplain areas and lands near riverbanks, as well as alluvial soils resulting from torrents and floods. These soils are characterized by high fertility compared to other soil types, and permanently flowing water resources contribute to enhancing the degree of environmental suitability in these regions. This category covers an area estimated at approximately 130.63 \ km², which is equivalent to 2.24% of the total area of the district.

Land Capability in Rawa District

This classification refers to determining the capacity level of the land and its uses for specific purposes in a defined manner; however, this level does not necessarily imply the optimal use of these lands. To generate the land capability map, the study relied on (the spatial suitability map for each season, the slope map, and the topographic map). Accordingly, the region was classified into four levels based on essential criteria, foremost among which are the nature of land uses, the availability and distribution of suitable soil and water, their degree of suitability for various uses, and monitoring the capability levels for the characteristics of both the wet and dry seasons for the period 2004–2024.

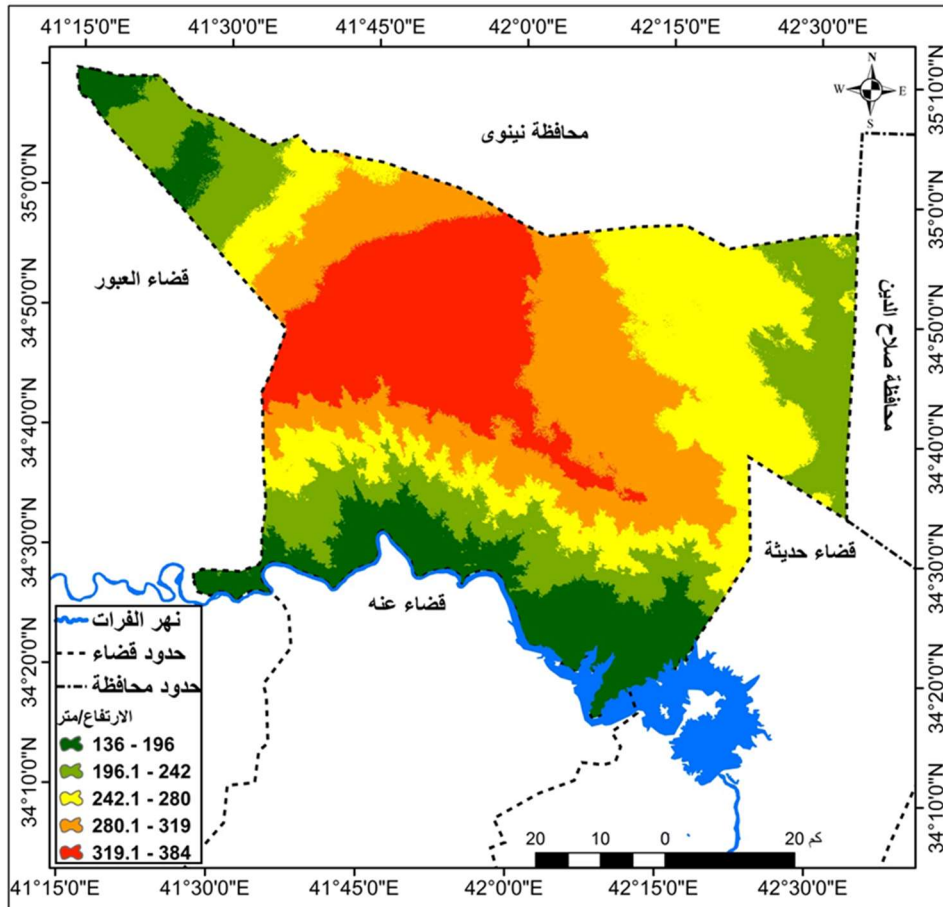
Map (4): Land Slopes in Rawa District



Source

Based on the Digital Elevation Model (DEM) with a spatial resolution of (30 times 30, and outputs of ArcMap 10.8 software.

Map (5): Topography of Rawa District



Source

Based on the Digital Elevation Model (DEM) with a spatial resolution of (30 \times 30 m), and outputs of ArcMap 10.8 software.

