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Temporal and Spatial Variation of Agricultural Drought and Desertification using Spectral Indices in Salah Al-Din Governorate

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ABSTRACT

The aim of study to temporal and spatial variation of agricultural drought and desertification using Spectral Indices and Landsat Images. A time series of satellite images (TM and OLI) were coducted Latitudes (34°52'29.386" - 34°42'54. 584") N and longitudes (43°26'15.703" and 43°31'22.753") E and the area study is (33.98) km^2. The (18) eighteen of satellite images were selected and then image processing was carried out using ERDAS imagen Ver 15 and ArcGIS 10.6. The spectral indices (Normalized Difference Vegetation Index (NDVI), Land Surface Temprature (LST), Vegetation Condition Index (VCI), and Vegetation Health Idex (VHI) were calculated. The regression and correlation coefficient between rainfall and spectral indices were determined using SPSS programm. The result show that VHI at 1990, 2000 and 2010 are sever drought class and its area 63.66, 57.63 and 63.85% respectively. In addition, the simple linear regression and correlation coefficient were positive between a rainfall and spectral indices reach ≥ 0.70. The years 1998, 2008, 2013 and 2022 were suffering from sever drought and desertification compared with 2006, 2016 and 2019, respectively.

التغاير الزماني والمكاني للجفاف الزراعي والتصحر محافظة صلاح الدين باستخدام المؤشرات الطيفية في

علي حسن حمادي ، اياد عبدالله خلف
قسم علوم التربة والموارد المائية، كلية الزراعة، جامعة تكريت، العراق

الخلاصة

هدفت هذه الدراسة الى تحليل السلاسل الزمنية للجفاف الزراعي والتصحر باستخدام الادلة الطيفية والصور الفضائية. تم اختيار سلسلة زمنية من المرئيات الفضائية للقمر الصناعي لاندسات (7و 8و9) وللفترة من 1990-2022. تقع منطقة الدراسة عند الاحداثيات ("584 .34°42'54 - "34°52'29.386) شمالاً ("43°26'15.703" and 43°31'22.753) شرقاً وتغطي مساحة 33.98 كم2. تم اختيار 18 صورة فضائية للقمر الصناعي لاندسات ومن ثم تم اجراء المعالجة الرقمية باستخدام برنامج ايرداس وتحليل وحساب المؤشرات واعداد الخرائط باستخدام برنامجArcGIS . كما تم حساب الادلة الطيفية وهي(دليل الاختلاف الخضري الطبيعي NDVI ودليل حرارة سطح الارض LST ودليل حالة الغطاء النباتي VCI ودليل صحة النبات VHI. تم تقدير علاقة الارتباط والانحدار بين معدلات الامطار الساقطة والادلة الطيفية المحسوبة باستخدام برنامج SPSS. النتائج توضح دليل صحة النبات VHI خلال السنوات 1990و 2000و 2010 كانت ضمن الصنف الشديد ومساحتها 63.66و 57.63و 63.85% من مساحة منطقة الدراسة. واظهرت نتائج التحليل الاحصائي ان معامل التحديد R2 ومعامل الارتباط كانت قوية موجبة بين معدلات الامطار والادلة الطيفية ووصلت الى اعلى من 0.70 . كما اظهرت النتائج ان السنوات 1998و 2008و 2013و 2022 كانت تعاني من شدة الجفاف والتصحر مقارنة بالسنوات 2006و 2016و 2019 على التوالي.

الكلمات الافتتاحية: الجفاف، دليل صحة النبات، دليل حرارة السطح، دليل الغطاء النباتي الطبيعي، التصحر

INTROUCTION

Desertification is one of the most environment problems around world; it is affecting the lives of 20 % and 6 million hactar per year from lands. The drought known as "deficiency in precipitation over an extended period, usually a season or more, causing adverse effects on plant, animals, and/or people (NOAA, 2008; Unesco, 2014). Iraq has been suffer from drought and desertification because different factors including rainfall, rate of temperatures, low of soil moisture and decrease of plant cover, lower discharge of Tigris and Euphrates Rivers, and agricultural land degradation (Unesco, 2014). Drought always derelated to a lack of water resources and affect in the agricultural use, rangeland, low of soil moisture, groundwater scarcity, human action and crop growth. The drought was classified into agricultural, meteorological, and socioeconomic.

Several studies have been description that remote sensing application and geographic information system are essential techniques through spatial and temporal data acquired from reflectance, spectral indices and spectral ratio for assessing vegetation healthy, soil, land desertification and drought (Yang *et al*., 2012;; Orimoloye *et al*., 2018b; Stephen *et al*., 2017;Khalaf and Hussien, 2021). Several drought indices have been developed and applied to degree of duration and drought/desertification severity as Normalized Difference Vegetation Index (NDVI) (Ji and Peters, 2003; Rhee and Carbone, 2010; Mishra *et al*., 2015). The vegetation health Index (VHI) is better performance to detect drought and temperature- stressed vegetation caused (Choi *et al*., 2013). The study in Vietnam was used satellite images from 1989 to 2016 to assess of drought through spectral indices as NDVI, VCI, TCI, and VHI and results showed that two-thirds of Suipeng County were affected by moderate drought (Trana *et al*., 2017). The time series of VCI images and Standardized Precipitation Index (SPI) were used for monitoring agricultural drought in Rajasthan (India) (Dutta *et al*., 2015). The Temperature

Conditions Index (TCI), the effects of drought status leading to a low in soil moisture and an increase in surface heat stress. Therefore, the relationship is inverse between the vegetation density and surface temperature (Kogan *et al*, 1995). VHI is common around the world (Zargar *et al*., 2011;Kogan *et al*., 2013) to quantify agricultural drought, like america states (Kogan *et al*., 2012; Anderson *et al*. 2013), Russia (Kogan *et al*., 2015), Iran (Jalili *et al*., 2014). The VHI and SPEI are recognied indices for assessing drought hazard (Ejaz et. al., 2023). The several studies around a world are adopted spectral indices(VHI , LST, TCI,NDVI and VCI) for monitoring drought, desetification and land degeradation (Karnieli *et al*., 2010; SHAHABFAR and EITZINGER, 2011; Eastman *et al*., 2013;Ibrahim *et al*., 2015; Jiao *et al*.,2016;Zuhro *et al*., 2020). This paper focused on time series analysis of agricultural drought and desertification using spectral indices (VCI, LST, NDVI and VHI) and Landsat Satellite Images and GIS techniques in Tikrit City, Iraq from years 1990 to 2022.

