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The Effect of Temporal Resolution of Climatic Factors on Agriculture Degradation in Southern Baghdad by Applying Remote Sensing Data

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Abstract

The climate changes had been recognized as one of the major factors responsible for land degradation, which has a significant impact on diverse aspects. The present study aims to estimate how the climate change can influence land degradation in the south areas of Baghdad province (Al-Rasheed, Al-Mahmudiyah, Al-Yusufiyah, Al-Madaen, and Al-Latifiyah). The Satellite Landsat-8 OLI and satellite Landsat-5 TM sensor imagery were used to extent land degradation for the period (2010-2019). ArcGIS V.10.4 was applied to manage and analysis the satellite image dataset, including the use of climate factors data from the European Center for Climate Forecasts (ECMWF) by reanalyzes and extraction datasets. To achieve work objectives, many ground data were collected, including the temperature, rain precipitation, evaporation, and relative humidity from 30 meteorological monitoring stations. These data help us to utilize the interpolation methods for the extraction process of contour lines maps, to be scientific indicators of the relationship between climatic factors and satellite images classifications, involving the spectral indicators of the vegetation cover and water bodies. The results showed the agriculture degradation through the decreasing of vegetation cover rate from 56.57% in (2010) to 43.43% in (2019). This deterioration is thought to be related to climate changes with other factors such as water shortage that was 0.52 and 0.44, respectively, the greatest temperature reading was (24.57), the greatest precipitation was (0.21), the greatest relative humidity was (60.73), and vapor rate (-0.2) for the studied period.

Keywords: Agriculture degradation, Climate factors data for (ECMWF), Landsat Satellite imageries, NDVI, NDWI, Remote Sensing.

تأثير التحليل الزمني للعوامل المناخية على تدهور الزراعة في جنوب بغداد بتطبيق بيانات الاستشعار عن بعد

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الخلاصة

عرفت التغيرات المناخية كأحد العوامل الرئيسية المسؤولة عن تدهور الأراضي، والتي لها تأثير كبير على جوانب مختلفة. تهدف الدراسة الحالية، إلى تقدير إمكانية تأثير تغير المناخ على تدهور الأراضي في

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المناطق الجنوبية من محافظة بغداد (الرشيد، المحمودية، اليوسفية، المدائن، اللطيفية). استخدمت صور مستشعر القمر الصناعي Landsat-8 OLI ومستشعر القمر الصناعي Landsat-5 TM على امتداد الأراضي المتدهورة في منطقة الدراسة للفترة (2010 -2019). استخدم برنامج ArcGIS V.10.4 لمعالجة وتحليل مجموعة بيانات مرئيات الأقمار الصناعية، كما تم استخدام بيانات عوامل المناخ من المركز الأوروبي للتنبؤات المناخية (ECMWF) في اعادة تحليل واستخراج مجموعات البيانات المؤثرة. ومن أجل تحقيق أهداف البحث، جمعت العديد من البيانات الأساسية مثل درجات الحرارة وهطول الأمطار والتبخر والرطوبة النسبية لمحطات الأرصاد الجوية الموزعة على منطقة الدراسة والتي يبلغ عددها 30 محطة، للمساعدة في استخدام تقنية الاستيفاء لاستخراج خرائط الخطوط الكنتورية لمنطقة الدراسة وبالتالي لتصبح مؤشرات علمية لعلاقة العوامل المناخية بتصنيفات مرئية الأقمار الصناعية، بما في ذلك المؤشرات الطيفية للغطاء الارضي والمسطحات المائية. أظهرت نتائج الدراسة تدهور الزراعة، فبلغ الغطاء النباتي 43.43٪ في عام 2019 مقارنة بـ 56.57 في عام 2010 في نفس الشهر 5. يُعتقد أن هذا التدهور مرتبط بالتغيرات المناخية وعوامل أخرى مثل نقص المياه الذي كان 0.52 و0.44 على التوالي، وكانت أعظم قراءة لدرجات الحرارة (24.57)، وأكبر هطول للأمطار (0.21)، وأكبر رطوبة نسبية كانت (60.73)، وأخيرا معدل التبخر (-0.2) لنفس مدة الدراسة.

