# INVESTIGATING VEGETATION COVER AND SAND DUNES EVOLUTION IN RUMAITHA DISTRICT USING DIGITAL INDICATORS FOR THE YEARS (2000 – 2023)

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**Abstract**

The study utilized spectral indicators such as NDVI and NDSDI, along with satellite imagery interpretation, to detect changes in vegetation cover and sand dunes areas in the Rumaitha district between 2000 and 2023. American satellites, Landsat 4 for 2000 and Landsat 9 for 2023, with a spatial resolution of 30m, were employed for data collection to compare the changes that occurred to the land cover during that period. Digital data from satellite imagery were analyzed using Erdas 2016 software, and final outputs were generated using ArcMap 10.8 to create digital maps. The research employed descriptive and analytical approaches, analyzing climate data, satellite imagery, and administrative maps. Results revealed that barren, uncultivated lands constituted 66.24% of the district in 2000, decreasing to 53.45% in 2023. Similarly, sand dune areas decreased from 77.2% in 2000 to 66.6% in 2023. These findings suggest a positive trend toward increased vegetation cover in the study area, at the expense of barren lands and sand dunes.

**keywords** :Remote Sensing, Spectral indicators ,Vegetation, Sand dunes, Rumaitha District.

## 1 - Introduction:

Geographic Information Systems are integral modern technologies widely utilized in geographical and environmental studies. These tools provide accurate information for monitoring Earth's surface phenomena without direct contact, enabling the creation of high-precision digital maps quickly and cost-effectively, especially when studying vast areas like our target region.[1] Due to the high costs and logistical challenges of traditional field studies, remote sensing has become indispensable. Utilizing digital indicators such as NDSDI and NDVI, commonly employed by geographers and environmental scientists, enables the monitoring of vegetation cover, desertification manifestations like sand dunes and soil erosion, floods, and changes in pasture areas over time. Therefore, this study aims to provide insights into the environmental situation of Al-Muthanna Governorate's second-largest district, enhancing digital databases. By highlighting developments in sand dunes and vegetation cover, it aids decision-making, spreads environmental awareness, and fosters sustainable development.

## 2 - Study Area:

The study area is represented by Al-Rumaitha District, which is one of the Iraqi districts located in Al- Muthanna Governorate of southern Iraq. The area of the district is about (1299.09 km2) and constitutes (2.5%) of the total area of Al-Muthanna Governorate, which is about (51,740 km2). It is considered the second largest district in the governorate in terms of Population. Geographically, it lies between latitudes ( $31^0$ $^-15 – 31^0$ $^-44$) north and longitudes (44°-59' - 45°-1')East. The district includes four administrative units: (Al-Najmi District, Al-Hilal District, Al-Majd District, Al-Rumaitha District Center). As far as the borders is concerned, Al-Diwaniyah Governorate borders it to the north and west,