MATERIAL AND METHODS

Study area

This paper was carried out in the Salah Al-Din Province of Iraq, in the AL-Botamaa area and and has a land cover area of about 33.98 km^2 (Fig. 1). This area is situated between latitudes (34°52'29.386" - 34°42'54. 584") N and longitudes (43°26'15.703" and 43°31'22.753") E. Weather data have been collected during the period 1990-2022 from Tikrit station (Iraq). The area has a warm Mediterranean climate with cold winter in Jan. and Feb. and very warm summer. The mean annual rainfall range from 42 to 295 mm, and the highest mean month in Jan, Feb and Mar. The maximum temprature about 38.9 C° and a minimum about 5.5 C°.

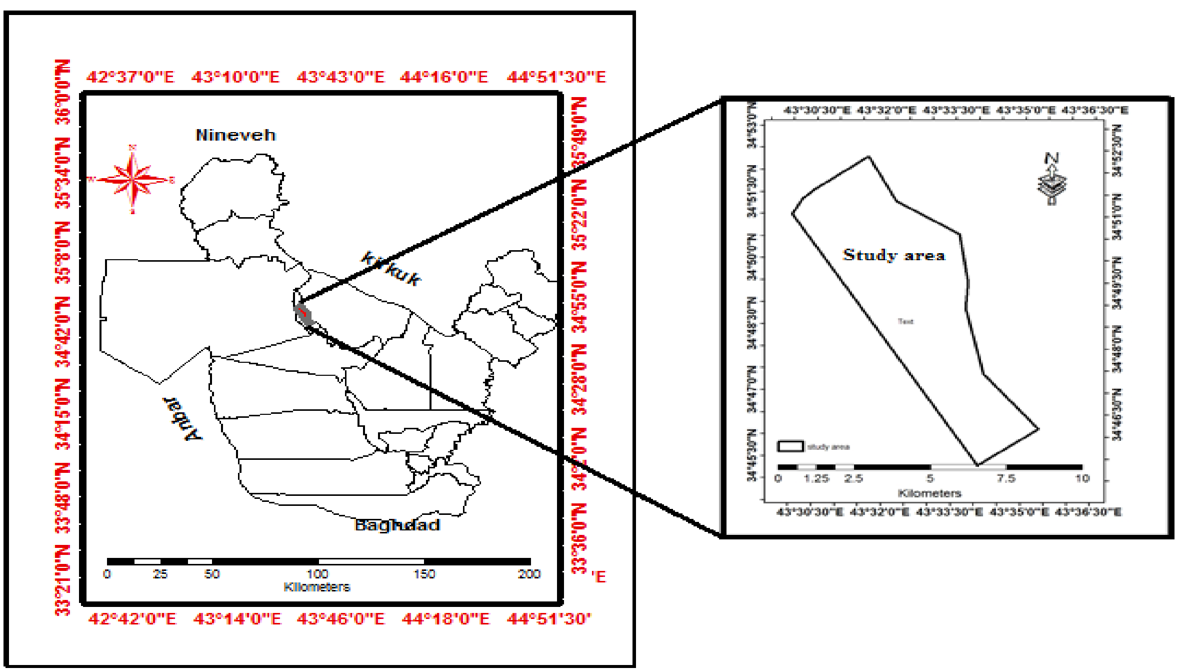

Figure 1. : A map of study area for monitoring drought

Digital processing of Landsat 9 and Landsat 7. The time series of satellite images were collected and peroid from 1990 to 2022 for monitoring drought and desertification in study area and digital processing were coducted using ERDAS imagen Ver. 15 (table 1).
In the case of Satellite Landsat 9 (OLI) will be use of following equation:

$$p_{\lambda} = \frac{M_p * Q_{Cal} + A_p}{\sin(\theta_{SE})} \text{ ...... (1)}$$

where

p_{λ} =Top Atmosphere (TOA).

M_p = multiplicative rescaling factor.

Q_{Cal} = digital number (DN) value

A_p = Additive rescaling factor.

θ_{SE} = The local Sun elevation angle.

In the case of Landsat 7 images, will be following equation:

$$L_{\lambda} = \left(\frac{L_{Max.\lambda} - L_{Min.\lambda}}{Q_{CalMax.} - Q_{CalMin.}}\right) * (Q_{Cal.} - Q_{CalMin.}) + L_{Min.\lambda} \quad (2)$$

$$p_{\lambda} = \frac{\pi * L_{\lambda}}{ESUN_{\lambda} * \cos\theta * d_r} \text{ ....} \qquad (3)$$

Where: p_{λ} : Spectral reflectance at each band. L_{λ} : Spectral radiance at each band. $ESUN_{\lambda}$: The mean solar of atmospheric radiance (USGS). DN: The numeric number of the sensor at each band. L_{max}: The highest value in the MTL file (255). L_{min}: The lowest value (0 or 1). Cos θ: The cosine of the solar irradiance angle. d_r: EARTH_SUN_DISTANCE.