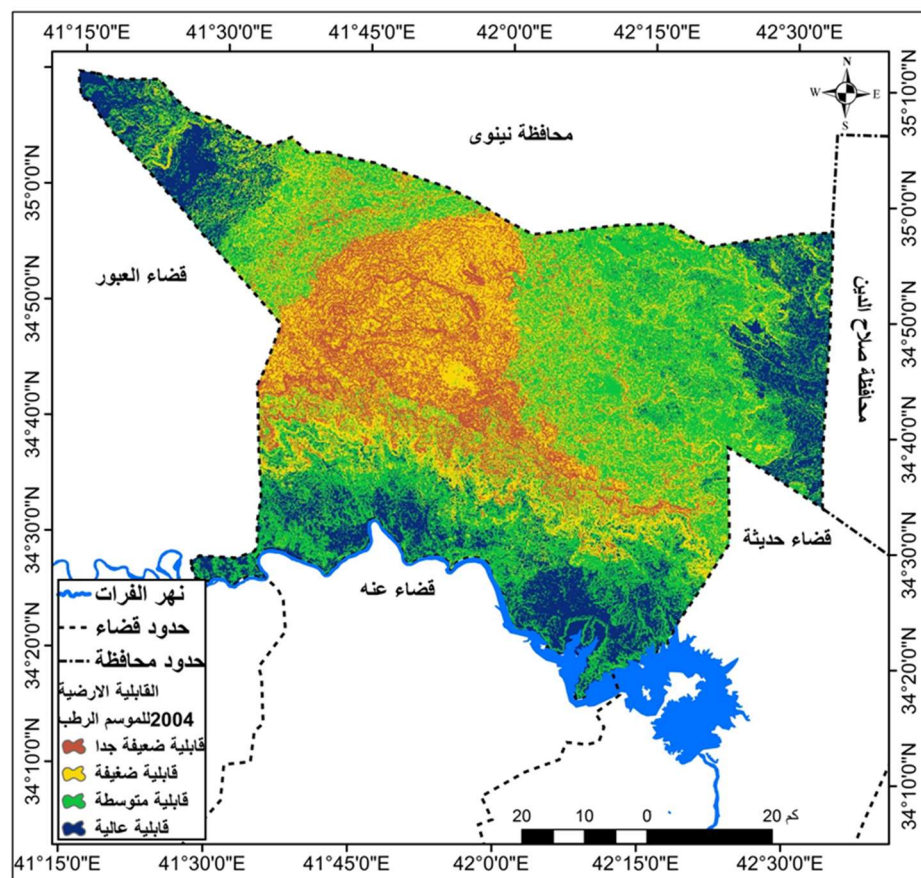
Constructing the Land Capability Map for the Wet Season in Rawa District

The research aimed to study the environmental variation and its spatial distribution in Rawa District during the wet season for the period (2004–2024), employing a standardized methodology based on three primary determinants: land use patterns, soil distribution, and the availability of water accessible for various uses, as detailed below:

Land Capability for the Wet Season in Rawa District (2004)

Based on the data presented in Table (3) and Map (6), the study area during the 2004 rainy season was classified into four ecological and spatial levels. This classification relied on a suite of key indicators, including land use patterns, the geographical distribution of soil, the availability of water resources suitable for various activities, and the levels of environmental threats and risks surrounding the region. These categories are distributed as follows:

Map (6): Land Capability Levels for the Wet Season in Rawa District (2004)



Source

Based on data from Maps (2, 4, 5) and outputs of ArcGIS 10.8 software.

Table (3): Land Capability Levels for the Wet Season in Rawa District (2004)

No.		Area (km ²)	Percentage (%)
1	Very Low Suitability	765.88	13.10
2	Low Suitability	1655.94	28.33
3	Moderate Suitability	2397.51	41.02
4	High Suitability	1025.51	17.55
Total	5844.84		100

Source

Based on Map (6) data.

1. Very Low Capability

This category appears in specific, limited patches within the central zone of the district, particularly in areas characterized by higher ruggedness or aridity. These zones represent the lowest capability levels within the study area, consisting of arid lands or regions that lack the essential prerequisites for agricultural investment or sustainable vegetation cover during that season. This level occupies an area of 765.88 \ km², accounting for 13.10% of the total district area.

2. Low Capability

Geographically, this land is concentrated in the central and northeastern parts of the study area, which are dominated by barren lands and include sand dunes in certain localities. This zone represents plateau lands or slightly elevated areas that suffer from low soil moisture or degradation in the soil's chemical and physical properties, thereby reducing its productive efficiency. This category extends over an area of 1,655.94 km², constituting 28.33% of the total study area.

3. Moderate Capability

The geographical distribution of this category covers vast territories, constituting more than half of Rawa District's area, and is illustrated by the green section on the map. These lands are classified as areas viable for agricultural use dependent on irrigation, utilizing available groundwater and harvested rainwater, in addition to their suitability as natural rangelands. Furthermore, the sedimentary soils deposited in the valleys draining toward the Euphrates River can be effectively exploited. This category occupies an area of 2,397.51 km², equivalent to 41.02% of the total area of the district.

