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MONITORING DROUGHTS PHENOMENON USING REMOTE SENSING AND GIS IN WASIT/ IRAQ

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Abstract

Drought considered being the most vulnerable natural hazard that affects a large number of people. Drought has nonstructural effects that spread across a vast geographic area, endangering human lives. The Normalized difference vegetation index (NDVI) based on Landsat 8 imaging and the meteorological-based Standardized Precipitation Index (SPI) were used to monitor the drought in Wasit governorate eastern Iraq for 2013 and 2018. To accurately assess the drought-affected area and provide appropriate drought-proofing, the Arc GIS Desktop 10.5 program was utilized to examine the spatial and temporal variance of drought across the study area. Using NDVI analysis in the study area, the vegetation area decreased by 7 %. Drought classification based on 12-month SPI indicated the drought of the near-normal type. The SPI data analysis data show that in 2013, SPI values were lower in Badrah station's northern part of the study area. While in 2018, the lower SPI value - was 0.54033 in Ali al Gharbi terrestrial station. This result is considered near normal according to the SPI usual range. These findings could aid drought management programs and reveal the genuine drought situation in the area.

Introduction

Drought is one of the major natural hazards for the agricultural sector, which causes about 84% of agricultural losses due to all-natural hazards (FAO, 2014). Drought is a frequent slow-moving climate event that increases in intensity and gradually persists depending on water availability; it is an inevitable phenomenon affecting more than half of the terrestrial earth yearly (Kogan, 1997). Generally, droughts are classified into three types that are interconnected to each other, which are; meteorological, hydrological, and agricultural drought. The limitations of traditional drought monitoring indicators make

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drought monitoring a complicated task. Satellite imagery rapidly provides a wide range of monitoring capabilities, especially for areas not available for field survey due to terrain, dense vegetation, or another obstacle (Varga et al., 2015). Utilizing remotely sensed data, drought phenomena could be studied with less time and lower cost, essentially in association with GIS, which provides an appropriate platform for data analysis, updating, and retrieval (Chilar, 2000). Several studies used remote sensing data and GIS to monitor the drought phenomenon in Iraq and achieved good results (Jawad et al., 2018; Al-Timimi et al., 2102; Fadhil, 2009; Obaid and AL-Samarrai, 2013; Mahmood and Shukar, 2014). To map and identify drought, numerous indices have been established. The most used metric for describing droughts is the Standardized Precipitation Index (SPI), which is the most prevalent one (Mishra and Singh, 2010). this index is based on precipitation, a practical and straightforward method. SPI could also be calculated at different times to track the meteorological drought (Hayes et al., 1999). SPI index was developed by McKee et al. in 1993. Due to its robustness, it has then been widely employed to research droughts. There are many different vegetation indicators, however the NDVI is a useful and popular indicator (Liu and Huete, 1995). NDVI is used repeatedly to monitor drought and agricultural production. The agricultural drought could be studied utilizing the NDVI (Sruthi and Aslam, 2014).

Using remote sensing and GIS, the study study aims to evaluate and monitor the spatial pattern of Wasit's drought severity between 2013 and 2018. Moreover, to concentrate on evaluating the agricultural drought by looking at the vegetation stress brought on by the decreased rainfall. For agricultural and environmental policies, this study could be helpful to regional planners.

2. MATERIALS AND METHODOLOGY

2.1 STUDY AREA

Wasit governorate is located in the middle east of Iraq between longitudes 44° 40' – 46° 40' E and latitudes 32° 00'−33° 50' N (Fig. 1). It is shaped like a peninsula surrounded by water from the East, the West, and the South. It is located 172 km south of Baghdad (the Iraqi capital). Wasit is bordered to the northeast by Diyala governorate and to the South- West of Dhi Qar Governorate. It is also bordered to the west by Al-Diwaniyah and Babil governorate, whereas it is bordered to the east by Iran Mehran City. The city of Kut is the center of the governorate, penetrated by the Tigris River and divided into almost equal parts. The

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governorate is considered one of the agricultural governorates; its agricultural arable land is about four square kilometers.