while Al-Warka District borders it to the east. As for the southern border, it is represented by Samawah and Salman Districts. Naturally, the study area is part of the Iraqi Alluvial Plain and Western Plateau. The terrain primarily consists of the Iraqi Alluvial Plain and Western Plateau regions, with two main soil types: floodplain soil, characterized by soft clay and silt deposits from the Euphrates River floods, and sand dune soil, containing a high sand content from wind-blown sediment deposition, Al-Rumaitha district is located within a dry climate, receiving large amounts of solar radiation due to the lack of clouds and low relative humidity, as well as experiencing a high number of hours of sunshine for most months of the year. This leads to increased heating and high temperatures, especially during the summer months, (Table 1). The amount of rainfall also decreases, reaching an annual total of only 98.5 mm. All of these factors contributed to the drying out of the soil, its disintegration, and the spread of sand dunes in the area. Additionally, the district is characterized by the presence of surface water, including the Euphrates River and its branches, as well as Lake Sawa. Lake Sawa is a closed natural lake located in the Hilal region, relying on groundwater as a source of water replenishment, with an average depth of 4.2 meters[2] , (see Fig 1).
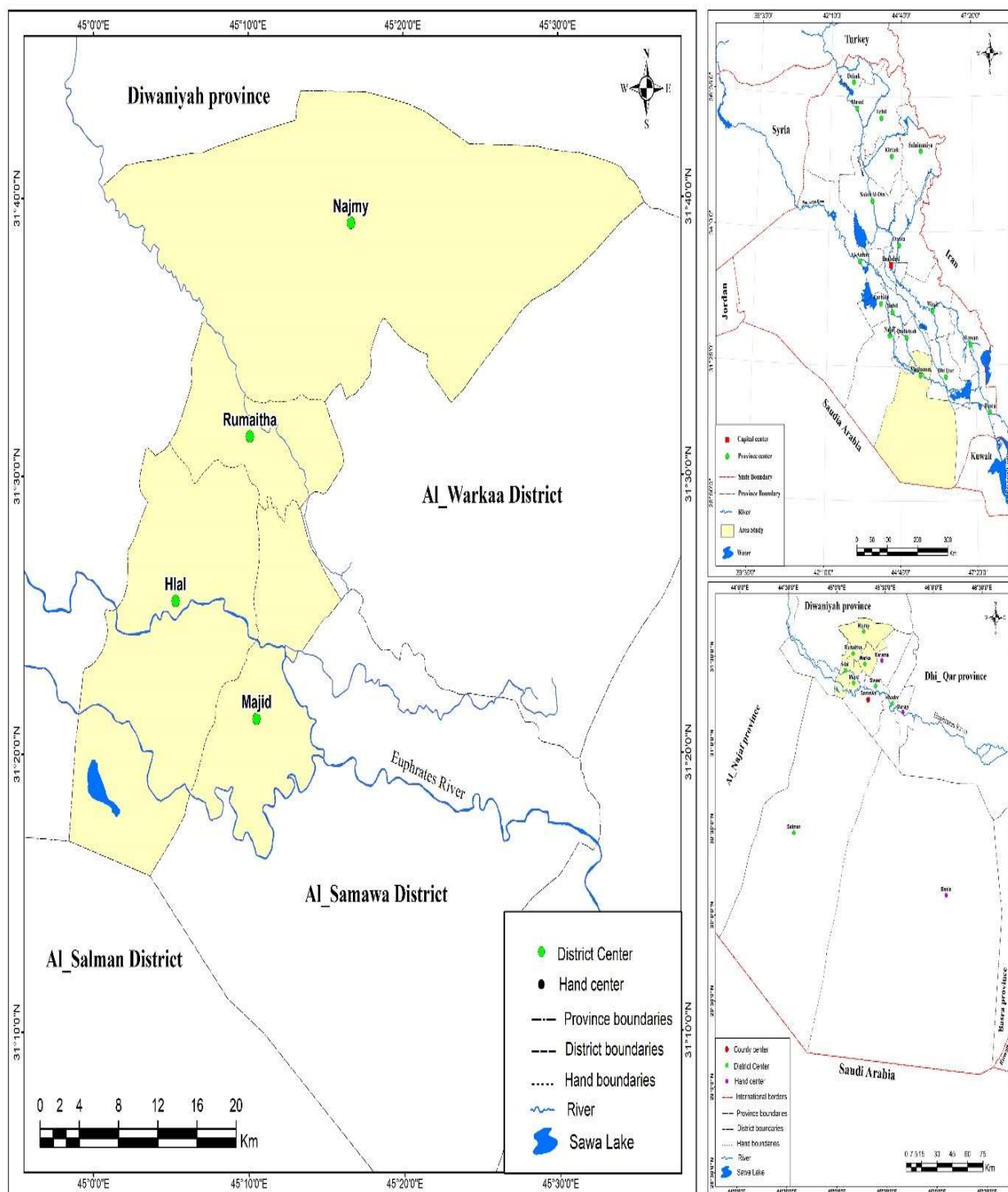
**Figure 1**. Location of Rumaitha District from Iraq .

**Table 1. Monthly and annual average temperatures and total monthly and annual rainfall in the Rumaitha district for the period 2000-2023.**

| Months | Temp. (C$^0$) | Precipitation (mm) |
|---|---|---|
| January | 11.5 | 13.6 |
| February | 14.1 | 11.6 |
| March | 18.9 | 14.3 |
| April | 24.7 | 10.4 |
| May | 30.8 | 5 |
| June | 34.9 | 0 |
| July | 36.3 | 0 |
| August | 36.1 | 0 |
| September | 32.4 | 0 |
| October | 27.3 | 4.6 |
| November | 18.7 | 23.4 |
| December | 13.6 | 15.6 |
| Mean | 24.9 | 98.5 |

## 3 - Analysis of variation in vegetation cover of the study area

Vegetation cover is one of the most important natural resources, especially in dry fragile regions, to maintain their environmental balance. Vegetation cover encompasses the extent of plant growth covering the soil surface, comprising both natural and cultivated varieties. It serves as a visual representation of the interplay between the environmental conditions and human activities within a particular area. For the purpose of analyzing the amount of variation in vegetation cover in Al-Rumaitha District for the years (2000, 2023), the vegetation index (NDVI) was used, which is one of the important and accurate standard indicators to detect and study the change in vegetation density within different wavelengths. This indicator represents the difference between the spectral reflectances of the near infrared band (NIR) Band5 and the visible red band (RED) divided by the sum, which is shown by the following equation[3] :

