DOI: 10.24996/ijs.2024.65.8.43

ISSN: 0067-2904

# Analysis of the Agricultural Drought Causes in Babylon Province

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Received: 7/3/2023 Accepted: 23/7/2023 Published: 30/8/2024

**Abstract**

Drought is one of the challenges Iraq faced during this period, and the negative environmental effects that are apparent due to climate change have become essential topics that attracted the attention of urban planners. As the lack of rain and high temperatures are among the reasons for the drought increase, especially in desert areas, the Babil governorate was chosen as one of the governorates that suffered from agricultural drought. Agricultural drought indices were analyzed and monitored by downloading satellite images from the United States website for the period 1995-2021, where the area of the Babylon governorate was 5119 $km^2$. It was used to calculate agricultural drought for 1999-2015-2021; climatic elements data (temperature and precipitation) were taken for the same period. As it was found that the Babil governorate suffers from severe agricultural drought; in 2021 amounted to an area of 1982 $km^2$, 32% due to a decrease in the rain and a rise in temperatures by 2 degrees compared to the general average, while the agricultural area amounted to 1263 $km^2$, 27%, which is the highest rate recorded in 1999.

**Keywords**: (VCI), Remote sensing, agriculture drought, climate change.

# تحليل أسباب الجفاف الزراعي في محافظة بابل

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**الخلاصة**

ظاهرة الجفاف هي أحد التحديات التي تواجه العراق في هذه الفترة ، قلة سقوط الامطار وإرتفاع درجات الحرارة هي من الاسباب التي تجعل ظاهرة الجفاف تزداد وخصوصا منطقة الفرات الاوسط , في هذا البحث تم إختيار محافظة بابل كأحد المحافظات التي تعاني من الجفاف الزراعي ، تم إستخدام بيانات التحسس النائي وتنزيل مرئيات فضائية من الموقع الاميركي وبرنامج Arc map 10.8 لمراقبة الجفاف للفترة من 1995 الى 2021 ، حيث تبلغ مساحة محافظة بابل (5119 كم2) ، وان المؤشر الذي تم إستخدامه لحساب الجفاف الزراعي هو VCI لمنطقة الدراسة ، إذ تم إستخدام المرئيات الفضائية للقمر لاندسات هي للسنوات (1999-2015-2021) ، تبين إن محافظة بابل تعاني من جفاف زراعي عالي حيث إن مساحة الجفاف الزراعي الحاد في عام 2021 بلغت مساحة (1982 كم2) أي 32٪ , ولوحظ إنخفاض في كمية الامطار مع إرتفاع في درجات الحرارة بمعدل 2 درجة عن المعدل العام ، والمساحة الزراعية بلغت (1263 كم2) اي بنسبة 27٪ وهي أعلى نسبة سجلت في سنة 1999 .

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## 1. Introduction

Global warming is one of the most pressing issues humanity has faced in the past years, and the result of human activities that release large amounts of greenhouse gasses (water vapor, carbon dioxide, methane, nitrous oxide, Ozone, and CFC) into the Earth's atmosphere and the use of fossil energy [1] Based on that, climate change began, which is currently facing the world and Iraq in particular; one of its effects is the lack of green spaces, irregular water supply, and health [2] These are the effects of drought, which is most closely related to desertification, as drought varies from region to region according to the extent of precipitation [3].

Drought is one of the essential topics that aroused the interest of many researchers and regional bodies [4]. The international institutions, on a spatial and temporal scale, affected the various resulting sectors that depend on water resources and high temperatures, leading to changes in the vegetation cover. The uncovered areas with plants reflect Babil province's aridity level [5].

The Babylon province suffers from an increase in the urban area compared to the open and agricultural lands. This increases greenhouse gas emissions from burning fossil fuels used in electricity generation, production, transportation, industrialization, home heating, urban landfills, cement production, etc [6].

Remote sensing and GIS are the most influential technologies in different scientific applications, which provide valuable datasets and a comprehensive view of the Earth's surface. Moreover, this system joins remote sensing data and the capability to process and analyze geospatial data into a data bank management system, which can update, store, process, and modify these data [7] to investigate drought. Therefore, it can be utilized to assess the spatial distribution of drought [8].

