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## Monitoring of Agricultural Drought in the Middle Euphrates Area, Iraq Using Landsat Dataset

**Abstract-** This study was conducted to monitor the agricultural drought in the Middle Euphrates area, Iraq during the period from 1988 to 2018. Multispectral Landsat TM, ETM+, and OLI images were used. The images dated 1988, 1993, 2000, 2005, 2010, and 2018, which obtained during growth months of plants (January, February, March, November, and December). A computerized drought monitoring was adopted using ERDAS Imagine 2015, ENVI 3.2, and ArcGIS 10.5 environments to process and analysis the data. The spectral indices, which used in this study were: The Normalized Difference Vegetation Index (NDVI) and Vegetation Condition Index (VCI). The change analysis presented in this study is based on the statistics extracted from the six resultant drought maps. The final results were illustrated that drought area in the region had a noticeable increase compared with no drought area. The results revealed that percentage of no-drought area ranged between (7%) and (17%) during the period from 1988 to 2018. The extremely and severely drought classes recorded high percentage followed by moderately and mild drought in the region. From this study can be concluded that there is a high rate of drought in the region, especially in its southern and western parts.

**Keywords-** Agricultural drought, Landsat, NDVI, VCI, Middle Euphrates.

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### 1. Introduction

Drought is an intricate risk, and it negatively effects cultivation, environmental, biological, and ecosystem. It is the most costly hazard that can influence on living, economic system, environment, agrarian sector and water supplies [1]. Drought is an insidious natural risk that outcomes from a lack of rainfall from expected such that when it is stretched longer timeframe, the amount of rainfall is deficient to satisfy the requirement of the environment and human activities. Drought is a regional phenomenon and its characteristics will differ from one climate system to another [2]. Drought can deactivate both ecological and economic systems, prompting to populace migration. Moreover, continued drought also promotes land degradation and desertification, which are particularly destructive for vulnerable landscapes bordering arid and semi-arid areas [3]. Agriculture is considered one of the most sector vulnerable to drought compared with the other sectors. In regions, which suffered from drought, the poor farmer is the most vulnerable to threat when severe weather conditions could undermine the yields efficiency and increment economic losses. Agricultural drought season causes the plant covering lose vegetation water content and colors [4].

Agricultural drought can have extreme economic and social outcomes, particularly in areas with limited water resources or with imbalances between water request and natural supply ability [5]. Drought can be observed efficaciously over substantial regions utilizing remote sensing techniques. Satellite-borne remote sensing dataset gives a succinct perspective on earth surface and thusly can be utilized to assess drought event spatially [6]. The aim of this study is to monitor the agricultural drought in the middle Euphrates area, Iraq using Landsat dataset during the period from 1988 to 2018.

### 2. Materials and Methods

#### 1. Location of the study area

The current study was carried on the Middle Euphrates area which extended on about 26611 square kilometers and located between latitudes 31° and 33° N and longitudes 43° 30' and 45° 30' E. The study area consists parts of five governorates, which are: Qadisiya, Babel, Karbala, Najaf and Muthana as illustrated in Figure 1.

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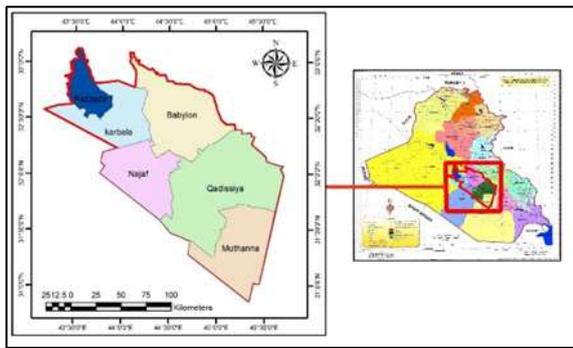


Figure 1: Location of study area

The weather of the region is arid to semi-arid with dry hot in the summer season and cool in the winter season. The rainy season in the area starts with the beginning of October and extended to the end of May as illustrated in Figure 2.

II. Software package

In this study, ERDAS Imagine 2015, ENVI 3.2, and ArcGIS 10.5 software were used to process and analysis the datasets.

III. Available Data

In order to monitor the agricultural drought statement in the study area, the Landsat satellite TM, ETM+ and OLI images have been used to obtain the dedicated agricultural drought indices. The study area is covered by three Landsat images as shown in figure 3. Multispectral Landsat (path 168 / row37, path 168 /row 38, and path 169 / row37) are dated 1988, 1993, 2000, 2005, 2010, and 2018, respectively. All images were acquired during plants growth seasons (January, February, March, November, and December) in each year from 1988 to 2018. The remotely sensed dataset were used to analysis the agricultural drought in the study area by using visible and near infrared bands with spatial resolution of 30 meter. All the aforementioned images were freely downloaded from the USGS website: <http://earthexplorer.usgs.gov>. The overall study-downloaded images were 90.