Table 1. Time series selected of landsat images.

Satellite	Sensor	Date	Satellite	Sensor	Date
Landsat-5	TM	1990-05-31	Landsat-5	TM	2006-04-09
Landsat-5	TM	1992-04-02	Landsat-5	TM	2008-04-14
Landsat-5	TM	1993-04-05	Landsat-5	TM	2009-04-01
Landsat-5	TM	1995-04-27	Landsat-5	TM	2010-04-04
Landsat-5	TM	1997-04-16	Landsat- 8	OLI	2013-04-28
Landsat-5	TM	1998-04-19	Landsat- 8	OLI	2016-04-20
Landsat-7	ETM	2000-04-16	Landsat- 8	OLI	2019-04-13
Landsat-7	ETM	2002-04-22	Landsat- 8	OLI	2020-04-15
Landsat-5	TM	2005-03-21	Landsat- 9	OLI	2022-04-13

Spectral Indices for monitoring drought and desertification

drought indices calculated from satellite-based surface parameters have been widely used to study drought conditions. The Normalized Difference Vegetation Index (NDVI), Vegetation Condition Index (VCI), and Temperature Condition Index (TCI) are some of the most commonly used vegetation indices. Spatial and temporal data can be easily acquire through satellite images and then calculate of spectral indices for assessing drought and desertification.

Normalized Difference Vegetation Index (NDVI): During the early 1980s, the NDVI was defined and developed by scientists at NASA for monitoring vegetation health based on the difference between red(Chlorophyll absorption bands and near-infrared band(high reflectance, respectively. Normally, the NDVI range from −1 to +1, with +1 indicating healthy vegetation cover and high plant density, and lower values refer to pland density is low, and negative values representing surface water resources. The higher NDVI values are, the healthier vegetation is. The range value of NDVI in wet seasons is much wider than in dry seasons.

$$\mathrm{NDVI} = \frac{\mathrm{NIR-RED}}{\mathrm{NIR+RED}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

Vegetation Cover Index (VCI): The Vegetation Condition Index is one of the important indices for assessing vegetation status, based on the NDVI, with ranging from 0 to 100. The high value of the index refer to the conditions suitable for vegetation cover growth, and this is related to the climatic conditions and the distinctive soil characteristics such as texture, moisture content, organic matter, and availability of nutrients**.** Zero indicates extreme conditions. NDVImin and NDVImax signify the lowest and highest NDVI during time series. The VCI values less than 40 indicate drought conditions.

$$\mathrm{VCI} = 100 \times \frac{(\mathrm{NDVI-NDVImin})}{(\mathrm{NDVImax-NDVImin})} \ldots \ (2)$$

Where: NDVImax and NDVImin represent maximum and minimum NDVI and NDVI refer to image.

Land Surface Temprature (LST): Land Surface Temperature (LST) was derived from the Top of Atmosphere Brightness Temperature (T) as formula (4) where K1 and K2 are Thermal conversion constants for band 6 for Landsat 5,7 and band 10 and band 11 for Landsat 8 OLI, and Lλ is spectral radiance

$$LST = \frac{TB}{1+(L\lambda \times \frac{TB}{14380}) \times LN(\varepsilon)} - 273.15 \ \ldots(3)$$

$$\mathrm{TB} = \left(\frac{\mathrm{K2}}{1+\left(\frac{\mathrm{K1}}{\mathrm{L\lambda}}+1\right)} \right) - 273.15 \quad \ldots \quad (4)$$

TB=Top of atmosphere brightness temperature (C˚) where

K1, K2: Band-specific thermal conversion constant from the metadata (K1_constant band x, where x is the thermal band number) Band-specific thermal conversion constant from the metadata (K2_constant band x, where x is the thermal band number)**.**

Lλ= TOA spectral radiance (Watts/ (m2 * srad * μm))**.**

Temperature Condition Index (TCI)

According to Kogan (1995) that Temperature Condition Index (TCI) can be calculate using the equation (4). This index base on land surface temprature which increase with lack of vegetation, low of rainfall, and low of soil moisture content..ect.

$$\text{TCI} = 100 \times \frac{(\text{LST max} - \text{LST})}{(\text{LST max} - \text{LSTmin})} \quad \ldots.. (5)$$

LST: monthly Land surface temperature.
LST_{min}: Land surface temperature minimum.
LST_{max}: Land surface temperature maximum.

Vegetation Health Index (VHI)

The Vegetation Health Index (VHI) is express of status of vegetation health and their have revers relationshipe with land surface temprature and drought (Kogan, 1997). Many of studies use NDVI and VCI as indices in monitoring vegetation and thermal indices as LST and TCI to obtain a more information and remote sensing data about vegetation statut (table 2). This index explains the strong negative correlation between increase of NDVI and decreas land surface temprature (Guttman, 1998).

$$\textbf{VHI} = \textbf{a VCI} + (\mathbf{1} - \mathbf{a})\ \textbf{TCI} \quad \ldots\ (\mathbf{6})$$

VHI : Vegetation Health Index.
VCI: Vegetation Cover Index.
TCI :Temperature Condition Index.
$a : weigh$ from VCI (humidity) and TCI temperature to leafs condition (0.5).