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

The reflectivity of plants is notably high within the infrared range (NIR) but considerably low within the red range (RED). These spectral bands contribute over 90% of the pertinent information regarding vegetation. The outcome of the equation falls within the range of (+1, -1), with higher positive values indicating denser vegetation cover and greater reflectivity. The negative result indicates surface features

that are not green, while areas with little vegetation cover appear with a low reflectivity [4]. The results of the Normalized Difference Vegetation Index (NDVI) for discerning vegetation cover in the study area from 2000 to 2023 revealed that barren lands, devoid of vegetation cover, comprised 860.55 square kilometers in 2000, accounting for 66.24% of the total area of Al-Rumaitha District. By 2023, this area decreased to 694.27 square kilometers, representing 53.45% of the district's total area. Additionally, the area of land with sparse vegetation cover was approximately 246.95 square kilometers, or 19.01% in 2000, increasing to 380.1 square kilometers, or 29.3%, in 2023. The area with medium vegetation cover comprised 125.94 square kilometers, accounting for 9.69% of the total area in 2000. By 2023, this area increased to 174.96 square kilometers, representing 13.5% of the total area. In terms of dense vegetation, it covered 57.39 square kilometers, or 4.42%, in 2000, decreasing to 47.74 square kilometers, or 3.6%, in 2023 (refer to Table 2). Regarding water bodies, their area was approximately 8.26 square kilometers, or 0.64%, in 2000, declining to 2.02 square kilometers, or 0.15%, by 2023 due to the droughts experienced in the region, see Figure (2,3) .

**Table 2.** The results of the index ( NDVI ) OF Rumaitha district for the years (2000-2023)  .

| Years / Class. | 2000 | | 2023 | |
|---|---|---|---|---|
| | Area (Km$^2$) | percentage | Area (Km$^2$) | Percentage |
| Water | 8.26 | 0.64% | 2.02 | 0.15% |
| Lake of vegetation | 860.55 | 66.24% | 694.27 | 53.45% |
| Little vegetation cover | 246.95 | 19.01% | 380.1 | 29.3% |
| Medium vegetation cover | 125.94 | 9.69% | 174.96 | 13.5% |
| Dense vegetation cover | 57.39 | 4.42% | 47.74 | 3.6% |
| The total | 1299.09 | 100% | 1299.09 | 100% |

## 4 - Analysis of variation in sand dune area for the study area

Sand dunes are prominent geomorphological features found in arid and semi-arid regions, including the study area. A sand dune is essentially a hill composed of sand, formed through the accumulation of sand particles in areas where wind speed is hindered, causing the deposition of sediment [5]. The figure (5) shows that the sand dunes in the Rumaitha district are distributed in two main ranges. The first range extends on the left side of the Euphrates River forming part of the central belt of sand dunes in Iraq. hese dunes originate from recent sediments of the Tigris and Euphrates rivers, as well as disintegrated soils from the alluvial plain, particularly affected by prevailing drought conditions [6]. These dunes are categorized as false dunes due to their composition of soft sand, silt

grains, clay, and remnants of river shells. Conversely, the second range of sand dunes in the study area lies on the eastern side of the Euphrates River within the Western Plateau region. This range is part of the western sand dune belt, the largest in Iraq, characterized by true dunes composed of over 90% sand particles [7] , (see figure 4) . The analysis of satellite visuals from the Landsat satellite revealed that the area occupied by high and very high sand dunes in the year 2000 was approximately 1003.02 km2, constituting 77.2% of the total area of the region. However, by 2023, this area had decreased to 864.81 km2, representing 66.6% of the total area. The reason for this is the Iraqi Ministry of Environment's interest in stabilizing sand dunes using mechanical or biological methods in order to limit their encroachment towards neighboring lands (see Fig. 6-7). The area of medium-sized sand dunes constituted 255.52 km2 at a rate of 19.7% in the year 2000, then increased to about 386.33 km2 at a rate of 29.7% in the year 2023. As for the area of the few scattered sand dunes, it constituted 31.8 km2 at a rate of 2.4% in the year 2000, then its area increased to 43.89 km2 at a rate of 3.4%. The area of land free of sand dunes reached about 8.75 km2 at a rate of 0.7% in the year 2000. However, this area decreased in 2023 to 4.06 km2 at a rate of 0.3% (see table 3).