This work addresses some of the previous studies that dealt with the drought concept from different aspects, as follows: Generally, Babil has remarkable changes in its temperature and climate, especially in recent years. For this reason, many researchers focus on drought in this city, such as Al-Shujairy et al. [9] aimed to investigate the efficiency of drought monitoring indicators. The standardized precipitation index (SPI) and the Normalized Difference Water Index (NDWI) to the spatial description of drought conditions of Babil province for the period 1980-2016; the results confirmed that the use of NDWI and SPI was supportive of the meteorological indices in detecting and monitoring the intensity and severity of the drought effect. Shamkhi [10] studied the environmental effects of climatic drought in the Babil province and how to limit them. The study was carried out by applying the Dimarton index, where the study area is located within the desert climate, and the drought coefficient was 0.290. However, applying the Lang coefficient to measure the drought showed that it is located within the severe drought region (0.300), reflected in the high percentage of water deficit. It became clear through the study that drought significantly impacts environmental systems such as soil salinization, dryness, and disintegration, making them vulnerable to wind erosion.

In this study, the Vegetation Cover Index (VCI) was used to measure drought levels, reflecting the effect of moisture stress on the plant. Green spaces have an essential role in dealing with climate change, as they affect the adjustment of temperature improvement. The values of this indicator were extracted based on the derivation of the normalized difference vegetation index (NDVI) [11]. This study includes an identified study area for 1995-2021, data collection, and the vegetation condition index.

## 2. The Study Area

Babil governorate is located in southern Baghdad, about 100 km from the Baghdad center. Its area is about 5119 $km^2$, constituting 2% of the total area of Iraq. It is one of the provinces of the Middle Euphrates (Najaf, Karbala, Babel, Qadisiya, Wasit). It is located between latitudes 32.7 and 33.8 north and between longitudes 43.42 and 45.50 east [12], Figure (1)

The climate of Babil province is a hot desert, with a low rain rate between 50-200 mm. It is characterized by a very high-temperature difference between day and night, summer and winter, ranging between 45-50 °C in the summer [13].