Table 2. VHI drought classification schemes

DROUGHT CLASSES	**VHI**
Extreme drought	<10
evere drought	<20
Moderate drought	<30
Mild drought	<40
No drought	>40

RESULTS AND DISSCUSION

The results show different in degree of degradation and desertification based on NDVI. The divided into four degrees along time series: slightly, moderate, severe and very severe (Khalaf and Hussien, 2021). The results of table (3) Fig 2 show a significant increase in the degree of severe drought, becoming the largest area in 1992, 1993, 1998 and 2022 with percentages 78.12, 75.51, 61.44 and 88.91%, respectively. The results also showed that the areas of very sever drought were 24.14, 28.04, 27.43, and 26.50 km^2 in 1990, 2000, 2009, and 2010 respectivelity and the percentages 71.01, 82.50, 80.70 and 77.96%, respectively. In addition, that moderate drought is 84.08 and 44.65% in years 2002 and 2019. While, the degree of slightly drought was low along the time serie, and the highest area was in the year 2019, reaching 3.41 km^2 (10.04%). As rainfall increases may be increase NDVI along to time series, NDVI increases and reaches up to a range of 0.4 (Anyamba and Tuker, 2005). The NDVI indicates to vegetation health and spatial variability has occurred mainly because of the uneven distribution of rainfall(Dutta *et al*., 2015).

Table 3. Degree of drought /desertification based on NDVI

YEARS	Very sever		Sever		Moderate		Slightly	
	Area(km^2	%	Area(km^2	%	Area(km^2	%	Area(km^2	%
1990	24.14	71.0	6.16	18.1	2.48	7.30	1.21	3.56
1992	4.40	12.9	26.55	78.1	2.50	7.36	0.54	1.59
1993	3.63	10.6	25.67	75.5	3.31	9.74	1.38	4.07
1995	16.90	49.7	12.53	36.8	2.98	8.78	1.58	4.64
1997	11.69	34.4	18.18	53.4	3.41	10.0	0.71	2.10
1998	8.72	25.6	20.88	61.4	2.75	8.09	1.64	4.83
2000	28.04	82.5	3.07	9.04	2.66	7.84	0.21	0.63
2002	1.72	5.04	3.67	10.8	28.58	84.0	0.03	0.07
2005	11.59	34.1	18.86	55.4	2.82	8.30	0.72	2.11
2006	22.67	66.6	7.10	20.9	2.46	7.25	1.76	5.17
2008	22.67	66.6	7.10	20.9	2.46	7.25	1.76	5.17
2009	27.43	80.7	2.56	7.53	2.25	6.61	1.75	5.15
2010	26.50	77.9	0.40	1.18	5.93	17.4	1.16	3.42
2013	0.11	0.33	29.08	85.5	4.27	12.5	0.53	1.55
2016	27.58	81.1	2.94	8.64	3.22	9.48	0.25	0.74
2019	0.03	0.08	15.37	45.2	15.18	44.6	3.41	10.0
2020	15.25	44.8	13.31	39.1	3.80	11.1	1.63	4.80
2022	0.02	0.06	30.22	88.9	3.59	10.5	0.16	0.47

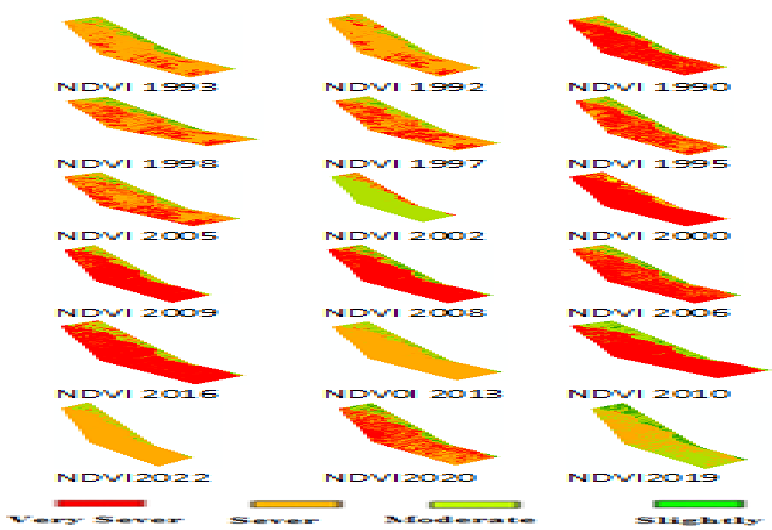

Figure 2. Satellite images of monitoring of drought/desertification based on NDVI.

Vegetation condition Index (VCI)

The results show that extremely severe drought was the highest, with an area of 25.51 km^2 (75.06%) in year 2000. While, the severe drought degree was increase in 1990, 1995, 1998, 2008, 2009 and 2010, respectively to reach 25.79, 23.43, 20.03, 26.78, 27.07 and 25.47 km^2 and percentage 75.88, 68.94, 58.94, 78.80, 79. 0.63 and 74.93 % respectively. The moderate drought was highest in years 1997, 2005, 2006 and 2022 to reach 27.04, 26.76, 20.58 and 28.61 km^2. The slightly drought in 1992, 2013 2016, 2019 and 2020 is area 18.96, 25.01, 29.03, 18.40, 27.45

km^2, and percentage reached to 55.77, 73.58, 85.40, 54.14, 80.76 %. The last variety did not suffer from drought, so it gave the highest area 30.13 and 12.46 km^2 in 2002 and 2019, with a percentage of 88.65 and 36.66%(fig. 3; table 4). Most of the study areas have relatively low vegetation cover, low water content, and water stress that reflects the very severity and severity of drought during the study period (Mahajan and Dodamania, 2015;Dutta *et al*., 2013; Yagci *et al*. 2015; Kocaaslan *et al*., 2021). Vegetation Condition Index (VCI) have been accepted importance for detecting drought around world with different of climate condition (Quiring and Ganseh, 2010; Mohamed, *et al*, 2013).