**Table 3.** The results of the index (NDSDI ) OF Rumaitha district for the years (2000-2023) .

| The years / Class. | 2000 | | 2023 | |
|---|---|---|---|---|
| | Area(Km$^2$) | percentage | Area (Km$^2$) | Percentage |
| Very high sand dunes | 366.48 | 28.2% | 232.41 | 17.9% |
| High sand dunes | 636.54 | 49% | 632.4 | 48.7% |
| Medium sand dunes | 255.52 | 19.7% | 386.33 | 29.7% |
| Few sand dunes | 31.8 | 2.4% | 43.89 | 3.4% |
| Free of sand dunes | 8.75 | 0.7% | 4.06 | 0.3% |
| The total | 1299.09 | 100% | 1299.09 | 100% |
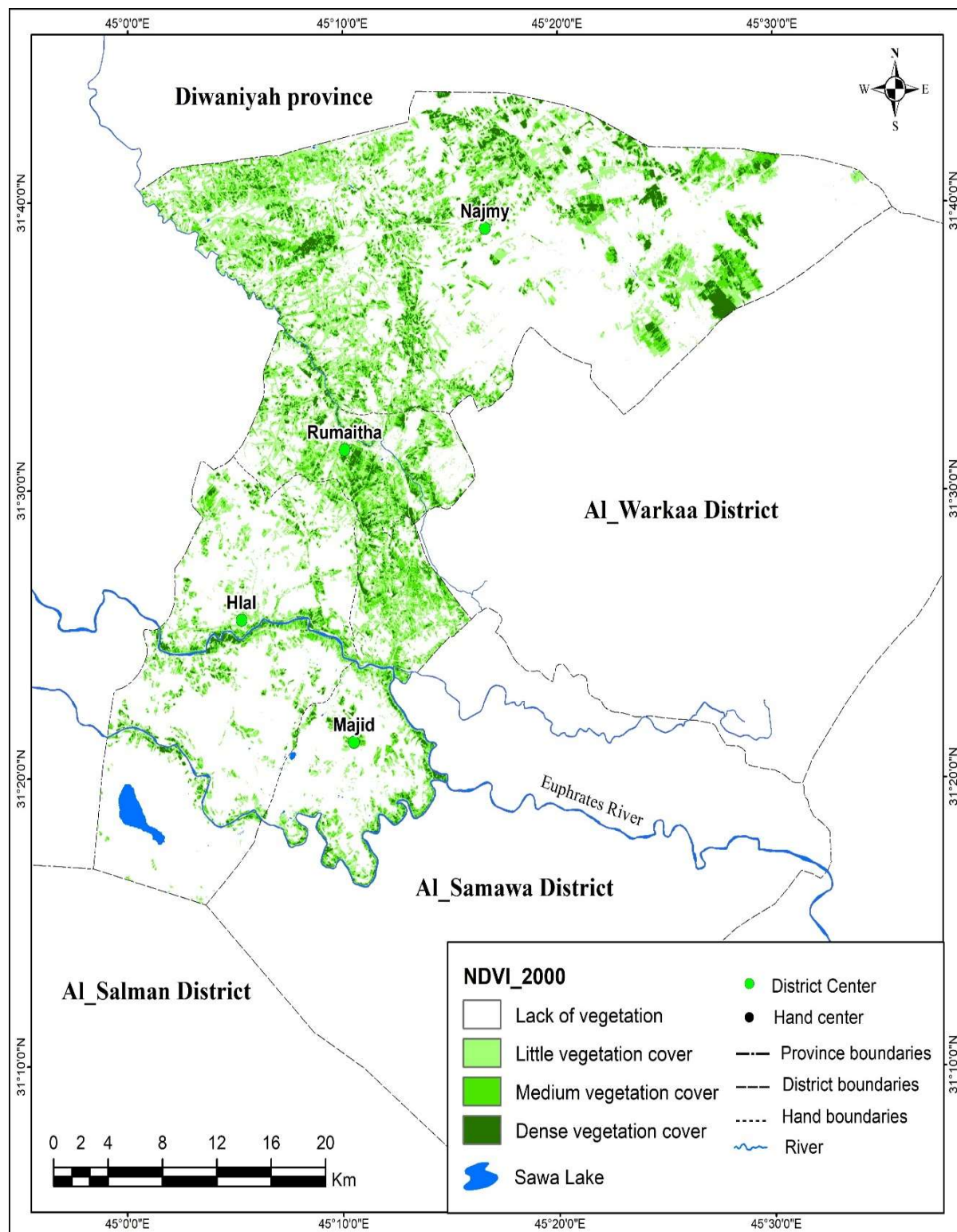