1. Introduction

Agriculture and monitoring the vegetation cover is considered the oldest and most important aspect in the history of human life and human societies, its continuation is still a main source that provides the necessities of life in several aspects. The most important of which is food security and the provision of the food basket for the entire population at reasonable prices [1]. Different times are suitable for agriculture due to drought and destruction which affect the lands to be unfit for different human life. Generally, the lands are exposed to desertification in the absence of interest and studied plans. Therefore, interest in it and its development should be a priority for individuals and countries, through monitoring and classifying human activities [2], measuring their areas and comparing them, and identifying ways to develop them and avoid the region's factors of degradation, including the climatic factors through using the data of the European Center for Climate Prediction (ECMWF). These data are more realistic and accurate than the two ground monitoring stations in the study area, which do not reflect the reality of the studied area climate [3]. They were processed simultaneously with the pictures of Landsat 8 and 5 in a month. The land area survey of the interested region, with a time accuracy of ten years, was used to analyze the data of the ArcGIS V.10.4 program, which helped this program to overcome the problems and develop appropriate solutions to take a suitable decision. The facts proved that the used climatic factors in the study as (temperature, sedimentation, relative humidity, and evaporation) have an impact on the Agriculture Degradation areas [4], then are considered standard and ideal indicators to monitor this degradation and develop appropriate solutions for it [5]. Land degradation can define as the reduction or loss of biological or economic productivity and complexity of agroecological systems as a consequence of land use, or from one or more processes that may arise from human activities, and natural phenomena like drought, heavy rainfall, or fire [6]. So far, the agricultural sector in Iraq has been severely affected, and it seems clear that the current negative climate change trends will continue in the future [7].

Climatic variations are recognized as one of the major factors contributing to land degradation, therefore greater attention must be paid to understand the role of different climatic factors in land degradation. Climate changes due to the global warming have influenced all weather elements not only in Iraq but in all surrounding countries, these changes included temperature rise, rainfall intensities, atmospheric pressure variations, and its temporal and spatial distribution.

Decreasing rainfall is one of the significant factors, where the variation in rainfall amounts lead to change in the land vegetative cover for long dry years or seasons [8]. In addition, the increasing trend of population growth, technological development and transformed economic and social structures on one side, and climate changes on the other side, have caused many issues such as the considerable degradation of natural resources and increased desertification [9]. For example, Population growth and economic development directly and indirectly increase the pressure on land use, especially in vulnerable environments. The least developed countries are severely affected by this detrimental process. This includes the territory of Iraq, where it affects 75% of the total land area, particularly the arable area [10]. Land surface conditions can be affected by another climatic elements such as temperature, sunlight, wind, and human activities such as overgrazing, logging and over-lumbering [11]. Interactions between the two systems as climatic elements and human activities determine the severity of the degradation process, Inclusion of climate, vegetation, and land use [12].

Geographic information systems (GIS) technology becomes a fundamental tool for combining various maps and satellite information sources in models that simulate the interactions of complex natural systems. It is currently applied to computerized processing, storage, and retrieval systems which have software and hardware particularly designed to cope with geographically referenced spatial [13]. GIS can serve as an extremely useful tool for determining different criteria values. In fact, GIS as a system capable of managing, modifying, displaying, and analyzing spatial information so as to facilitate the modeling of spatial issues. Geospatial technologies including geographic information systems (GIS), satellite imagery, and aerial photography give a great promise for improving the quantity and quality of information on degradation trends over large areas, and provide more effective management of this information [14].

At the present time, remote sensing (RS) become a routine approach for diverse fields, including land surveying geography, and most Earth science disciplines (like hydrology, meteorology, glaciology, ecology, oceanography, and geology) all that because of the acquired data can provide the cost-effective, macroscopic, real-time, and dynamic information [15].

In other words, RS can be defined as the science of deriving information about an object from measurements made at a distance from that object, without actually coming in contact with it. The satellites of this technique collect multi-spectrum, multi-period, multi resolution data and provide a valuable information in understanding and monitoring the processes of land use change, and in constructing land use databases [16]. Both Remote sensing (RS) and geo-information technology (GIS) are considered as a modern discipline of sciences, modeling, integrating an acquisition, management and analysis of spatially referenced.

2. The Studied Area

The capital of Iraq, Baghdad province is located at a latitude and a longitude of (33.452°N → 33.184°N and 44.189°E → 44.576°E) decimal degree of the Geographical coordinate system. For Iraq population, it comes in the first place where the vast majority of people live in Baghdad, approximately 8,126,755, with an area of approximately 205,100 m^2. Iraqi capital includes 14 administrative units, six in Karkh (west of the Tigris River), and eight in Rusafa

(East of the Tigris River). This research covers five sub-districts which are Al-Rasheed, Al-Mahmudiyah, Al-Yusufiyah, Al-Madaen, and Al-Latifiyah, with total area of 2744541900 m^2, Figure 1 shows the units boundary of the studied area [17].