Table 4. The classify of drought degree based on VCI through period 1990-2022

Year	**Extreme Drought**		**Sever Drought**		**Moderate Drought**		**Slightly Drought**		**No Drought**	
	Area	**%**	**Area**	**%**	**Area**	**%**	**Area**	**%**	**Area**	**%**
1990	1.59	4.68	25.79	75.88	2.07	6.10	1.54	4.52	3.00	8.83
1992	0.01	0.02	0.01	0.02	11.37	33.46	18.96	55.77	3.65	10.73
1993	0.08	0.22	14.49	42.64	13.60	40.03	1.50	4.41	4.32	12.71
1995	0.19	0.55	23.43	68.94	5.06	14.88	1.45	4.25	3.86	11.37
1997	0.00	0.01	1.10	3.23	27.04	79.56	1.61	4.73	4.24	12.47
1998	0.15	0.44	20.03	58.94	8.22	24.19	1.49	4.37	4.10	12.06
2000	25.51	75.06	2.63	7.75	1.22	3.59	1.43	4.20	3.19	9.39
2002	0.03	0.10	0.44	1.31	1.56	4.58	1.82	5.36	30.13	88.65
2005	0.00	0.01	2.26	6.65	26.76	78.72	1.98	5.82	2.99	8.80
2006	0.00	0.01	7.77	22.85	20.58	60.56	1.30	3.82	4.34	12.76
2008	0.65	1.91	26.78	78.80	2.07	6.09	1.41	4.14	3.08	9.07
2009	1.02	3.01	27.07	79.63	1.69	4.96	1.42	4.17	2.80	8.22
2010	0.41	1.19	25.47	74.93	2.97	8.74	1.83	5.37	3.32	9.77
2013	0.02	0.05	0.05	0.15	3.89	11.46	25.01	73.58	5.01	14.75
2016	0.00	0.01	0.00	0.01	0.11	0.31	29.03	85.40	4.85	14.27
2019	0.01	0.02	0.02	0.06	3.10	9.12	18.40	54.14	12.46	36.66
2020	0.00	0.01	0.01	0.04	0.93	2.73	27.45	80.76	5.60	16.46
2022	0.02	0.06	0.16	0.48	28.61	84.17	1.91	5.63	3.28	9.65

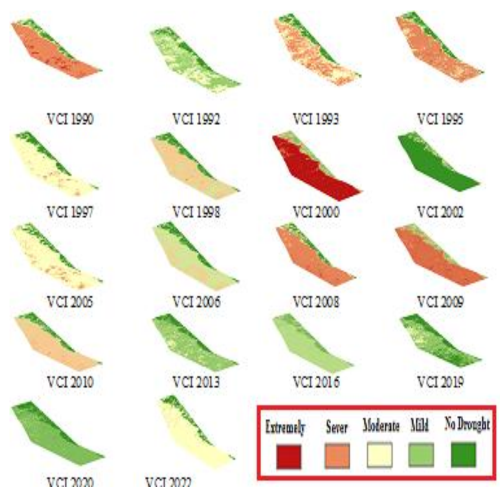

Figure 3. Satellite images of monitoring of drought/desertification based on VCI.

Temperature Condition Index (TCI): The results showed that the largest area affected by a very severe drought occurred in year 1992 to reach 7.61 km^2 (22.39)% of the total area. The largest area for the sever drought was recorded in years 1990, 1992, 2010 and 2013 with an area of 13,78, 15.08, 14.47, 13.40 km^2. The modrate drought degree had the highest area in 1993, 2000, 2002, 2008 and 2016 to reach 16.63, 21.80, 16.44, 22.89 and 15.57 km² with percent 48.94, 64.13, 48.37, 67.34 and 45.82 % of the total area. While, slightly drought degree with the largest area was in years 1995, 2005 and 2009 with areas of 9.79, 12.65 and 19.76 km² and its percentages 28.81, 37.21 and 58.15%, respectively(table 5; fig. 4). Therefore, the result explained that the study area is suffer from increase heat stress, low of soil content, wind erossion and lack vegetation growth. Singh *et al*., (2003) explain that rise of surface temperature is unsuitable of plant growth. The TCI is related to surface temperature, which is the result of multiple factors including vegetation cover, precipitation, topography, elevation, soils and climate condition, in contrast to the NDVI-based VCI, which does not express vegetation (Ejaz, 2023).

Table 5. The classify of drought degree based on TCI through period 1990-2022

Year	**Extreme Drought**		**Sever Drought**		**Moderate Drought**		**Mild Drought**		**No Drought**	
	Area	%	Area	%	Area	%	Area	%	Area	%
1990	1.21	3.56	13.78	40.53	11.27	33.15	2.89	8.50	4.85	14.26
1992	7.61	22.39	15.08	44.37	8.25	24.26	2.24	6.60	0.81	2.39
1993	0.79	2.33	4.76	14.01	16.63	48.94	5.87	17.27	5.93	17.45
1995	0.56	1.65	3.28	9.65	12.99	38.23	9.79	28.81	7.36	21.66
1997	1.84	5.40	11.25	33.09	11.84	34.85	4.73	13.91	4.33	12.75
1998	2.88	8.48	8.14	23.93	10.64	31.31	5.52	16.23	6.81	20.04
2000	0.05	0.14	1.68	4.95	21.80	64.13	4.71	13.87	5.75	16.91
2002	0.66	1.95	4.91	14.46	16.44	48.37	6.46	19.00	5.51	16.22
2005	0.09	0.25	1.05	3.10	9.50	27.96	12.65	37.21	10.70	31.48
2006	1.07	3.16	9.07	26.67	15.36	45.19	2.63	7.75	5.86	17.23
2008	0.07	0.21	2.48	7.30	22.89	67.34	3.43	10.10	5.11	15.05
2009	0.06	0.17	0.17	0.50	7.85	23.10	19.76	58.15	6.14	18.08
2010	1.76	5.19	14.47	42.58	9.65	28.39	2.96	8.70	5.15	15.14
2013	2.59	7.63	13.40	39.42	8.86	26.07	2.64	7.76	6.50	19.12
2016	0.90	2.66	4.94	14.53	15.57	45.82	6.58	19.37	5.99	17.62
2019	1.40	4.13	6.07	17.85	13.45	39.58	6.84	20.13	6.22	18.30
2020	2.00	5.87	7.94	23.37	9.34	27.47	6.13	18.05	8.58	25.24
2022	2.31	6.79	11.42	33.59	12.38	36.41	3.17	9.31	4.72	13.89