**Figure 2.** Results of the (NDVI) index for the summer season in Rumaitha district, source: Landsat5 satellite, Visible by OLI, bands 3-4 , with a resolution of 30m , 2000.
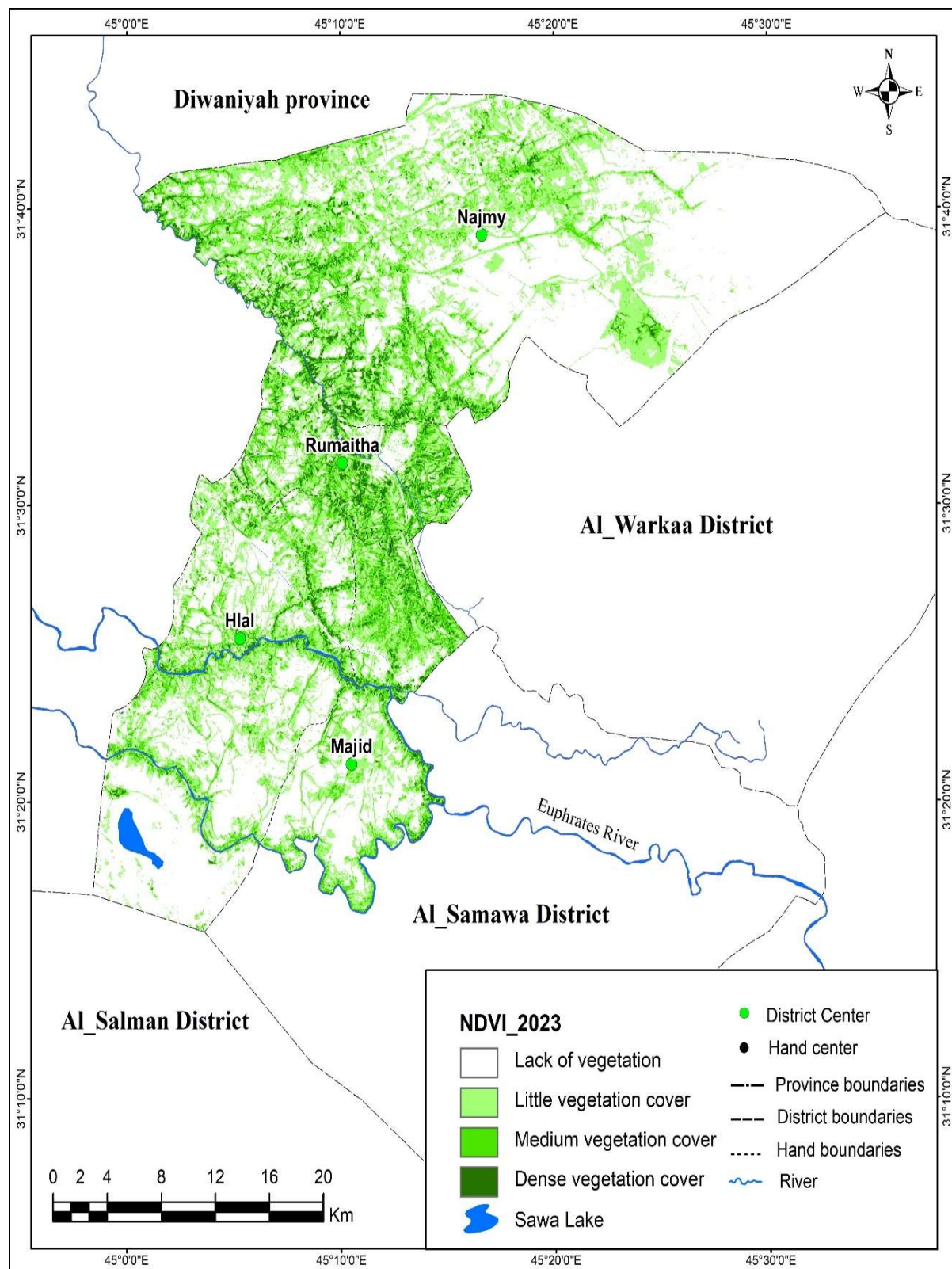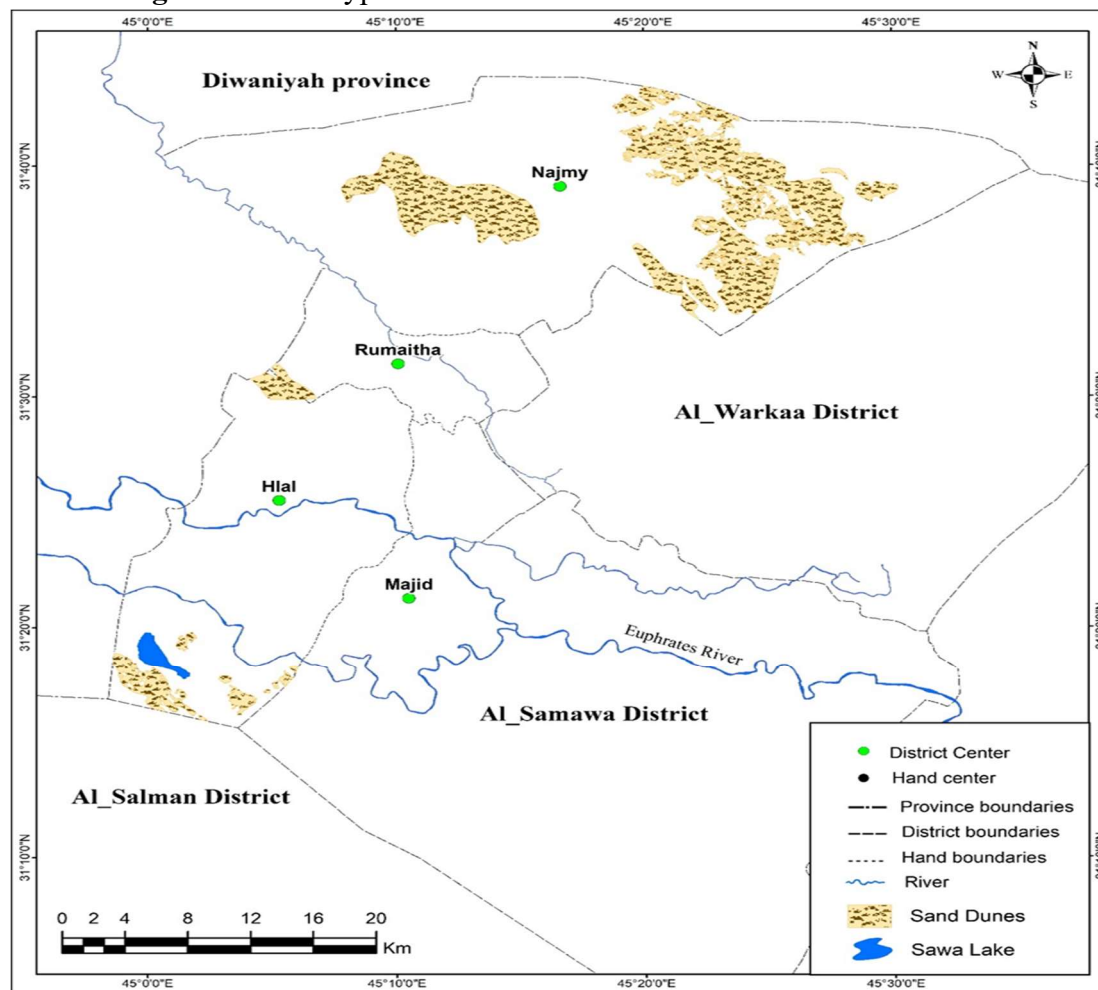