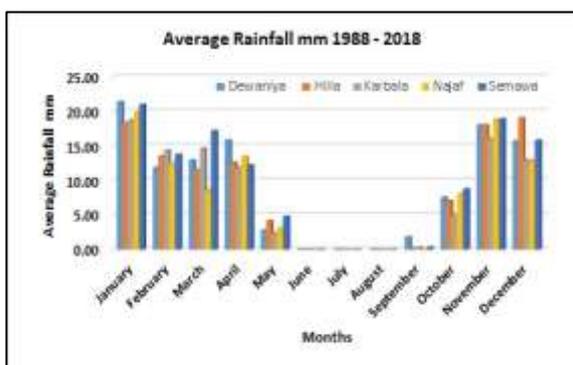


Figure 2: Average rainfall mm in study area 1988-2018

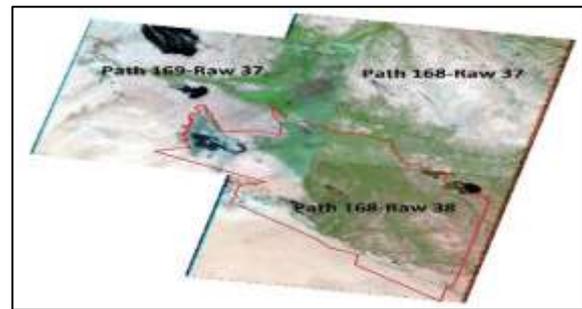


Figure 3: Land sat images of study area

IV. Preprocessing and geometric correction

In this study, the Landsat TM, ETM+ and OLI images have been transformed into spectral radiance and normalized for illumination properties by recalculating the pixel values into surface reflectance. All images have been converted from digital number to reflectance form depending on radiometric rescaling coefficients provided in the product metadata file for each image. Registration of Landsat images were based on twenty ground control points (GCP) collected from an intersection of the roads and rivers, at the study area. The remote sensing data were geometrically corrected in the datum WGS84 and projection UTM zone 38N utilize the first order of a polynomial method. Image to image registration was done in order to register the Landsat images dated 1988, 1993, 2000, 2005, 2010 with geocoded Landsat OLI image of 2018 (reference image).

V. Agricultural drought indices

Two spectral-based agricultural drought indices were used, they are:

1. Normalized Difference Vegetation Index (NDVI)

The NDVI is one of the most commonly utilized vegetation indices in ecological studies. It is computed based on the near-infrared and red bands. It is computed according to the following formula [7]:

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

Where:  $\rho_{NIR}$  is the near infrared reflectance and  $\rho_{RED}$  is the red reflectance (band).

The NDVI represents a dimensionless, radiometric measure that acquires diverse reaction from the incident red and NIR radiation with the vegetation. The NDVI correlates with the relative abundance and state of green plants, therefore the NDVI time series have been broadly utilized in studies associated with drought and agriculture, such

as estimation of seasonal events, land cover classification and vegetation conditions [8]. The NDVI values range between -1 to +1. A higher value of NDVI represents the presence of healthy vegetation in the region while its lower values is the indicator of sparse vegetation [9]. In this study, the NDVI values were calculated using Landsat satellite images of the months January, February, March, November, and December for each year from 1988 to 2018.

2. Vegetation Condition Index (VCI)

The VCI index was developed by Kogan (1990) depending on the ranges of NDVI index. The severity of agricultural drought can be evaluated by this index. It is computed by the following equation [10].

$$VCI = \frac{(NDVI - NDVI_{min.})}{(NDVI_{max.} - NDVI_{min.})} * 100$$

(2)

Where: NDVI<sub>max</sub>, NDVI<sub>min</sub> = Maximum and Minimum NDVI values at the study time of each pixel, respectively.

The VCI values varies from 0 to 100, which corresponds to the maximal and minimal vegetation phenology dynamic [11]. The NDVI images illustrates the seasonal vegetation dynamics, while the VCI rescales vegetation dynamics between 0 and 100 to reflect relative changes in the moisture condition from extremely bad to optimal [12]. The classes of VCI index were classified as shown in table 1. In this study, the VCI values were calculated from Landsat images for the years 1988, 1993, 2000, 2005, 2010, and 2018 as presented in Figures 4-9.