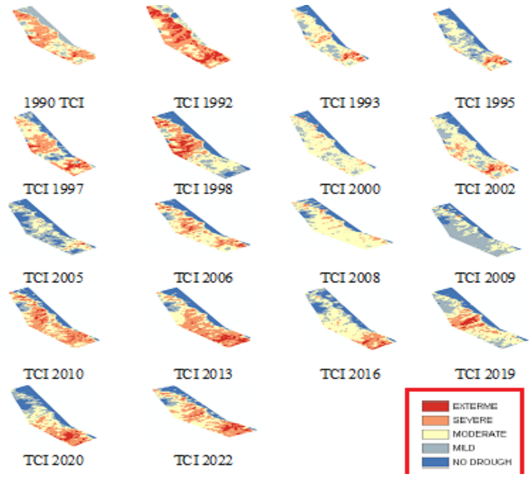

Figure 4. Satellite images of monitoring of drought/desertification based on TCI

Vegetation Health Index (VHI)

The results show that extremely drought was the highest area recorded in year 2010 with percentage is 1.17%. While, severe drought class in years 1990, 1998, 2000, 2008, 2010 and 2022 was highest with area 21.64, 12.10, 19.59, 17.75, 21.70 and 8.70 km^2 and its percentage 63.66, 35.60, 57.63 and 52.23, 63.85 and 25.61%, respectively. The class of moderate drought in years 1992, 1997, 2009 and 2013 had an area of 25.69, 20.72, 24.81 and 19.55 km^2, and its percentage 75.58, 60.96, 72.98 and 57.53 % (Fig. 5). The slightly or mild drought area was 14.10, 17.94, 13.21 and 12.28 km^2 and percentage was 41.47, 52.78, 38.86 and 36.13% for years 2005, 2016, 2019 and 2020. While, the no drought degree in years 2002, 2019 and 2020, which reaching 24.92, 14.19 and 12.32 km^2 (table 6). So, the area study is suffer from many factors helps on the drought through of time series, such as heat stress, and its effect on the vegetation health, especially in areas of the Al-Jazeera region (Li *et al*., 2017). On the other hand, the soils in the study area are characterize by the content of gypsum, high of sandy soil, low of organic matter and lack of nutrient. In addition, the soil gypsum and sandy have a weak and fragile soil structure. In addition, gypsum and sandy soil have a weak and fragile soil structure, which plays an important role in the soil erosion caused by wind and sandstorm. It seems to us that in the selected time series that increase in the value of index over a number of years can be attribute on high of rainfall, which creates favorable conditions for the growth of vegetation such as grass, Shrubs and weed. Wherease, the results show that part of the study area at all years alonge the time series are high of vegetation, which includes shrubs and trees growing on along Tigris River such as *Poblus Euphratica Oliv, Tamarix L. and Prosopis farcta*.

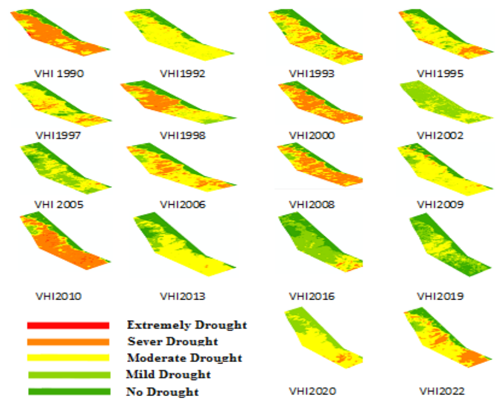

Figure 5. Satellite images of monitoring of drought/desertification based on VHI .

Table 6. The classify of drought degree based on VHI through period 1990-2022

Year	**Extreme Drought**		**Sever Drought**		**Moderate Drought**		**Mild Drought**		**No Drought**	
	Area	%	Area	%	Area	%	Area	%	Area	%
1990	0.20	0.59	21.64	63.66	5.92	17.41	1.24	3.66	4.99	14.69
1992	0.00	0.00	0.67	1.96	25.69	75.58	3.06	9.00	4.57	13.46
1993	0.00	0.00	6.91	20.33	18.32	53.90	2.58	7.58	6.18	18.19
1995	0.01	0.02	5.09	14.97	18.90	55.59	3.72	10.95	6.28	18.47
1997	0.00	0.00	4.10	12.07	20.72	60.96	3.09	9.08	6.08	17.88
1998	0.04	0.13	12.10	35.60	12.64	37.18	3.11	9.15	6.10	17.94
2000	0.06	0.17	19.59	57.63	8.09	23.82	0.79	2.32	5.46	16.06
2002	0.00	0.00	0.00	0.00	0.02	0.05	9.06	26.64	24.92	73.31
2005	0.00	0.00	0.31	0.92	12.23	35.98	14.10	41.47	7.35	21.62
2006	0.00	0.00	7.76	22.83	18.08	53.20	2.20	6.48	5.94	17.49
2008	0.01	0.03	17.75	52.23	9.28	27.30	2.17	6.38	4.78	14.05
2009	0.03	0.10	0.82	2.41	24.81	72.98	3.26	9.60	5.06	14.90
2010	0.40	1.17	21.70	63.85	4.31	12.67	2.19	6.45	5.39	15.86
2013	0.00	0.00	0.07	0.21	19.55	57.53	6.17	18.16	8.19	24.09
2016	0.00	0.00	0.82	2.41	5.10	15.00	17.94	52.78	10.13	29.80
2019	0.00	0.00	0.00	0.01	6.59	19.39	13.21	38.86	14.19	41.75
2020	0.00	0.00	1.34	3.95	8.13	23.93	12.28	36.13	12.23	35.98
2022	0.00	0.00	8.70	25.61	16.87	49.62	3.21	9.44	5.21	15.33