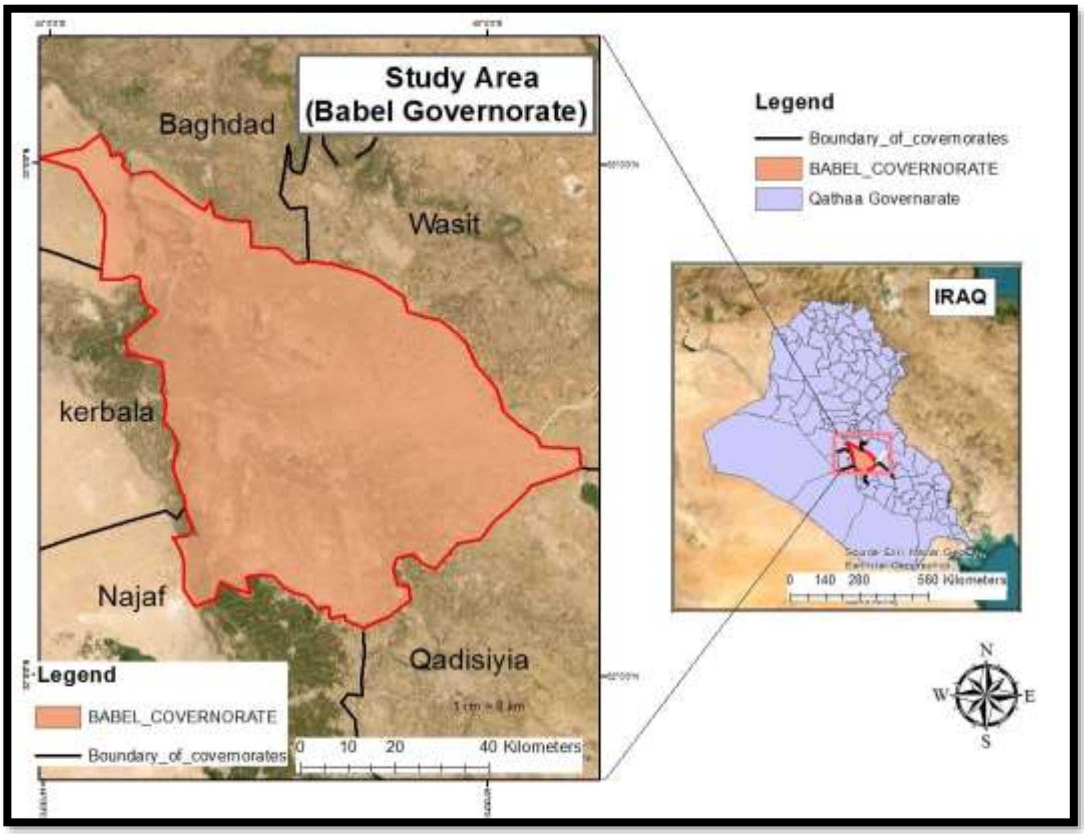


**Figure 1:** Location of the study area Babylon

## 3. Methodology

### 3.1 Data collection

Data were obtained using satellite images from Landsat 5 and 8 from the official website of the United States Geological Survey (USGS) [14]. These images were used to achieve the study's objectives for the period. Three different time years, 1999, 2015, and 2021 were used" to capture the images. The image projection is WGS84 UTM_38N. These satellite images were processed to calculate VCI maps [15], while the temperature and rainfall data were calculated using meteorological data from the meteorological station [16].

### 3.2 Agricultural Drought Indices

In this study, four agricultural drought indices were used, they are:

**1) Normalized Difference Vegetation Index (NDVI)**

NDVI is one of the most commonly used vegetation indices in ecological studies. It is computed based on red (RED) and near-infrared (NIR) light reflectance. It is calculated according to the following formula [17]:

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

RED and NIR are the red and near-infrared reflectance bands, respectively.

This index represents a radiometric measure that obtains different responses from the incident NIR radiation and the visible red vegetation canopy. NDVI correlates with the condition of green vegetation; therefore, NDVI time series have been widely used in research connected to agriculture and drought [18]. The values of NDVI range from $^{+}1$ to $^{-}1$; lower values of NDVI represent sparse vegetation, while higher values deduce the presence of healthy vegetation [19].

**1) Vegetation Condition Index (VCI)**

The VCI index was developed by Kogan, 1990 using the range of NDVI composition. VCI uses information from the visible and near-infra-red parts of the spectrum, calculated from the Normalized Difference Vegetation Index (NDVI). The agricultural drought severity can be evaluated depending on VCI and expressed in (%), which is defined as [20]:

$$VCI = \frac{(NDVI - NDVI_{min})}{(NDVI_{max} - NDVI_{\min})} x100 \quad (2)$$

Where: *NDVImax*, and NDVImin = Maximum and Minimum NDVI values at the study time of each pixel, respectively.

The VCI value varies from 0-100, corresponding to the maximal and minimal vegetation phenology dynamic [21]. The VCI reflects relative changes in the moisture status from extremely bad to optimal. High values of VCI reflect healthy and unstressed vegetation. The classes of the VCI drought index are classified as presented in Table (1).

**Table 1:** Classes of VCI drought index [22]

| Drought Classes | Extreme | Severe | Moderate | Mild | No.Drought |
|---|---|---|---|---|---|
| **Range** | < 10% | 10-20 | 20-30 | 30-40 | >=40 |

## 4. The Results

### 4.1 First Period (1995-2005)

Data was collected from the meteorological station in the Babil (Hilla) province. The data clarifies and indicates the relationship between the climatic elements represented in temperature and rainfall. Their relationship to the vegetation cover area showed a general rise in temperature and a decrease in rain, Figures (2) and (3). The high degree of temperatures contributes to increased drought in the province.

Agricultural drought was calculated using the function (VCI) by eq.(2) for the year 1999 and exported to a map in Figure (4) using ArcGIS 10.8 software. According to the international standard of drought classification in Table (1), the total drought area was 3446 $km^2$. Therefore, the extreme drought area was 338 $km^2$, the severe drought area was 1635$km^2$, the moderate drought area was 886$km^2$, and the mild drought area was 587 $km^2$, where most of it is very severe, such as the area of 1635 $km^2$, and the area of no drought was 1263 $km^2$, Table (2).