Table 1: Classes of VCI drought index [12]

Drought classes	Ranges
Extreme	<10
Severe	<20
Moderate	<30
Mild	<40
No	>=40

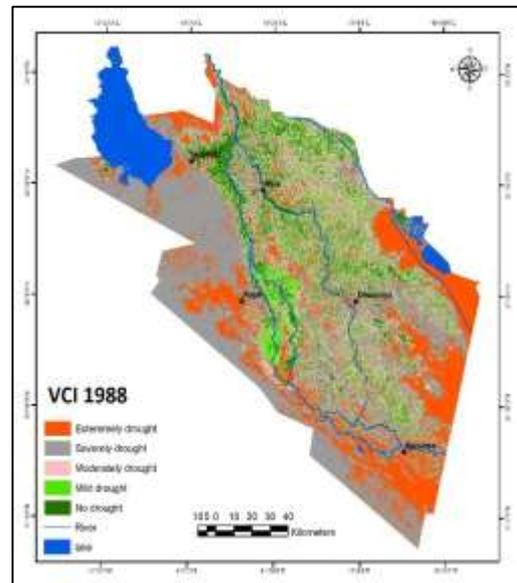


Figure 4: VCI index of study area 1988

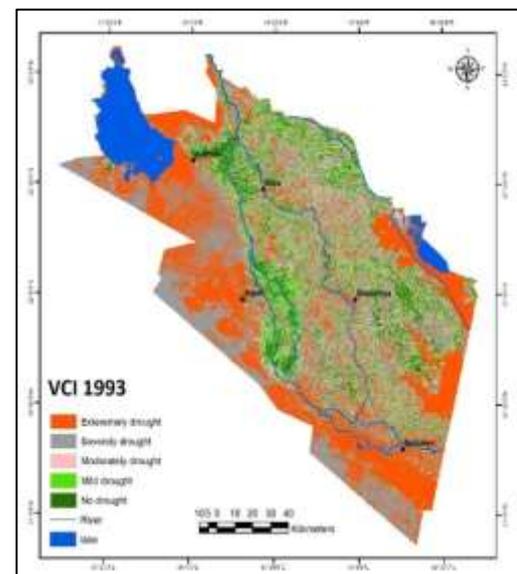


Figure 5: VCI index of study area in 1993

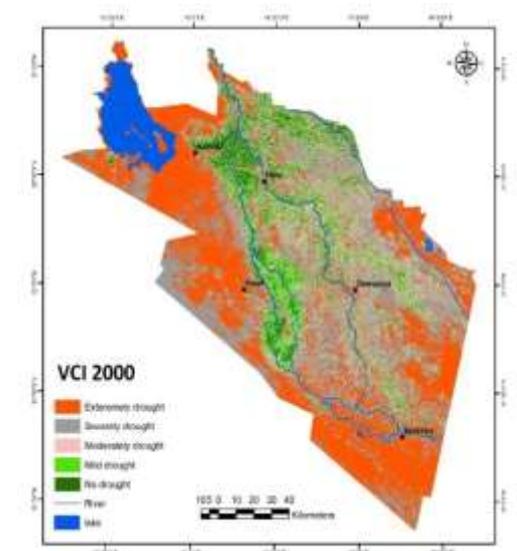


Figure 6: VCI index of study area in 2000

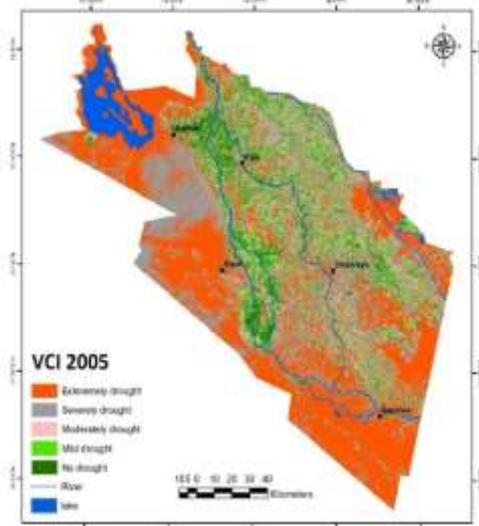


Figure 7: VCI index of study area 2005

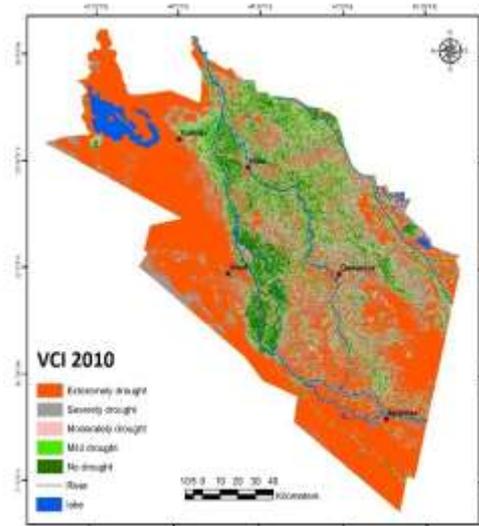


Figure 8: VCI index of study area 2010

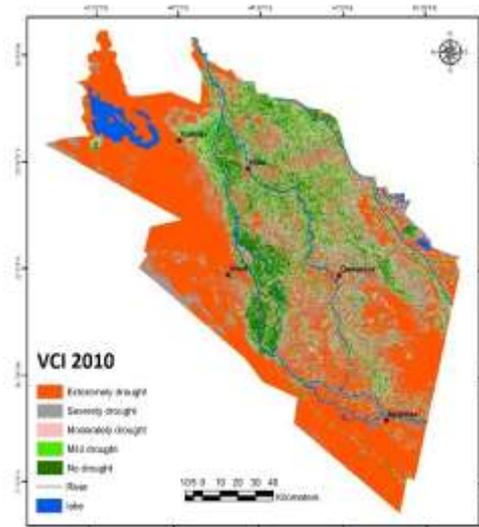


Figure 9: VCI index of study area in 2018

### 3. Results and Discussion

The middle Euphrates area in Iraq, is considered as one of the most areas threatened by drought. It is one of the agricultural areas in the country, which is characterized by its economic importance, therefore, this study was focused on monitoring the agricultural drought in the span from 1988 to 2018.

The change detection analysis that presented in this study is based on the statistics extracted from the six drought maps using the NDVI-based VCI index. The results revealed that the drought areas had a noticeable increase compared with no drought area; from the figures 4-10 we observed that the no-drought area was very smaller compared with drought area during the period from 1988 to 2018. The percentage of no-drought area was 2,209 km<sup>2</sup> (8%), 2,527 km<sup>2</sup> (9%), 1,830 km<sup>2</sup> (7%), 2,503 km<sup>2</sup> (9%), 2,846 km<sup>2</sup> (11%), and 4,597 km<sup>2</sup> (17%) in 1988, 1993, 2000, 2005, 2010, and 2018, respectively. The above mentioned results illustrated that the higher percentage of