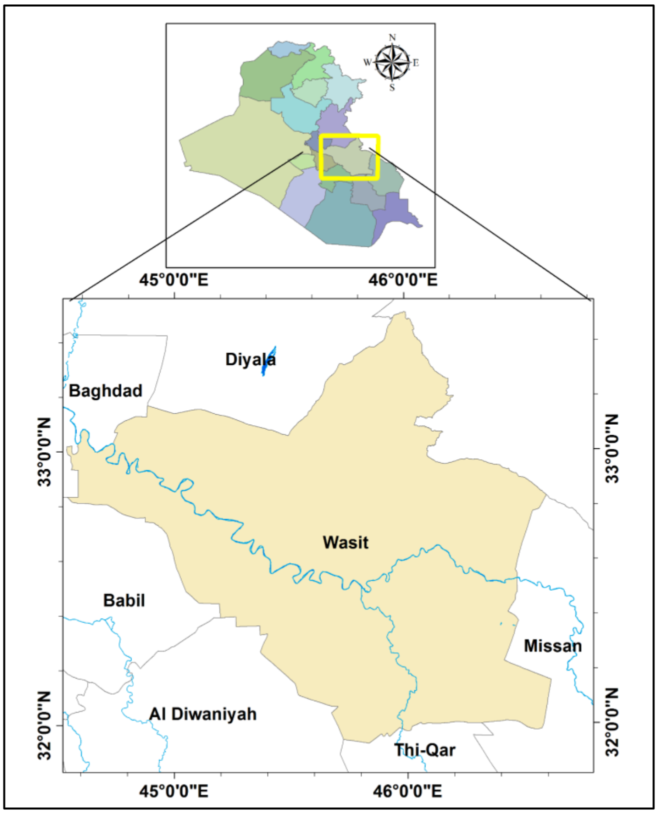

Figure 1: Study area location.

2.3 DATASETS

The LANDSAT 8 images are a vital resource for various agriculture applications. Landsat 8 images were obtained from USGS to analyze the drought phenomenon, with a spatial resolution of 30 m and April for 2013 and 2018 (Table 1). In addition, Eight metrological stations' worth of SPI data were also acquired and collated from the European Drought Observatory (EDO) website (Fig. 2). The data used to determine years of drought vs. non-drought conditions using SPI data for the selected years is shown in Table 2. The methodology flowchart is illustrated in Figure3.

Table 1: Satellite data specifications.

Path/Row	Date	Bands	Resolution (m)
167/37	4/2013	Multispectral	30
167/38	4/2013	Multispectral	30
168/37	4/2013	Multispectral	30
168/38	4/2013	Multispectral	30
167/37	4/2018	Multispectral	30
167/38	4/2018	Multispectral	30
168/37	4/2018	Multispectral	30
168/38	4/2018	Multispectral	30
• Data Source (USGS website) https://www.usgs.gov/			

Table 2: SPI-12 values for the years 2013 and 2018.

Name	Long	Lat	SPI 2013	SPI 2018
Al Hashimiyah	45.125	32.375	0.2056	-0.0365
Al Kut	45.78	32.54	0.2054	-0.037
Al Mahawil	44.875	32.625	0.0523	0.0975
Al Noamania	45.625	32.125	0.2057	-0.0373
Ali al Gharbi	46.692	32.464	0.1265	-0.54033
As Suwayrah	44.82	33.01	-0.1897	0.1265
Badrah	45.875	33.125	-0.3157	-0.0341
Balad Ruz	45.625	33.375	-0.3155	-0.0358
• Data source: European Drought Observatory (EDO) website.				

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https://edo.jrc.ec.europa.eu/edov2/home.static.html

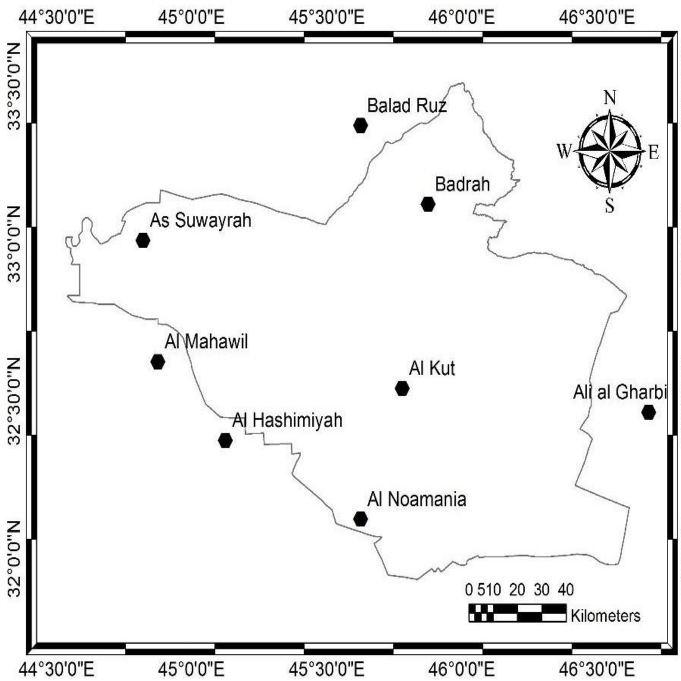

Figure 2: Metrological stations location.