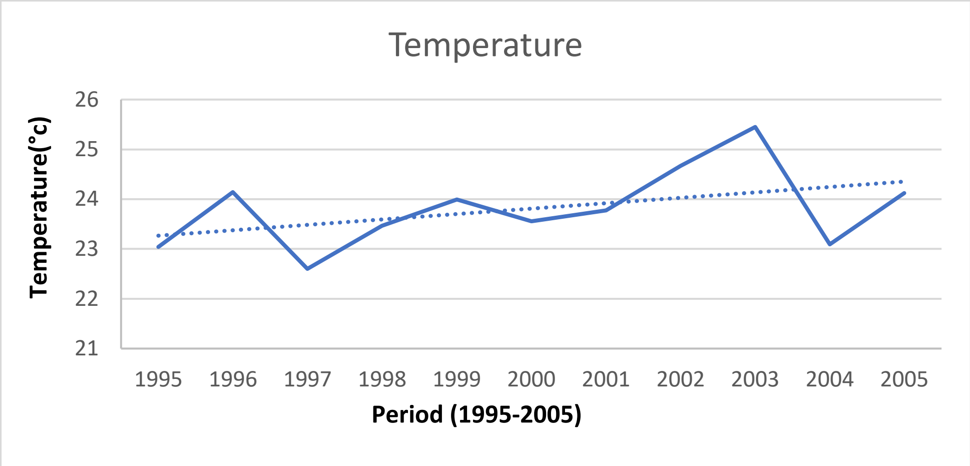


**Figure 2**: The temperature trend for the period 1995-2005

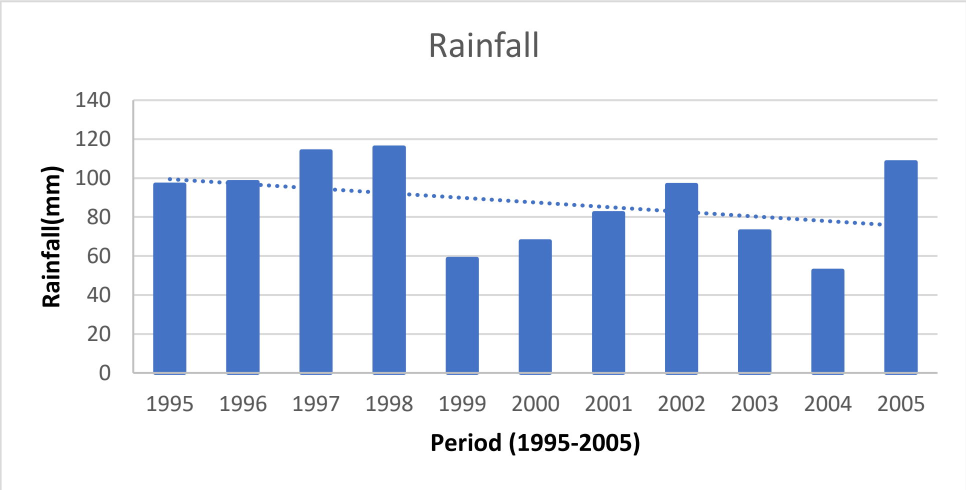


**Figure 3**: The rainfall trend for the period 1995-2005

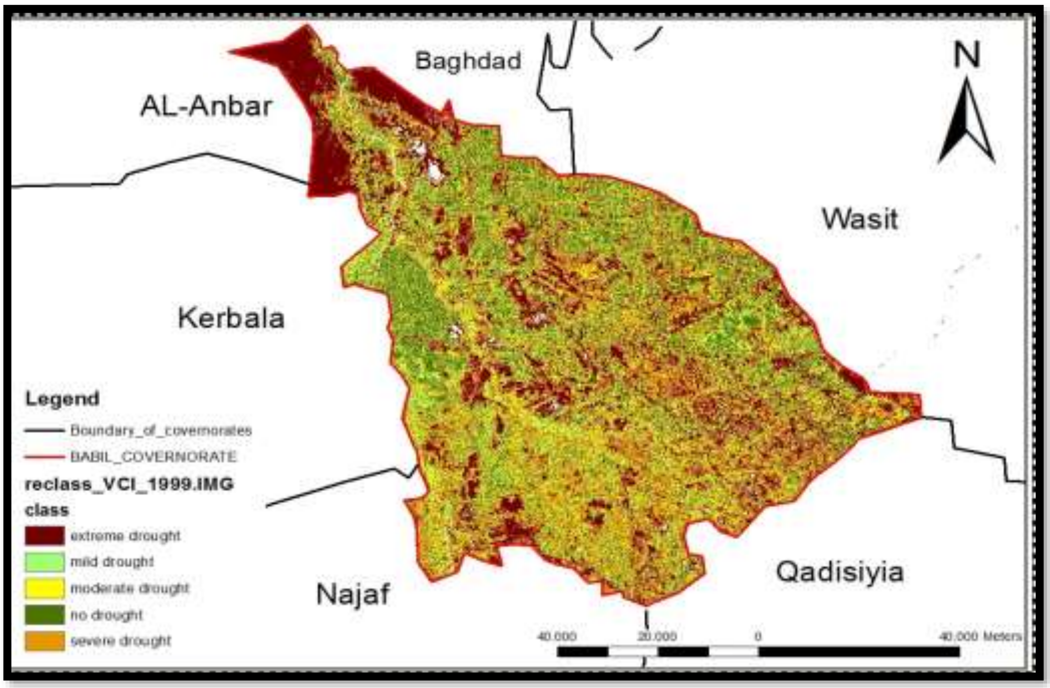


**Figure 4:** The VCI map of the study area in 1999

**Table 2:** Percentage of the VCI area for the study area in 1999

| classes | level of drought | Area $(Km^2)$ for VCI | Percentage % |
|---|---|---|---|
| **<10** | extreme | 338 | **7%** |
| **10-20%** | severe | 1635 | **35%** |
| **20-30%** | moderate | 886 | **19%** |
| **30-40%** | mild | 587 | **12%** |
| **> 40%** | no. drought | 1263 | **27%** |
| | **Total** | 4709 | 100% |

## 4.1 Second Period 2006-2015

Data for 2006–2015 were collected from the climatic station in the Babil (Hilla) province of the Department of Meteorology. The data clarify and indicate the relationship between the climatic elements, temperature, and rainfall. The relationship with the vegetation cover area showed a general rise in temperature with a decrease in the amount of rain, Figures (5) and (6). The high degree of temperatures contributed to increased drought in the province.

Agricultural drought was calculated using the function VCI by eq.(2) for 1999 and exported the map, Figure (7). The international standard of drought classification in Table (1) showed that the total drought area was 4134 $km^2$.Therefore, the extreme drought area was 597 $km^2$, the severe drought area was 1799 $km^2$, the moderate drought area was 1035 $km^2$, the mild drought area was 703 $km^2$, and the no-drought area was 1089 $km^2$, Table (3).