no-drought area reached to (17%) in 2018. On the other hand, the lower percentage of no-drought area reached to (7%) in 2000, which means that the ratio of no-drought area ranged between 7-17% compared with the drought affected area during the period from 1988 to 2018. There is an increase in the percentage of no-drought area in 2018 compared with the other years, but it does not reach to percentage value of drought affected area in the region. The extremely and severely drought classes recorded higher percentage followed by moderately and mild drought as illustrated in figure 10. The final extracted results illustrated that there is a high percentage of drought in the middle Euphrates area, particularly in its southern and western parts.

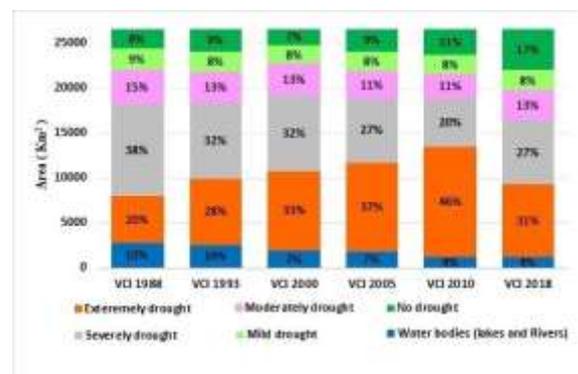


Figure 10: Areas and percentages of drought classes in the region 1988 – 2018

#### 4. Conclusions

From the results obtained in the current study, the following points can be concluded:

1. The drought area in the region had a noticeable increase compared with no-drought area.
2. The percentages of no-drought area were 8%, 9%, 7%, 9%, 11%, and 17% in 1988, 1993, 2000, 2005, 2010, and 2018, respectively.
3. The ratio of no drought area ranged between (7%) and (17%) compared with the drought area in the study area.
4. The extremely and severely drought classes recorded high percentage in the study area followed by moderately and mild drought.
5. The region suffered from a high percentage of agricultural drought during the period from 1988 to 2018.
6. There is a high rate of drought in the region, especially in its southern and western parts.

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