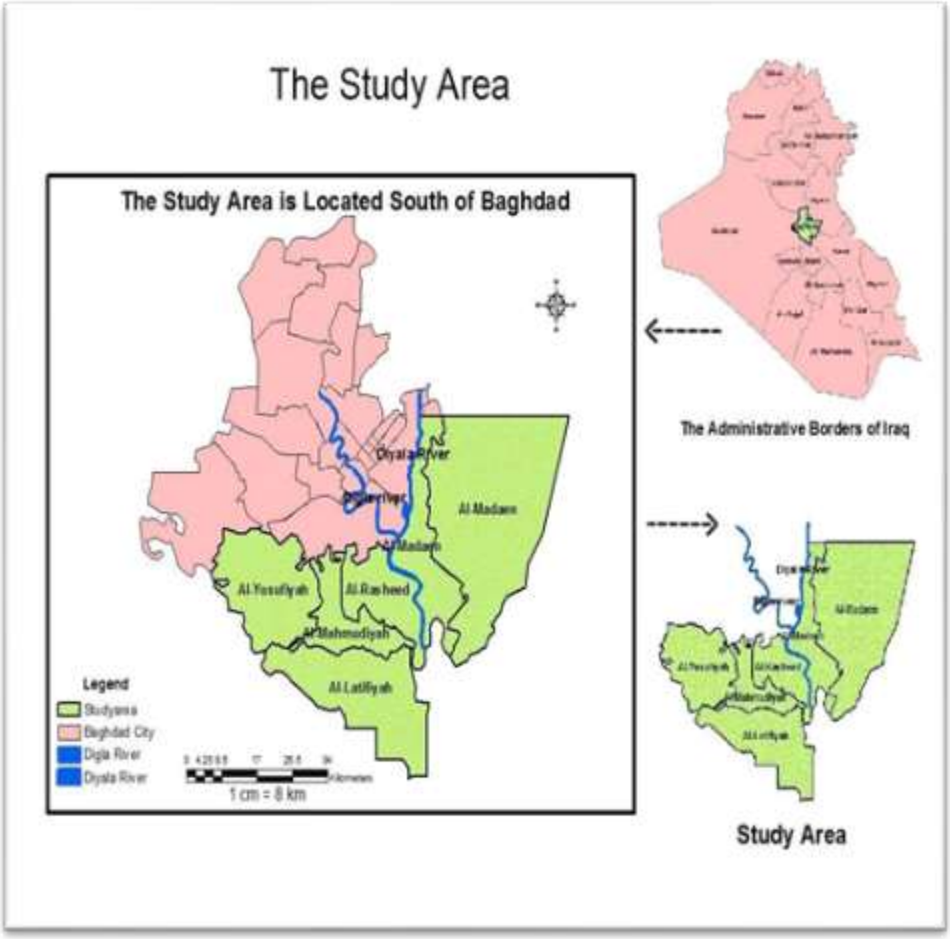


Figure 1: Illustrates the administrative borders of the study area that are located south of the Iraqi capital, Baghdad, which are (Al-Rasheed, Al-Mahmudiyah, Al-Yusufiyah, Al-Madaen and Al-Latifiyah) counties.

3. Baghdad Climate:

The climate of Baghdad is characterized as hot and arid, during the summer, temperatures often exceed the range between (40-50) °C in late June, all July and August. Dust storms frequently blow into Baghdad from the west, and cold and rainy in winter, during the time between early October and late April, with definite variation between day and night during all seasons. The temperature rises to the fifties in summer, which increase the percentage of evaporation, and it is noticeable that the low rainfall for the past few years led to increase land degradation possibilities [18].

Methodology and Material

4. Input Data

Landsat multi-band images were used to cover 10 years from 5 May 2010, where Landsat-5 TM imagery data (2 scenes) was used, to 2 May 2019, where Landsat-8 OLI imagery data (2 scenes), that obtained from the website (Earthexplorer.usgs.gov). Data processing was carried out using ArcGIS 10.4 software packages, a program that collects, analyses, inserts, displays and output data.

Remote-sensing techniques were used in the first stage to evaluate the surface changes and determine the features of land use classes. The second stage, the area was evaluated for climate change by using a prominent land degradation indicator method and GIS tools, then to analyses the impacts of land use/cover class expansion on agriculture degradation.

Result and Discussion

5. Normalized Difference Vegetation Index

The normalized difference vegetation index (NDVI) is widely used for remote sensing of vegetation, this index uses radiances or reflectance from a red channel around 0.66 µm and a near-IR channel around 0.86µm. The red channel is located in the strong chlorophyll absorption region, while the near-IR channel is located in the high reflectance plateau of vegetation canopies.

(NDVI) is a calculation that is used to identify vegetation and how healthy is it through the detected chlorophyll levels in the leaves. NDVI is calculated from the reflected visible and near-infrared light by vegetation [19], which is given by the formula:

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

where NDVI= Normalized Difference Vegetation Index; NIR= Near Infra-Red channel and R= Red band.

Total area of south Baghdad is (2744541900 m^2), the quantities of the vegetation cover were calculated from this area, and its area was (2461082400 m^2) about 89.67% for 2010. While in 2019, the area of vegetation cover was (1552698000 m2) and its rate was 56.57%. The area of land without vegetation was also measured in 2010 and it was estimated (283459500 m2) which represents 10.33% of the total area. In 2019, the total area without vegetation cover was estimated (1191843900 m^2) with a percentage of 43.43%, these values are shown in Table 1. While NDVI leads to the fact of decreasing in the vegetation area, which is the highest recorded rate in the controlled classification process for the study area, one can say that the NDVI process is accurate. The (NDVI) is illustrated in Figures 2 and 3.