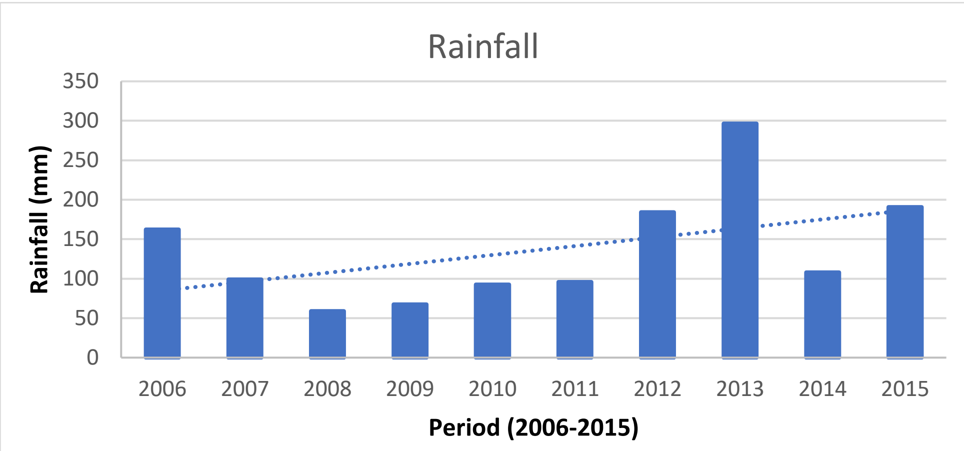


**Figure 5:** The rainfall trend for the period 2006-2015

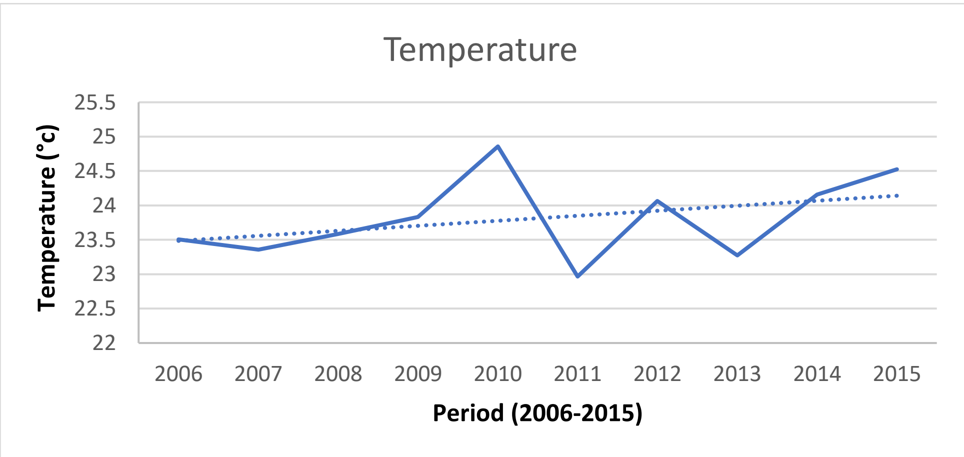


**Figure 6**: The temperature trend for the period 2006-2015

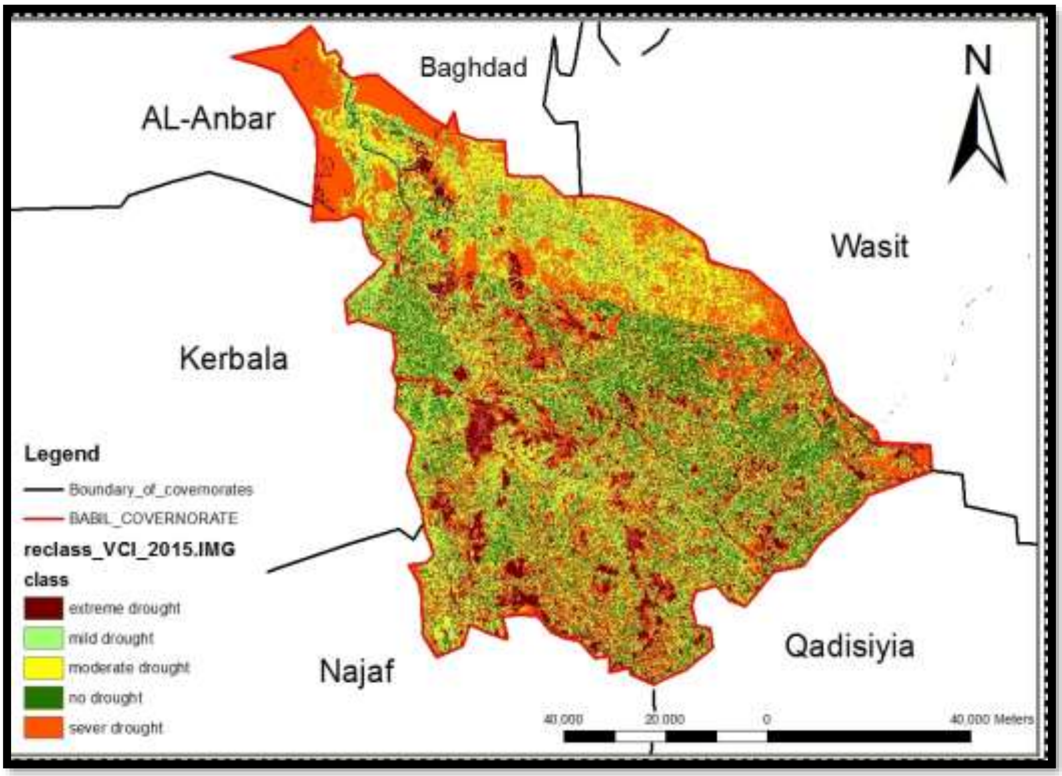


**Figure 7:** The VCI map of the study area 2015

**Table 3:** Percentage of the VCI area for the study area in 2015

| classes | level of drought | Area of drought $Km^2$ for VCI | Percentage% |
|---|---|---|---|
| **<10** | extreme | 597 | **11%** |
| **10-20%** | severe | 1799 | **34%** |
| **20-30%** | moderate | 1035 | **20%** |
| **30-40%** | mild | 703 | **13%** |
| ➢ **40%** | no. drought | 1089 | **21%** |
| | **Total** | 5223 | 100% |