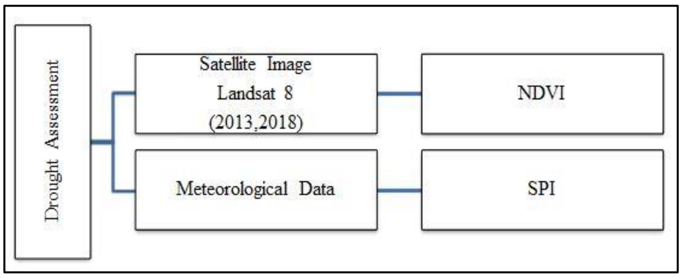

Figure 3: Methodology flowchart.

2.2 REMOTE SENSING INDICES FOR DROUGHT MONITORING

Remote sensing indicators have provided a new method to assess and monitor agricultural land. The remotely sensed data were obtained from different sources and indicators such as the vegetation indicators, e.g., NDVI, Vegetation condition index (VCI), Vegetation Temperature Condition Index (VTCI), etc. Vegetation indicators are one of the widest satellite data products used to assess, monitor, and measure the vegetation cover, biophysical processes, and changes (Basso et al., 2004).

2.2.1 NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)

NDVI is one of the most frequent indexes used by researchers to monitor agricultural drought (Peters et al., 2002). The NDVI's fundamental premise is that green vegetation strongly reflects Near Infrared (NIR). At the same time, it also absorbs a significant amount of visible red radiation (Red) in the electromagnetic spectrum. The NDVI values range from - 1 to 1. At the same time, the vegetation's typical range is between 0.2 to 0.8 (Ganie and Nusrath, 2016). Using Landsat 8 OLI, the red band and NIR band are the bands 4 and 5, respectively. According to Rouse et al. (1974), the NDVi equation is:

$$NDVI = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}} \quad \dots (1)$$

2.2.2 Standardized Precipitation Index (SPI)

Since vegetative drought develops from meteorological drought, which is caused by a lack of precipitation, SPI was employed to investigate meteorological drought. The SPI was developed by McKee et al., which is based only on precipitation. By calculating SPI, one

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can determine the climatic conditions for the period of interest in accordance with Table 1 and the SPI value. Considering the table, drought begins when the numbers are less than -1 (Rezaei et al., 2012). The SPI values range from -2 to 2, indicating extreme drought and extreme wet conditions. The SPI calculation is based on the following expression:

$$SPI= (Xi-Xi\ mean)/\sigma \ \ldots \ (2)$$

Where x is the mean annual rainfall.
Xi the annual rainfall at any year.
ρ the standard deviation.

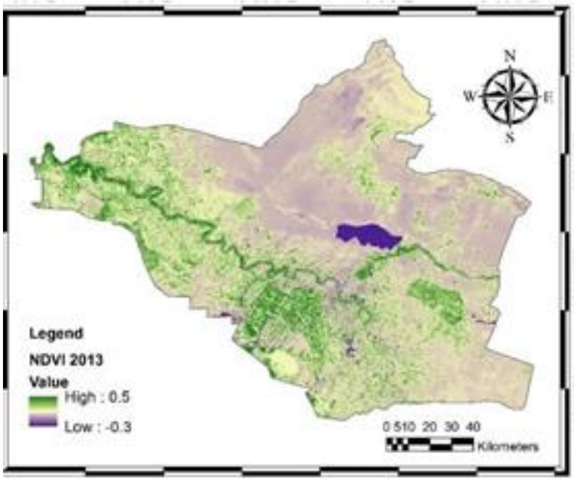
Table 3: The SPI category (Aswathi et al., 2018)

SPI Range	Category
≥2.00	Extremely wet
1.55_1.99	Very wet
1.0_1.49	Moderately wet
-0.99_0.99	Near normal
-1.00_-1.49	Moderately dry
-1.5 - -1.99	Severly Dry
≤ -2	Extremely Dry