The time series of Rainfall and their related with spectral indices

The results showed that the spectral indices are in agreement with the rainfall rates in the rangland along the time series, which indicates the importance of the climate factor in the growth and density of vegetation cover, as well as, its impact in the formation and development of the soil and its general properties such as the content of organic matter, nutrients and moisture content (Ibrahim, 2015). The results of the figure (9) refer to the multiple linear regression curves between the precipitation and the spectral indices, as the regression coefficient were 0.66, 0.80, and 0.81, respectively. The regression coefficient curves R^2 are a strongly positive between NDVI and rainfall (Ibrahim, 2015; Gedif et. al., 2014). While, the correlation coefficient(r) was reached 0.86, 0.86, and 0.96, respectively(table 7). The resulte explain that decrease of seasonal rain refer to high probability of drought hazard (Gedif et. al., 2014). Thus, the low values of the vegetation health index reflect the low soil moisture content, which is a main factor and plays an important role in the growth and density of vegetation cover, as well as the type of soil, its characteristics, and its ability to retain moisture. These advantages are almost unavailable in the gypsum soils are dominant in the study area.

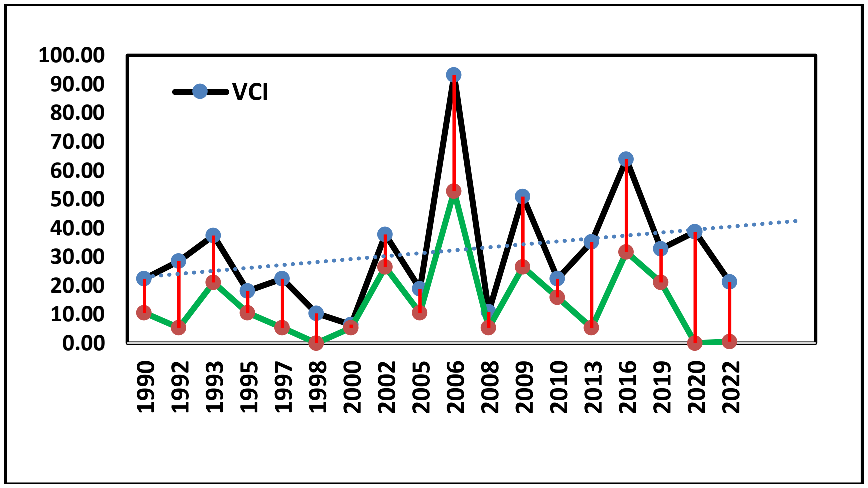

Figure 6. Time series of VCI for monitoring Drought and Desertification.

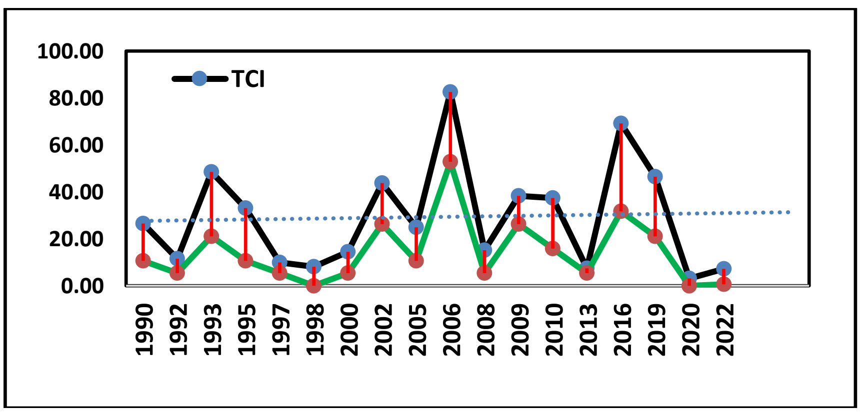

Figure 7. Time series of TCI for monitoring Drought and Desertification.

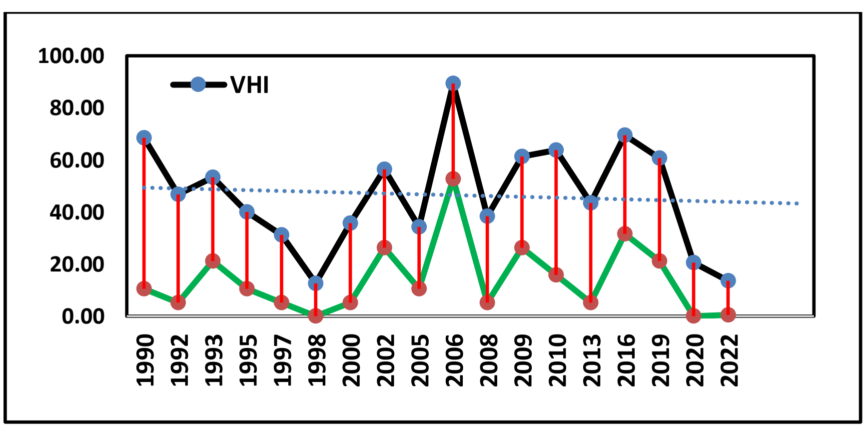

Figure 8. Time series of VHI for monitoring Drought and Desertification.