**Figure 3.**
Results of the (NDVI) index for the summer season in Rumaitha district, source: Landsat9 satellite, Visible by OLI , bands 4-5 ,with a resolution of 30m , 2023 .
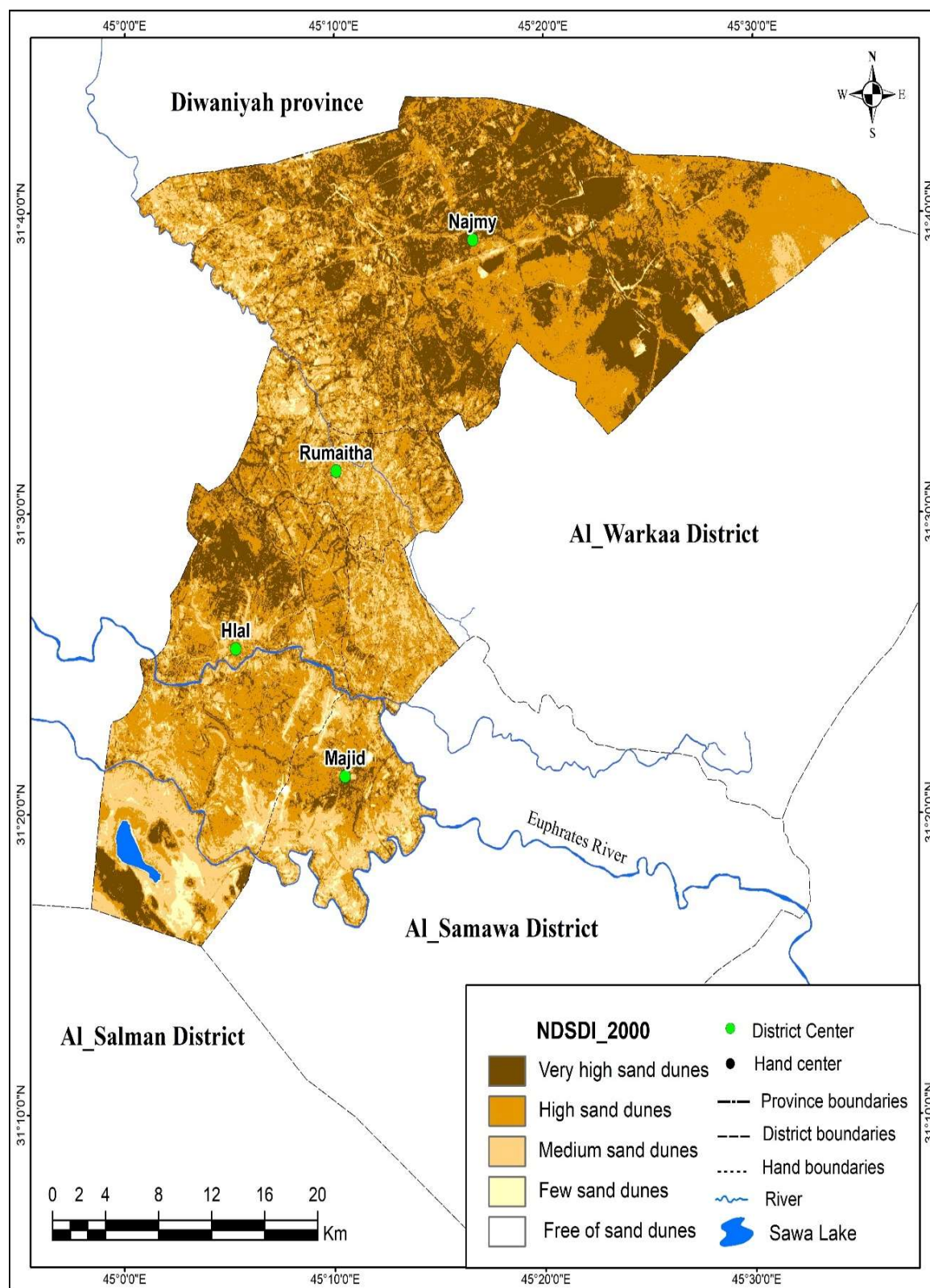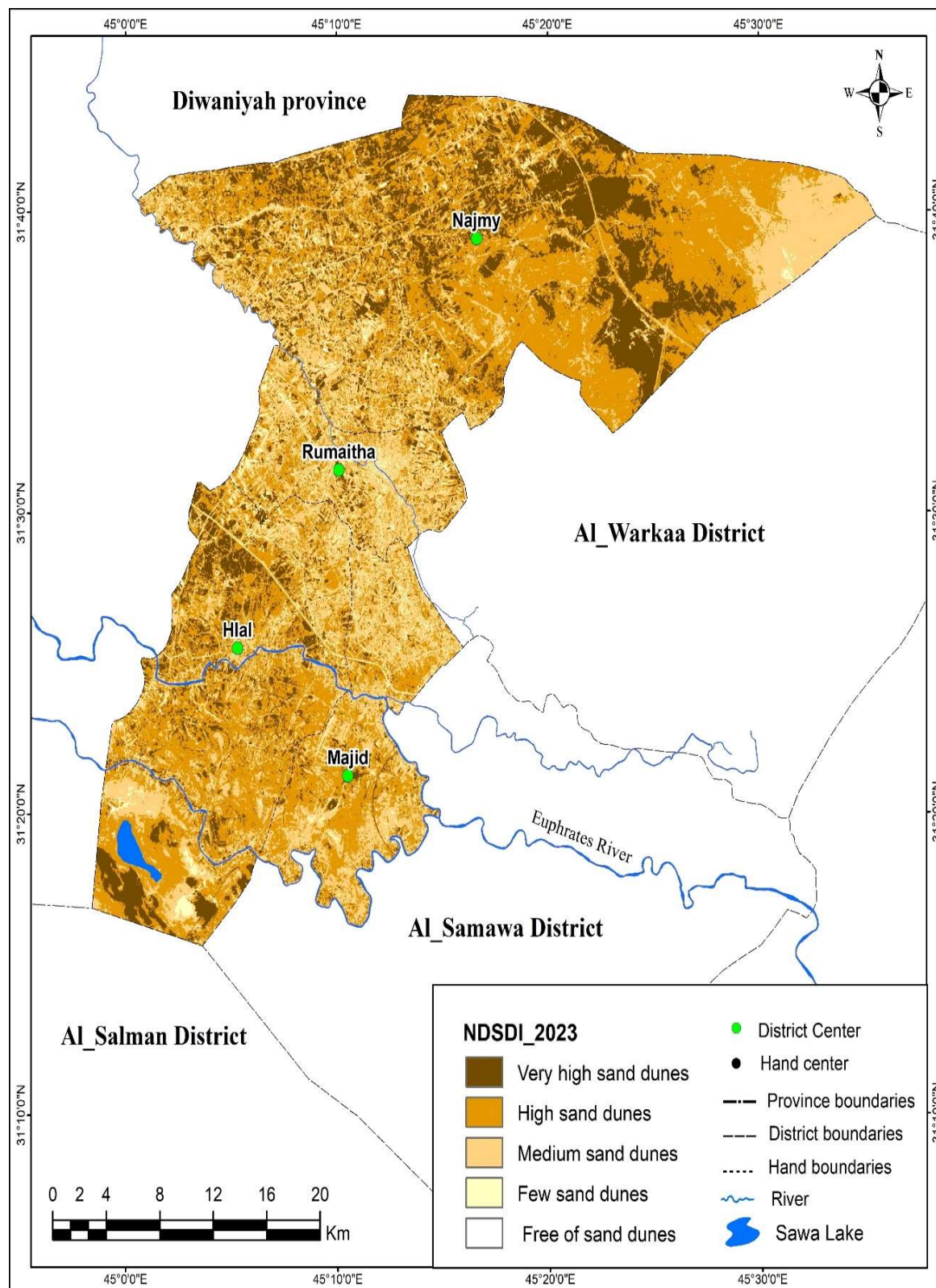
**Figure 4.** Some types of sand dunes in Rumaitha district .