## 4.2 Third Period 2016-2021

Data for 2016-2021 was collected from the climatic station located in the province of Babil (Hilla), Department of Meteorology. The data was used to clarify and indicate the relationship between the climatic elements, temperature, and rainfall. The relationship with the vegetation cover area showed a general rise in temperature with a decrease in the number of rains, Figures (8) and (9). The high degree of temperatures contributed to increased drought in the province.

Agricultural drought was calculated using the function VCI by the eq.(2) for 1999 and exported the map, Figure (10). According to the international standard of drought classification, Table (1), the total drought area was 5238 $km^2$, therefore, the extreme drought area was 1321 $km^2$, area drought was severe in 1982 $km^2$, the moderate drought area was 1196 $km^2$, the mild drought area was 739 $km^2$, and the no-drought area was 924 $km^2$, Table (4).

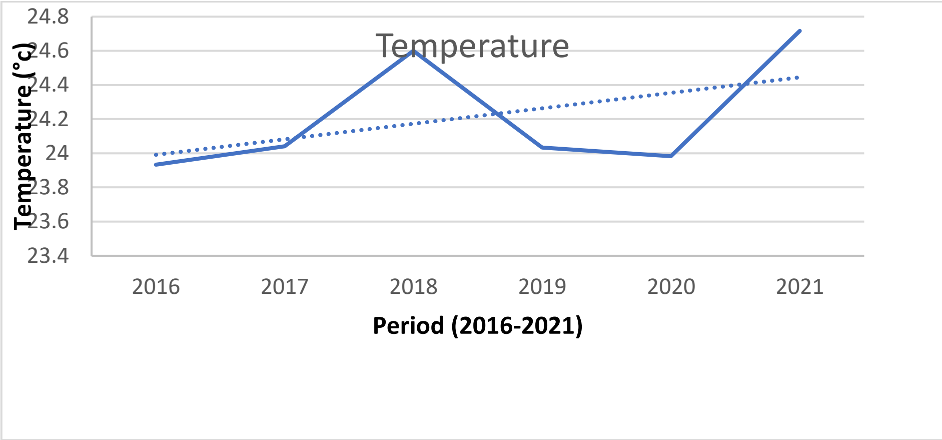


**Figure 8**: The temperature trend for the period 2016-2021

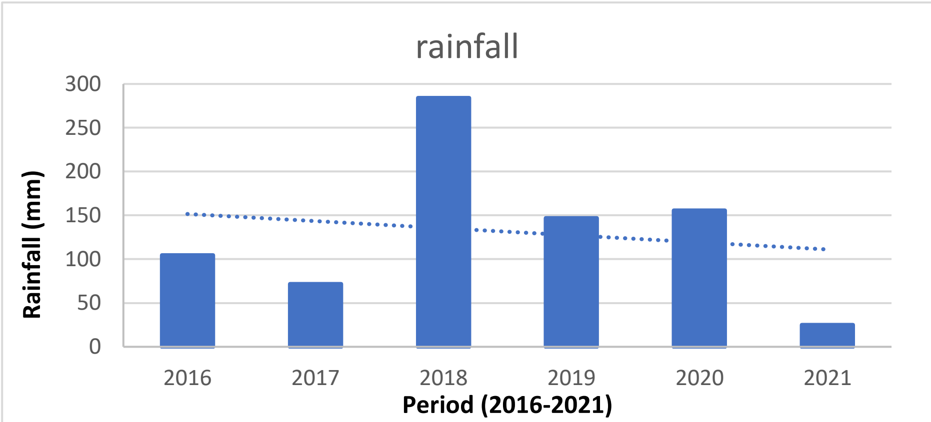


**Figure 9**: The Rainfall trend for the period 2016-2021

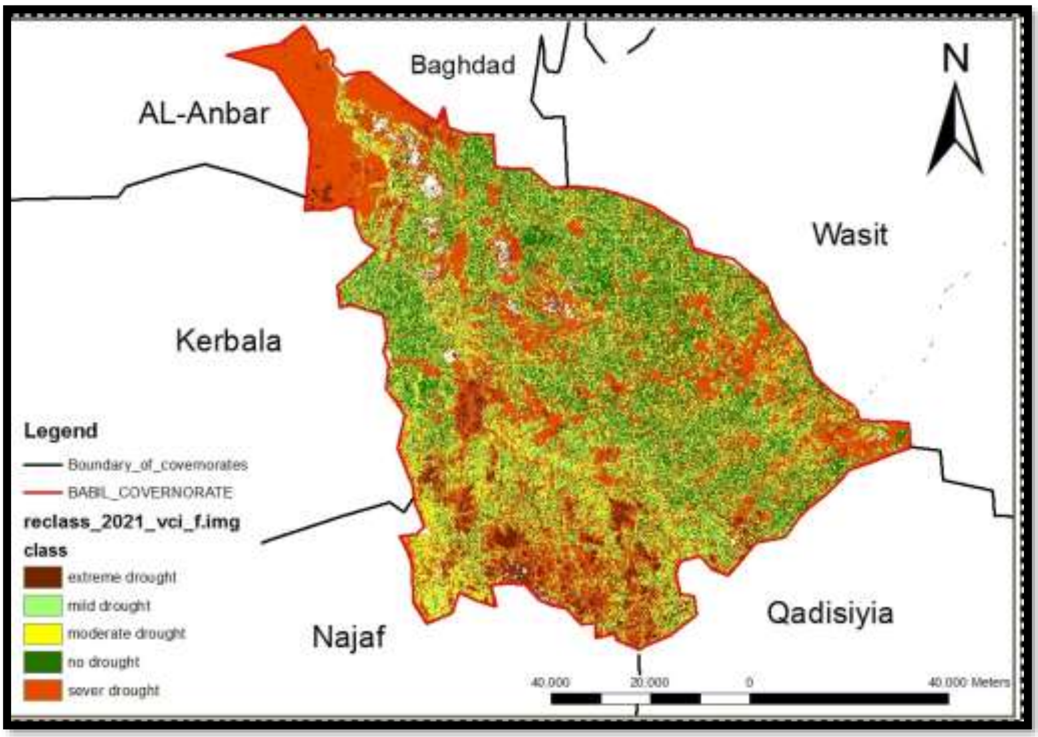


**Figure 10:** The VCI map of the study area in 2021

**Table 4:** Percentage of the VCI index area for the study area year 2021

| classes | level of drought | Area of drought $km^2$ for VCI | Percentage % |
|---|---|---|---|
| **<10** | extreme | 1321 | **21%** |