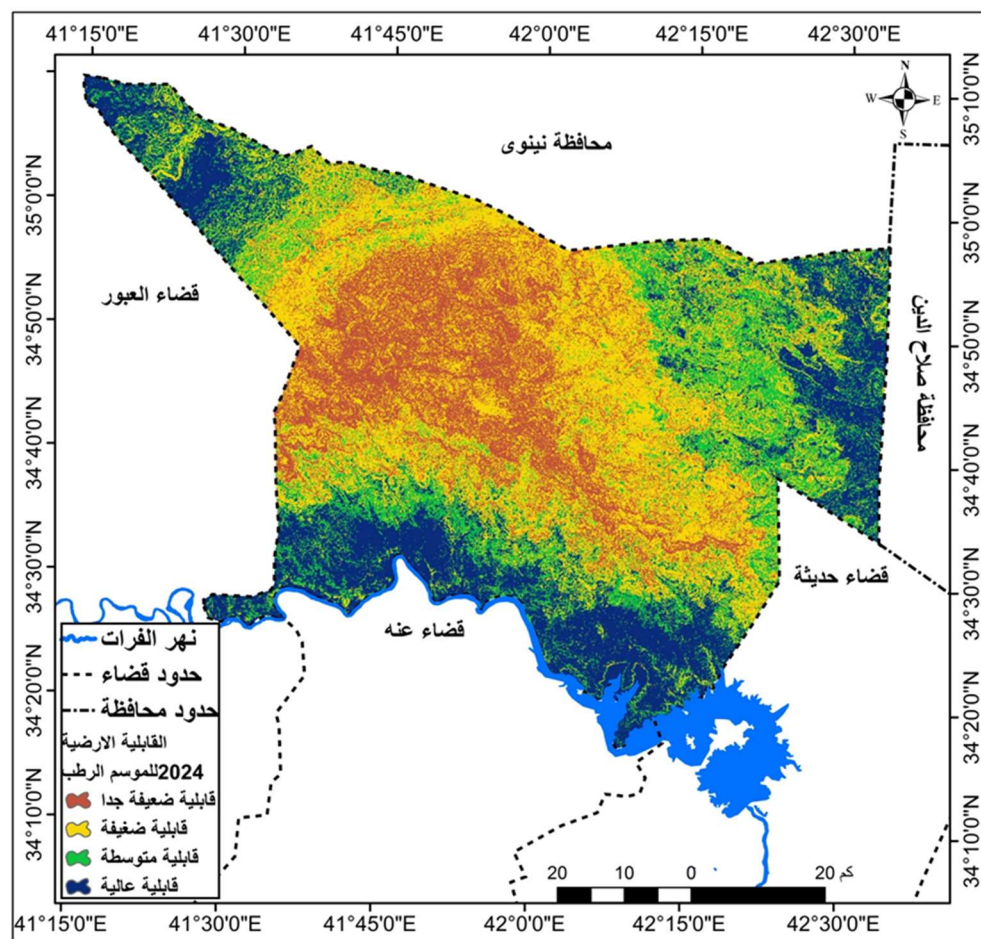
4. High Capability

Geographically, this category represents the floodplain lands and areas located north of the river, as well as zones affected by aggradational alluvial flash floods. In terms of soil and water quality, the soil is characterized by relatively high fertility, and permanently flowing water plays a decisive and vital role in elevating the efficiency of this ecological level. This level covers an estimated area of 1,025.51 km², which is equivalent to 17.55% of the total area of the study area. Farmers have contributed to expanding the extent of these lands through intensive agricultural activities and capitalizing on available opportunities, which has maintained the classification of these lands within this premium level.

Land Capability for the Wet Season in Rawa District (2024)

Based on the cartographic outputs and statistical data presented in Map (7) and Table (4), the spatial boundaries of four distinct categories were delineated within the study area during the 2024 wet season. This classification was subjected to an evaluation of integrated geographical and environmental criteria, including available land use patterns, spatial variation of soil, the quality and abundance of water for various uses, alongside monitoring environmental threat levels. These categories are defined as follows:

Map (7): Land Capability Levels for the Wet Season in Rawa District (2024)



Source

Based on data from Maps (3, 4, 5) and outputs of ArcGIS 10.8 software.