Table 1: The Calculation of statistical pixel content features classification for Change Vegetation (NDVI).

Change Vegetation (NDVI)							
		2010\5\5			2019\5\2		
No	Class	Area m^2	%Area	Sum of Pixels	Area m^2	%Area	Sum of Pixels
1	Vegetation	2461082400	89.67	2734536	1552698000	56.57	1725220
2	Without Vegetation	283459500	10.33	314955	1191843900	43.43	1324271
Total		2744541900	100%	3049491	2744541900	100%	3049491

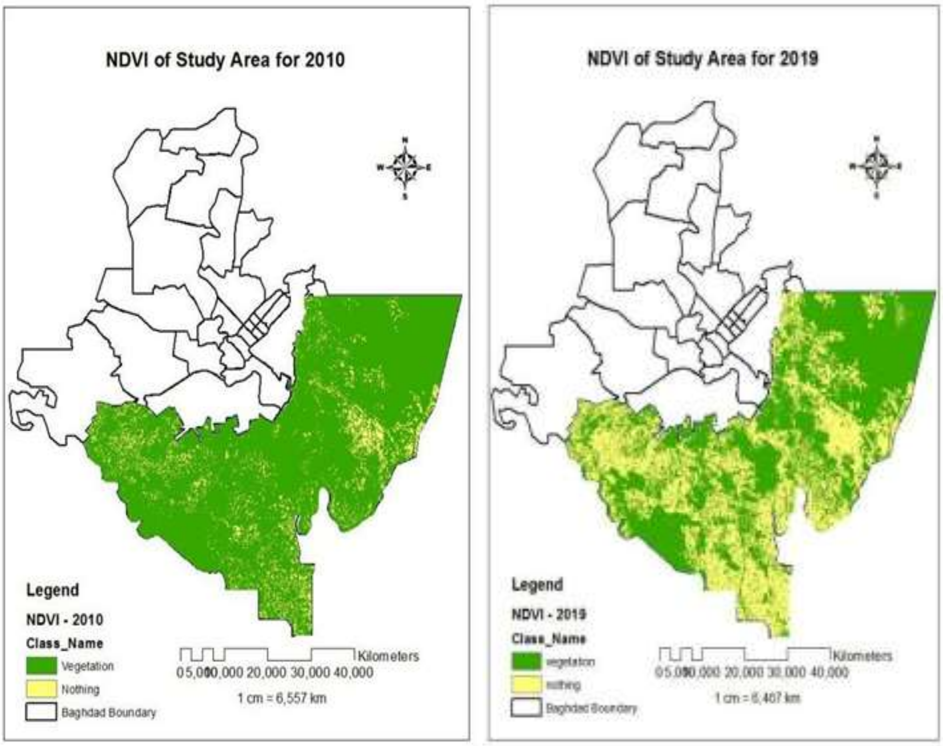
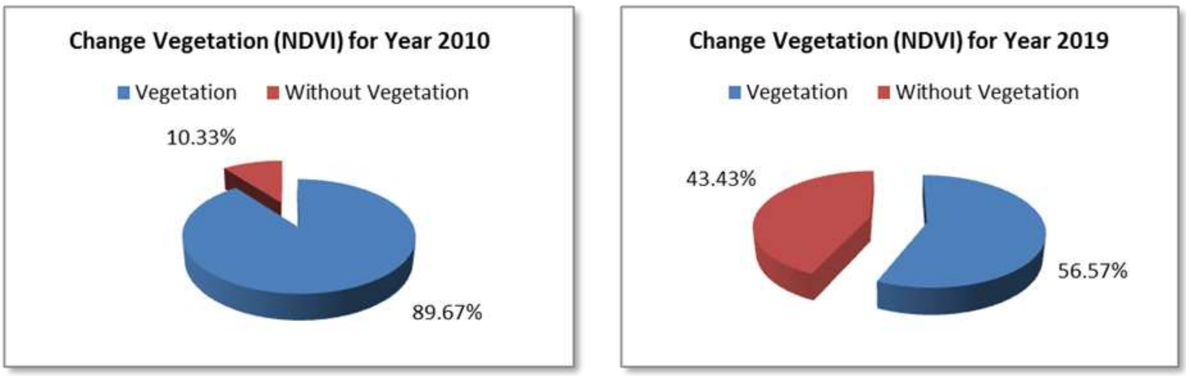


Figure 2: The band ratio process for the Normalized Difference Vegetation Index (NDVI) calculation of the studied area in 2010 and 2019.



(a) **(b)**

Figure 3: Chart of Supervised Classification techniques of Change Vegetation (NDVI) for years (2010) and (2019).