| **10-20%** | severe | 1982 | **32%** |
| **20-30%** | moderate | 1196 | **19%** |
| **30-40%** | mild | 739 | **12%** |
| **> 40%** | no. drought | 924 | **15%** |
| | **Total** | 6162 | 100% |

## 5. CONCLUSION

After analyzing the agricultural drought of Babil province using remote sensing techniques for 1995, 2015, and 2021, the result concludes:

1- The study area suffered from a high rate of agricultural drought during the period from 1999-2021, as noticed whenever in 1995 extreme agricultural drought of 1635 $km^2$ and 1635, with 35%, and the non-drought area reached 1263 $km^2$.

2- During 2015, the extreme agricultural drought area was about 597 $km^2$, and severe drought was 1,799 $km^2$ by 34%. As for the area of non-drought, it decreased to 1,089 $km^2$.

3- During 2021, noticed an increase in extreme drought in an area of 1321 $km^2$ , and the area of severe drought increased to 1982 $km^2$, and the area of non-drought was 924 $km^2$ by 15%.

4- These reasons are due to poor water resource organization and irrigation methods. If there is no chance of rain, sufficient water must be used to finance the agricultural lands. The farm drought is evidence that there is no rain, and we cannot control the farming lands and their health in production.

5- The absence of a good vegetation cover leads to changes in climate, balancing temperatures, and greenhouse gas emissions.

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