3. RESULTS AND DISCUSSION

3.1 Agricultural Drought

NDVI was calculated for 2013 and 2018 using Landsat 8 images for April via Arc Map 10.5 software (Fig. 4). These images underwent a temporal analysis to determine how the drought had changed in the study area. Only positive values were taken in the count to classify each image the vegetation was extracted, as shown in Figure 4. The green color shows healthy and wet vegetation areas for NDVI images. The vegetation class was extracted based on NDVI according to the typical value based on the Digital Number value. Finally, after extracting the vegetation class, the percentage of area for the vegetation was calculated for each year to determine the change in vegetation cover. The results show that the vegetation area decreased by 7 %, as shown in Table 4.



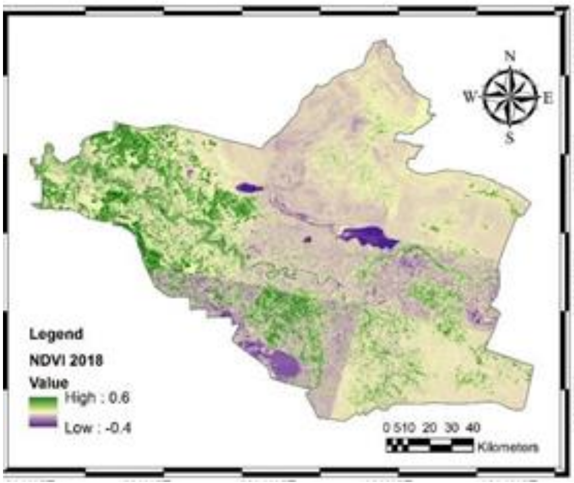


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Figure 4: shown the change in the NDVI index over the study area during the years.

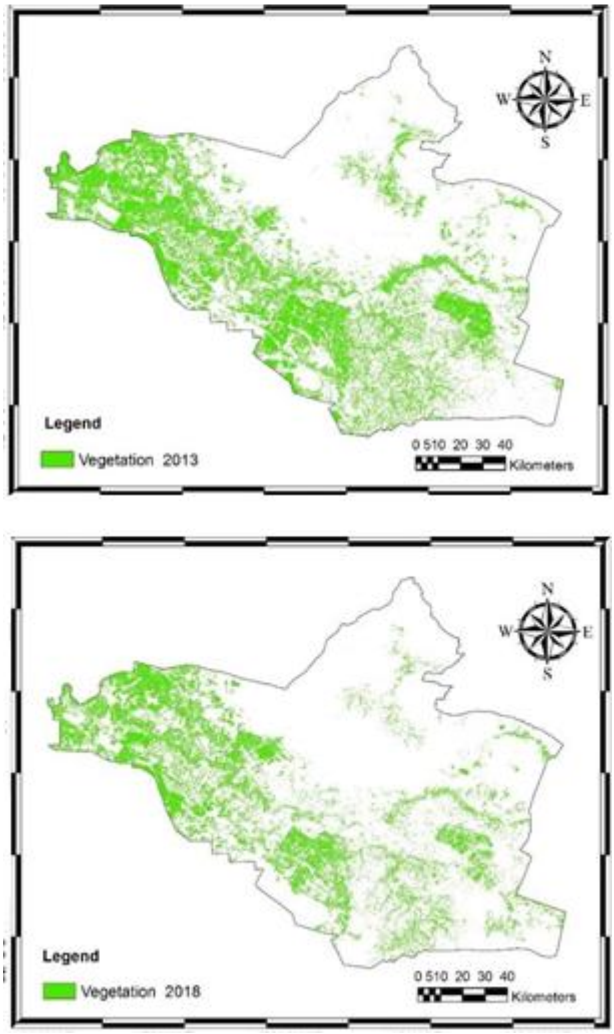

Figure 4: Extracted vegetation for the years 2013 and 2018.

Table 4: The area percentage for the vegetation cover.

Class	2013	2018	Change
Vegetation	24.5 %	17.2%	-7.3%

3.1 Meteorological drought

The SPI was designed to quantify the precipitation deficit for multiple time scales. These time scales reflect the impact of drought on the availability of the different water resources. For calculating SPI-12, you should calculate the average of the last 12 months. The 12-month SPI results indicated drought of the near-normal type. The SPI data values for 2013 and 2018 were analyzed (Fig. 5 illustrates SPI for eight stations in Wasit and the surrounding area). In 2013, SPI values showed a lower value in Badrah station's northern part of the study area. While in 2018, the lower SPI value was recorded as -0.54033for rainfall station in Ali al Gharbi, according to the SPI typical rang, this value is considered near normal.