6. Normalized Difference Water Index (NDWI):

This index is designed to maximize the reflectance of water by using green wavelengths bands, minimize the low reflectance of NIR by water features, and take advantage of the high reflectance of NIR by vegetation and soil features. As a result, water features have positive values and thus are enhanced, while the vegetation and soil features usually have zero or negative values and therefore are suppressed, the (NDWI) is expressed as follows:

$$\text{NDWI}=\frac{(\text{Green}-NIR)}{(\text{Green}+\text{NIR})}, \quad (2)$$

where NDWI= Normalized Difference Water Index; NIR= Near Infrared Band and SWIR= Short Wave Infrared Band.

Table 2 illustrates Water content area, where the total area for 2010 was (2744541900 m^2), which constitutes 0.52% of water body with area of (14166000 m^2), the remaining area without water was (2730375900 m^2) with a percentage of 99.48%. While the total area of water in 2019 was (2744541900 m^2), which constitutes 0.44% of water body with area of (12053700 m^2), the remaining area without water was (2732488200 m^2) with a percentage of 99.56%, as shown in Figures 4 and 5. The obtained results point out that the quantities of water in the south of Baghdad during 2010 were more than 2019, and this indicates that the rainy season was better. The decreasing in water will affect the spread of natural vegetation and consequents to human activity.

Table 2: The Calculation of statistical pixel content features classification for Change Water Body (NDWI).

		Change Vegetation (NDVI)					
		2010\5\5			2019\5\2		
No	**Class**	**Area m^2**	**%Area**	**Sum of Pixels**	**Area m^2**	**%Area**	**Sum of Pixels**
1	Water Body	14166000	0.52	15740	12053700	0.44	13393
2	Without Water	2730375900	99.48	3033751	2732488200	99.56	3036098
Total		2744541900	100%	3049491	2744541900	100%	3049491

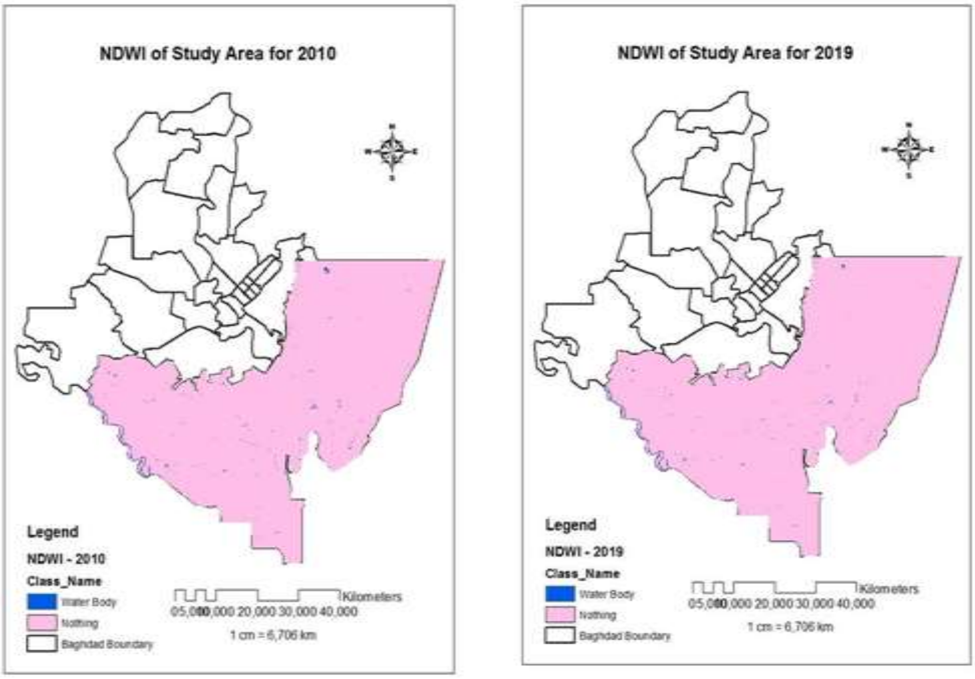
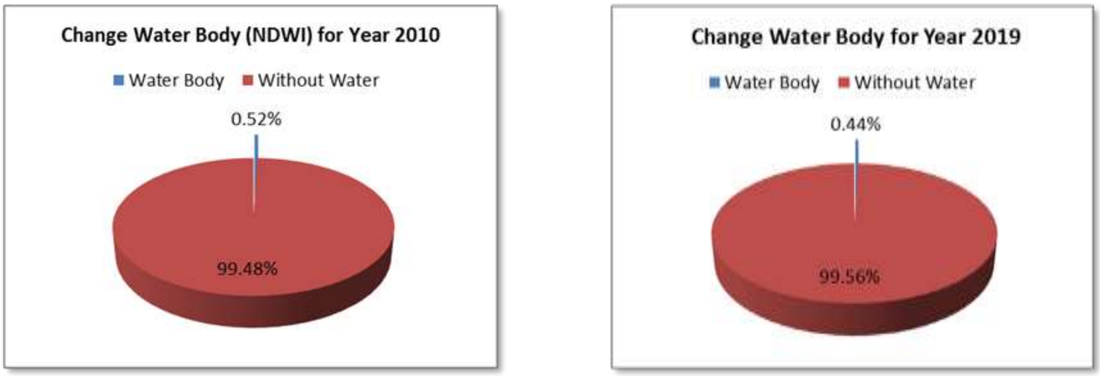


Figure 4: The band ratio process for calculating the Normalized Difference Water Index (NDWI) in the study area for 2010 and 2019.