Table (4): Land Capability Levels for the Wet Season in Rawa District (2024)

No.		Area (km ²)	Percentage (%)
1	Very Low Suitability	1128.48	19.31
2	Low Suitability	2191.29	37.49
3	Moderate Suitability	1094.70	18.73
4	High Suitability	1430.37	24.47
Total	5844.84		100

Source

Based on Map (7) data.

1. Very Low Capability

This level appears as focal hotspots within the brown-colored zone, heavily concentrating in the most rugged areas or in locations suffering from high salinity. In terms of spatial characteristics, these regions completely lack essential nutrients, and their geomorphological structure renders them entirely non-

reactive to rainfall regarding biological interaction. The optimal use of these areas is purely ecological, aimed at preserving harsh natural biodiversity. They must be completely excluded from any developmental plans due to their extreme vulnerability and the high risk of transforming into dead aggradational sabkhas if mismanaged. This level covers an area of $1,128.48 \text{ km}^2$, representing 19.31% of the total area of Rawa District.

2. Low Capability

This land dominates most of the central and northern regions of the study area, characterized by arid plateau terrains. Geologically, it consists of limestone or gypseous rocks that render the ground incapable of retaining water, and it is subjected to severe wind erosion. In terms of utilization, it is unsuitable for conventional agriculture and is mostly used as marginal lands for limited grazing. Any attempt to exploit it agriculturally would require massive investments in irrigation and soil management, which may not be economically feasible. This category extends over an area of $2,191.29 \text{ km}^2$, constituting 37.49% of the total district area, thereby representing the largest spatial category in the district.

3. Moderate Capability

The geographical distribution of this category appears in the southern, eastern, and western parts of the district. These lands are classified as viable areas for agricultural use dependent on irrigation, utilizing available groundwater and harvested rainwater, in addition to their suitability as natural rangelands. Furthermore, the sedimentary soils deposited in the valleys draining toward the Euphrates River can be effectively utilized. Their value is heavily enhanced by their proximity to the Euphrates River and the availability of groundwater. This category occupies an area of $1,094.70 \text{ km}^2$, equivalent to 18.73% of the total area of the district.

4. High Capability

Spatially, this category represents the floodplain lands located in the southern zone directly adjacent to the Euphrates River course, along with scattered pockets in the extreme northwest. In terms of soil and water quality, the soil is characterized by relatively high fertility, and permanently flowing water plays a decisive and vital role in elevating the efficiency of this ecological level. It acts as the "lung of the region," representing the most efficient lands for intensive and stable agriculture, where surface and groundwater provide continuous support, making it the least affected by dry season fluctuations. This level covers an estimated area of $1,430.37 \text{ km}^2$, which is equivalent to 24.47% of the total study area.

Conclusions

1. The results of the study demonstrated a clear spatial variation in spatial suitability and land capability levels across different parts of Rawa District, driven by variations in the influencing natural and human factors.
2. Areas with high spatial suitability and land capability were concentrated along the Euphrates River course and the floodplain areas due to water availability and soil fertility.
3. Spatial suitability and land capability levels declined in areas distant from the Euphrates River as a result of limited water resources and the heightened impacts of aridity and erosion.
4. Soil characteristics played a decisive role in determining spatial suitability levels, with modern alluvial soils achieving the highest efficiency levels compared to desert and plateau soils.
5. Land cover patterns underwent spatial changes during the period (2004–2024), which directly reflected on the distribution of spatial suitability and land capability categories within the district.

6. Remote Sensing (RS) techniques and Geographic Information Systems (GIS) proved highly efficient in monitoring environmental changes and producing precise spatial suitability and land capability maps.
7. The study provided a spatial database that can be utilized in environmental planning and guiding land uses toward the optimal exploitation of available resources.

Recommendations

1. Directing agricultural expansion toward areas with high spatial suitability and land capability to ensure maximum productivity and resource sustainability.
2. Adopting the spatial suitability and land capability results as a primary tool when preparing developmental plans and land use strategies in Rawa District.
3. Reclaiming lands with moderate and low land capability by improving soil characteristics and providing suitable water sources.
4. Mitigating environmental degradation and desertification indicators by expanding afforestation programs and protecting natural vegetation cover.
5. Implementing modern irrigation methods, such as drip and sprinkler irrigation, to rationalize water consumption and minimize water loss.
6. Establishing a periodically updated geographic database to monitor changes occurring in land cover and natural resources.
7. Promoting the utilization of Remote Sensing (RS) techniques and Geographic Information Systems (GIS) in future environmental and agricultural studies.

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