**Figure 5.** Distribution of sand dunes   in Rumaitha district,  source: Landsat 9 satellite, Visible by OLI , bands 2-3-4 ,with a resolution of 30m , 2023 .

**Figure 6.** Results of the (NDSDI) index for the summer season in Rumaitha district,  source: Landsat5 satellite, Visible by OLI , bands 2-5 ,with a resolution of 30m , 2000 .

**Figure 7.** Results of the (NDSDI) index for the summer season in Rumaitha district,  source: Landsat9 satellite, Visible by OLI , bands 3-6 ,with a resolution of 30m , 2023 .

**Results**

1 - Digital indicators such as (NDVI,NDSDI) are among the modern and important technologies that can be used to study the development of land cover for any place on the surface of the Earth due to their low costs and accuracy in providing information.

2 - The study, based on the NDVI indicator, revealed that in the year 2000, the area devoid of vegetation cover amounted to 860.55 km2, accounting for 66.24% of the total area. This area decreased to 694.27 km2 in 2023, representing 53.45% of the total area. Additionally, the areas with little vegetation cover and medium vegetation cover were approximately 246.95 km2 and 125.94 km2, respectively, constituting 19.01% and 9.69% of the total area in 2000. In 2023, these areas increased to 380.1 km2 and 174.96 km2, respectively, accounting for 29.3% and 13.5% of the total area.

3 - According to the NDSDI indicator, in the year 2000, the area covered by high and very high sand dunes was 1003.02 km2, accounting for 77.2% of the total area. By 2023, this area decreased to 864.8 km2, representing 66.6% of the total area. The area occupied by medium sand dunes was 255.52 km2, constituting 19.7% of the total area in 2000, and increased to 386.33 km2, accounting for 29.7% of the total area in 2023. Additionally, the area with scattered sand dunes was 31.8 km2, making up 2.4% of the total area in 2000, and increased to 43.89 km2, representing 3.4% of the total area in 2023.

4 - It is observed that the area covered by vegetation has increased proportionally due to the expansion of agricultural investment within the private sector.

**Recommendations**

1 - Continuous monitoring of vegetation cover and sand dune development in the study area is essential to detect environmental changes effectively and promote sustainable development.

2 - Attention must be given to stabilizing sand dunes to mitigate their threat and prevent encroachment onto agricultural lands, irrigation channels, drainage systems, and roads.

3 - Paying attention to reclaiming the land and expanding agricultural investment to stabilize the soil and avoid its erosion and transportation.

4 - Supporting environmental research by incentivizing researchers and facilitating access to resources in the field of remote sensing and geographic information systems.

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