(a) **(b)**

Figure 5: Supervised Classification techniques Chart of Water Body (NDWI) for years (2010-2019).

7. Interpolation (IDW)

Interpolation is one of the most techniques that used in geographic information system (GIS), where it carried out by assuming the point of appreciation is affected more by the proximal points, therefore each point of weight which is inversely proportional to the distance from the point, as given by the formula [20];

$$z(x + y) = \sum_{i=1}^{n} wi\, fi, \tag{3}$$

where n = the total observations number; fi = the observed value and wi = the weighted associated with each observation point, relative to an observation at point (x, y).
Where the weights were calculated by using the weight function:

$$\text{wi}=h_i^{-P} / \sum_{i=1}^{n} \quad h_i^{-P}, \tag{4}$$

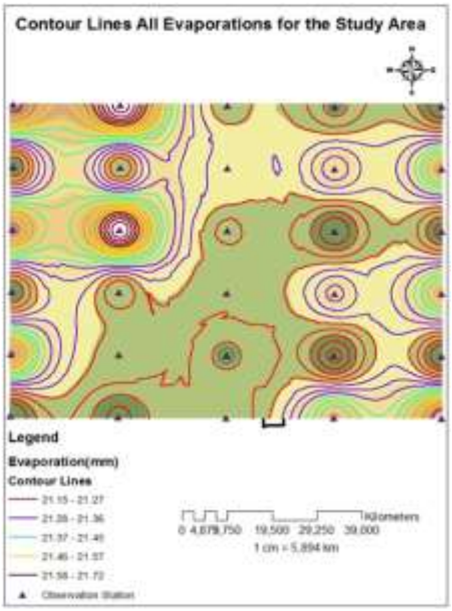
where P= the power parameter which defines the reduction rate of weights as distance increase and h = the distance between the observation point and the point to be estimated by the following:

$$hi = \sqrt{(x - x_i)^2 + (y - y_i)^2} \;, \tag{5}$$

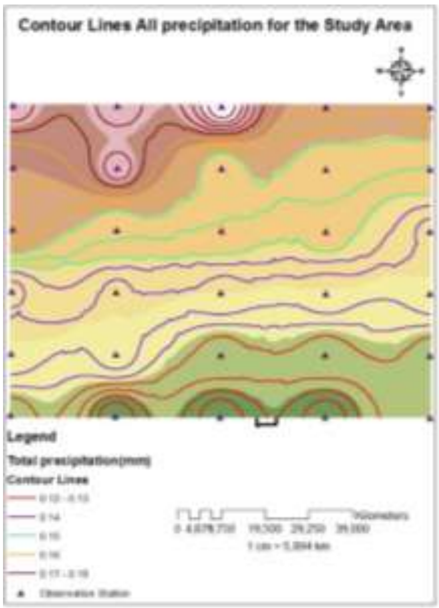
where (x, y) and (x_i, y_i) = the coordinates of the interpolation point and the scatter point.

The Interpolation was carried out for the climate factors, temperature, rainfall, humidity and evaporation, as shown in Figure (6).

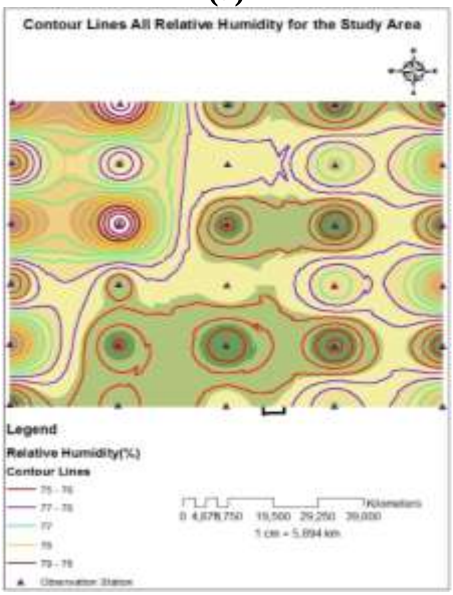
In Table 3, the average climate factors are calculated, where the truth ground data of temperature, rain precipitation, evaporation, and relative humidity were collected from the European Center for Climate Forecasts (ECMWF), of virtual stations such as meteorological monitoring, that engineered and distributed over the interested area, with 30 stations. The resulted data showed the highest degree of temperature was (24.57) while the lowest was (23.29), and the greatest precipitation value was (0.21) while the lowest value was (0.12). Furthermore, the greatest and lowest relative humidity values were (60.73) and (58.59), respectively, and the highest vapor rate equaled (-0.2) whilst the lowest rate was (-0.17).The obtained results for May and August are clarified in Figures 7 and 8.