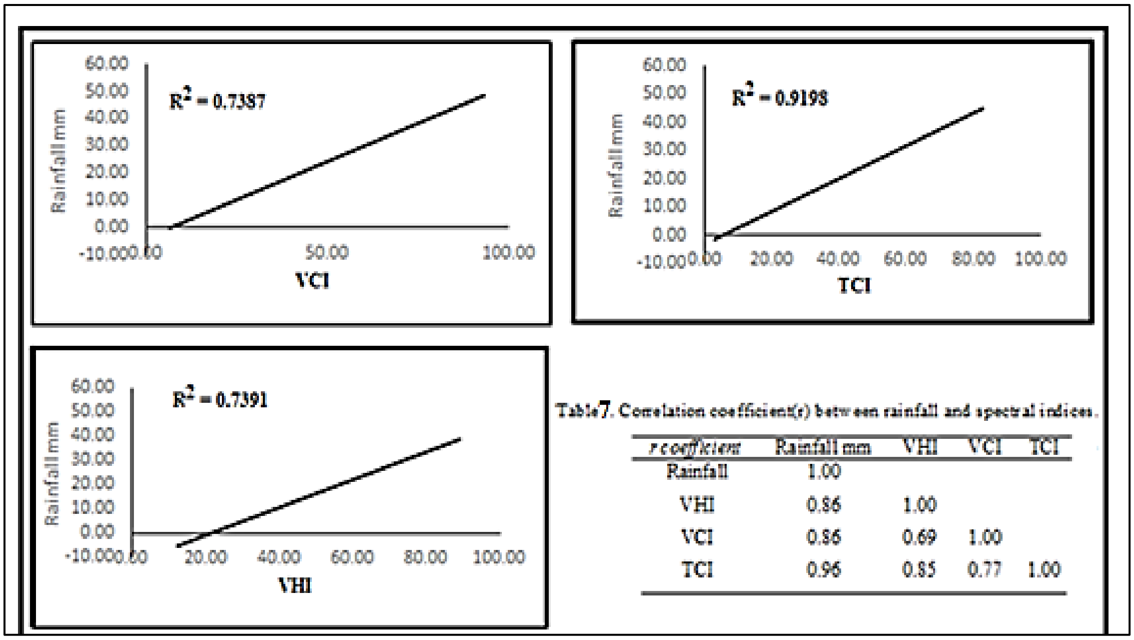

Table7. Correlation coefficient(r) between rainfall and spectral indices.

r coefficient	Rainfall mm	VHI	VCI	TCI
Rainfall	1.00			
VHI	0.86	1.00		
VCI	0.86	0.69	1.00	
TCI	0.96	0.85	0.77	1.00

Figure 9. The regression coefficient ® between Rainfall and indices.

All the spectral indices used in the current study are refers to drought hazar because they reflect the water interactions among plant and soil moisture. As we notice any decrease for rain will affect the lack of the vegetation, and also the drought can strongly impact the plant diversity and soil moisture which might adversely affect agricultural practices and increase of land degeradation and desertification processes (Qin *et al*., 2008; Nobre *et al*.,2016; Fensholt *et al*.,2015; Ibrahim *et al*, 2015).

Therefore, drought depends not only on its impact on agricultural production, people's livelihoods and economic policies, but also on the associated environmental impacts, as it exacerbates desertification and land degradation, especially in arid and semi-arid regions. Therefore, current research efforts are mainly focus on remote sensing, a technique that has played an important role in tracking changes in time and space for more than more than 30 years. Desertification and drought have significant effects on living organisms, especially those that inhabit desert lands. Desertification and drought are very dangerous phenomena, and it is not just words on paper, but its danger that we see every day when we see wild animals under the harsh rays of the sun, especially in the months of July and August, when the temperature reaches 50 C˚, and they do not get shade to protect them, and there is no source of water or trees to shade them. Then we realize that man is responsible for finding appropriate solutions through the establishment of pastoral reserves, the establishment of artificial forests, the exploitation of groundwater and the cultivation of land to reduce the accompanying environmental risks such as wind erosion, dust storms, deterioration of soil structure, and the removal of the fertile surface layer rich in organic matter and active particles (mud and silt).

The remote sensing based on assessment of drought hazard using vegetation indices derived from satellite landsat images time series are important role and provides spatial and temporal data on drought status depending on vegetation growth and it is density. The temporal and spatial information integrate between spectral indices such as VCI, TCI and VHI as indicators for assessing agricultural drought and precipitation as meteorological drought data are very essentially for monitoring of desertification, land degradation and drought. The high of TCI value and low of precipitation were in areas classified high drought risk. While, low drought risk areas experienced from increase VHI and VCI. The results of figures (6,7,8) indicate a variation in rainfall rates and spectral indices values during the month of April to assess the risk of drought. The highest mean values of precipitation were in the years 2006 and 2016, while the lowest rates of precipitation were in the year 1998 and the years 2020 and 2022, respectively.

CONCLUSION

Along the time series chosen to monitor drought and desertification in the study area, we note that the degree of severe drought occupied the largest area compared to the other degrees of drought and desertification for all spectral indices. Spectral drought indices have proved of great importance in monitoring and evaluating drought, and there is a correspondence with the climatic conditions of the region, where high rainfall rates have an impact and a close relationship with the growth and density of vegetation. The areas located on the banks of the rivers are characterize by abundant vegetation and have sedimentary soils that are prone to flooding, in contrast to the desert areas that are characterized by high gypsum content and sand separation, which do not help the growth and development of plants.

CONFLICT OF INTEREST

This paper is about monitoring and evaluating environmental problems as drought and desertification and there is no conflict of interest about our research paper.

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