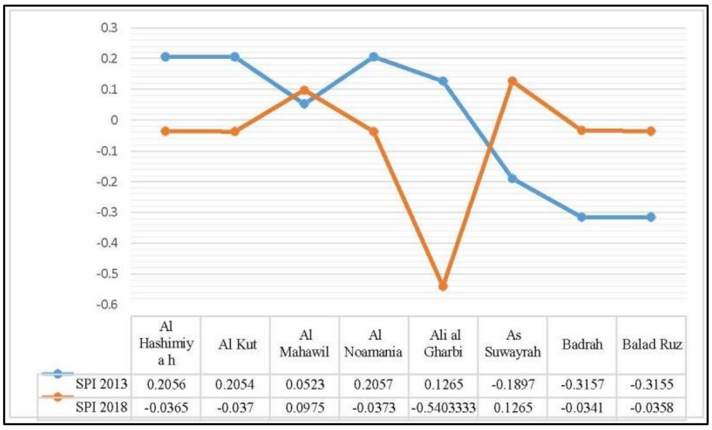

Figure 5: shown the change in SPI values during the years 2013 and 2018.

2. CONCLUSIONS

In this study, remote sensing data were used to monitor drought, especially considering the limited availability of measured ground data. The main conclusions are:

- The SPI index is thought to be an efficient technique that might be used to identify and map the drought. SPI has a high potential for analyzing drought, given its computational properties, for any spatiotemporal scale. A crucial tool for drought monitoring and mitigation is ArcGIS Desktop combined with the drought index (SPI). The depiction of scientific findings that are crucial for the decision-making process is supported by ArcGIS Desktop.
- The 12-month SPI results indicated drought of the near-normal type. The SPI data analysis shows that; in 2013, SPI values showed a lower value in Badrah station northern part of the study area. While in 2018, the lower SPI value was recorded as -0.54033for rainfall station in Ali al Gharbi, this value is seen as being close to normal based on the SPI usual range.
- Finally, after extracting the vegetation class, the percentage of area for the vegetation was calculated for each year to determine the change in vegetation cover. The results show that the vegetation area decreased by 7 %.

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رصد ظاهرة الجفاف باستخدام الاستشعار عن بعد ونظم المعلومات الجغرافية في محافظة واسط / العراق

ياسر عبد الأمير نايف الدباغ

علي ابراهيم زغير النصراوي

الملخص

يعتبر الجفاف من أكثر الأخطار الطبيعية عرضة للخطر الذي يؤثر على عدد كبير من الناس. للجفاف آثار غير هيكلية تنتشر عبر مناطق جغرافية شاسعة ، مما يعرض حياة البشر للخطر. تم استخدام مؤشر الفرق المعياري للغطاء النباتي (NDVI) المستند إلى تصوير لاندسات 8 ومؤشر الأمطار المعياري المستند إلى الأرصاد الجوية لرصد الجفاف في محافظة واسط شرق العراق لعامي 2013 و 2018. لتقييم المنطقة المتأثرة بالجفاف بدقة وتقديمها مقاومة الجفاف المناسبة ، تم استخدام برنامج Arc GIS 10.5 Desktopلفحص التباين المكاني والزماني للجفاف عبر منطقة الدراسة. باستخدام تحليل NDVI في منطقة الدراسة ، انخفضت مساحة الغطاء النباتي بنسبة 7٪. يشير تصنيف الجفاف على أساس المؤشر المعياري للهطول لمدة 12 شهرًا إلى جفاف شبه الطبيعي. تظهر بيانات تحليل البيانات SPI أنه في عام 2013 ، كانت قيم SPI أقل في الجزء الشمالي لمحطة بدرة من منطقة الدراسة. بينما في عام 2018 ، كانت قيمة SPI الأدنى -0.54033 في محطة علي الغربي الأرضية. تعتبر هذه النتيجة شبه طبيعية وفقًا لنطاق المؤشر المعياري للهطول المعتاد. يمكن لهذه النتائج أن تساعد برامج إدارة الجفاف وتكشف عن حالة الجفاف الحقيقية في المنطقة.

الكلمات المفتاحية : SPI, GIS, NDVI, الاستشعار عن بعد , واسط