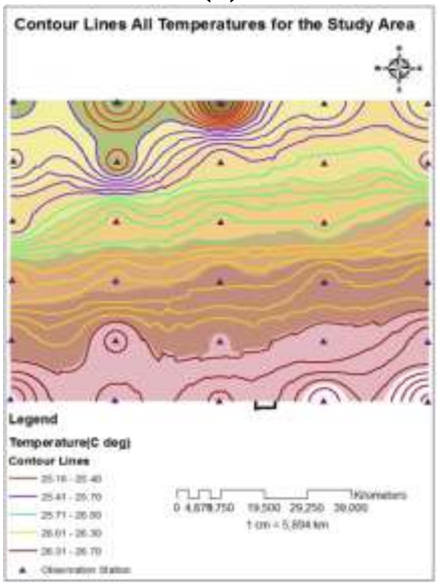
(a)



(b)



(c)

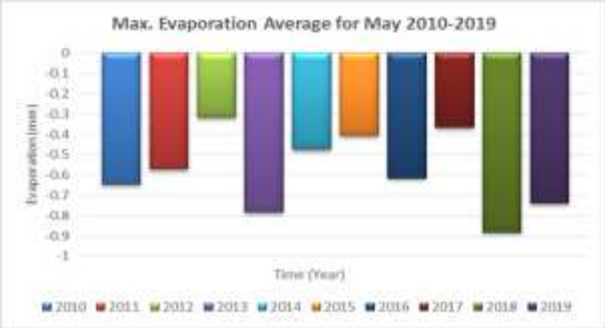


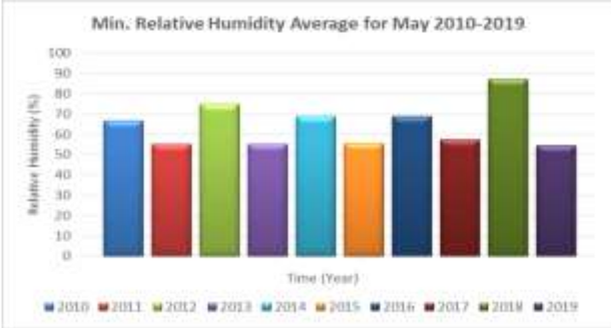
(d)

Figure 6: Illustrates that each point as meteorology station in addition to the interpolation technique of contour line values for results of (a) Evaporation, (b) Precipitation, (c) Relative Humidity and (d) Temperature.

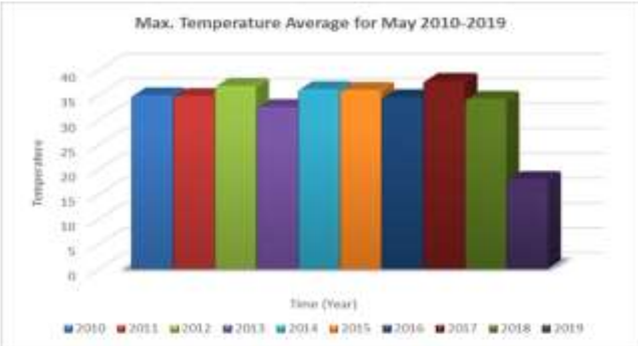
Table 3: Climate factors (Temperature, Precipitation, Relative Humidity and Evaporation) for the time period 2010-2019 years.

Station No.	**Latitude (ϕ)**	**Longitude (λ)**	**X-axis coordinate** (UTM)	Y--**axis coordinate** (UTM)	**Temper**ature	Precipitation	**Relative** Humidity	**Evapor**ation
1	33.45	43.95	402412.26	3701668.8	23.6	0.17	60.24	-0.18
2	33.45	44.2	425648.15	3701462	23.44	0.19	60.73	-0.19
3	33.45	44.45	448883.48	3701311.1	23.29	0.21	58.93	-0.2
4	33.45	44.7	472118.42	3701216.1	23.7	0.16	58.75	-0.17
5	33.45	44.95	495353.16	3701177	23.68	0.17	58.71	-0.18
6	33.33	43.95	402272.47	3687809.5	23.62	0.18	58.81	-0.19
7	33.33	44.2	425541.65	3687603.1	23.51	0.2	59.01	-0.2
8	33.33	44.45	448810.27	3687452.5	23.83	0.15	59.19	-0.17
9	33.33	44.7	472078.49	3687357.7	23.84	0.16	59.55	-0.18
10	33.33	44.95	495346.5	3687318.6	23.77	0.17	60.02	-0.19
11	33.2	43.95	402133.16	3673950.5	23.73	0.18	60.26	-0.19
12	33.2	44.2	425435.51	3673744.5	23.98	0.15	60.73	-0.17
13	33.2	44.45	448737.3	3673594.2	24	0.15	58.81	-0.18
14	33.2	44.7	472038.69	3673499.5	23.97	0.16	58.65	-0.19
15	33.2	44.95	495339.87	3673460.5	24.1	0.14	58.72	-0.17
16	33.08	43.95	401994.3	3660091.7	24.12	0.14	58.79	-0.17
17	33.08	44.2	425329.73	3659886.1	24.15	0.15	58.93	-0.18
18	33.08	44.45	448664.58	3659736.1	24.17	0.15	59.1	-0.18
19	33.08	44.7	471999.03	3659641.6	24.24	0.14	59.55	-0.17
20	33.08	44.95	495333.26	3659602.7	24.26	0.14	60.03	-0.17
21	32.95	43.95	401855.92	3646233.2	24.29	0.14	60.27	-0.18
22	32.95	44.2	425224.3	3646028	24.34	0.15	58.86	-0.18
23	32.95	44.45	448592.1	3645878.3	24.3	0.13	58.69	-0.17
24	32.95	44.7	471959.49	3645784	24.32	0.13	58.59	-0.18
25	32.95	44.95	495326.67	3645745.2	24.39	0.14	58.68	-0.18
26	32.83	43.95	401718	3632375	24.43	0.14	58.73	-0.18
27	32.83	44.2	425119.23	3632170.2	24.36	0.12	58.82	-0.17
28	32.83	44.45	448519.87	3632020.8	24.38	0.13	59.11	-0.18
29	32.83	44.7	471920.1	3631926.7	24.48	0.13	59.49	-0.18
30	32.83	44.95	495320.1	3631887.9	24.57	0.14	59.86	-0.18



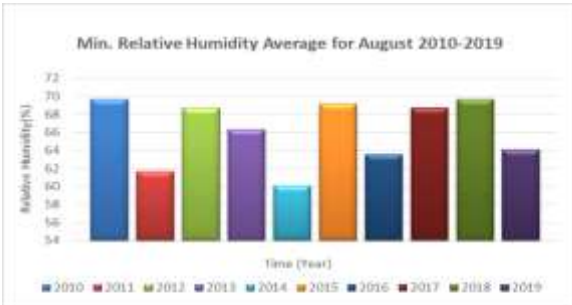


(a) **(b)**

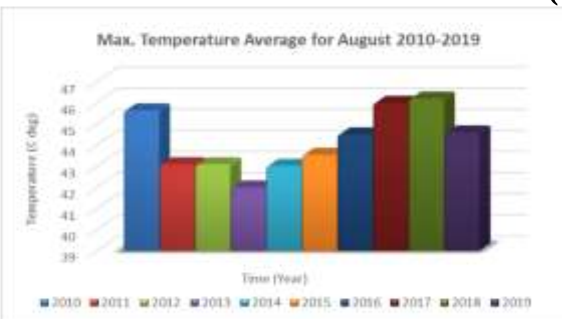


(c)

Figure 7: Chart of climate factor changes in 30 meteorological stations for (a) Maximum evaporation, (b) Minimum relative humidity, and (c) Maximum temperature for May.



(a) **(b)**



(c)

Figure 8: Chart of climate factor changes in 30 meteorological stations for (a) Maximum evaporation, (b) Minimum relative humidity, and (c) Maximum temperature for August.

8. Conclusions

Using Satellite Landsat-5 and Landsat-8 and temporal resolution images for different periods (2010-2019) provides a good assessment of changes in agricultural land degradation, providing a suitable visualization of future changes. The results of this paper clearly showed the state of land degradation that the studied areas suffered as a result of the change in climatic parameters (Temperature, Relative humidity, Evaporation, Precipitation), and they can be considered as a measure of future agricultural land degradation. The conclusion of this research can be summarised by the following:

1. Temperature rate showed an increasing pattern during the study period to reach a maximum average 24.57.
2. Rainfall recorded a decreasing pattern during the study period to reach a minimum value average 0.12.
3. The study highlighted the need to develop plans in short and long term to address the situation of land degradation and the loss of water bodies in the concerned counties.
4. It gives the opportunity to contribute in this field by developing the adapt and cope abilities with climate change, the assessment ability about how and where climate patterns are likely to change, and finally, the ability to predict the continuous fluctuations in risks.
5. The considered region was subjected to terrorist and war operations. Therefore, most of region's families were displaced while the rest of them relied on rapid gain by establishing fish ponds with the absence of the government control, which led to increase humidity ratios (60.73) that maintains soil moisture as it is.

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