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ASSESSING THE SEVERITY AND FREQUENCY OF DROUGHT IN THE ISLAND REGION OF IRAQ

Hind Fadel Ibrahim

Directorate of Education of Al-Karkh I - Al-Jana'an School, Iraq

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ABSTRACT

The problem of drought is one of the main and most serious problems that constantly threatens many countries, particularly poor countries that do not have the economic and scientific resources to address that problem, and with the increasing frequency of unity of climate change and its clearly defined effects, the result of which is the increase in the area of land affected by desertification, which has led to soil degradation, low productivity and a malfunction in its structure in such a way as to lose plant life.

In this research, the drought was studied and assessed in terms of its severity and frequency on the island region during the four study periods, especially since drought is a major cause and a clear indicator of desertification indicators in the island region through the study and calculation of wind and rain erosion, which is a key part of the drought, after which one of the evidence of drought will be applied, namely (reconnaissance drought plants).

Keywords: *Drought, Desertification, climate change affect, Evaporation*

STUDY PROBLEM

The main study problem can be formulated as follows :(Is there a drought in the island region of Iraq?)Through the main problem, secondary problems arise:

1. What climate indicators and evidence demonstrate the evolution of the drought problem in the island's territory?[(1)]

2. Has climate change affected the increase in drought in the island's territory?

STUDY HYPOTHESIS

(There is drought in the island region of Iraq)

The secondary hypotheses identified from the main hypothesis are:

1. There are clear climate indicators and indications of drought resulting from climate change in the island region: the frequency and severity of drought, the increased impact of high-temperature areas, the decline in rain bands and the disappearance of some of them,

[1] The duration of the study (1980-2017) will be divided into four terms, each length of which is (10) years except for the fourth period of (8) years. The purpose of that division is to monitor and follow up on changes in those periods as well as to make a comparison easier and thus to determine which of those periods is drier than others.

particularly at the end of the study period, the expansion of evaporation/erosion ranges, the decrease in wind speed and the decline in wind erosion and rain erosion during the study period.

2. Climate change has had a clear impact on increased desertification through reduced vegetation and water cover as a result of the change in the climate elements of the island's region.

STUDY AIMS:

The study aims are:

1- To know the nature and direction of changes in the climate elements of the island's territory.

2- Extracting climate indicators and evidence of drought.

3- Applying drought evidence, particularly the exploratory drought factors, and focusing on calculating the severity, frequency and area of each.

STUDY AREA:

1- Spatial dimension

Geographically located in the north-eastern parts of the Arab world in the area between the Tigris and Euphrates, the north-western part of Iraq is occupied in the form of a triangular plateau bordered to the east by the Tigris River, from the south-east, the sedimentary plain, to the south and southwest by the Euphrates River and to the west by the Syrian-Iraqi border, and the territory (62,285.7) is 2 km2 of Iraq's total area (437072) 2 km2, thus representing 14% of Iraq's total area.

The region is divided into three provinces (Nineveh, Salah al-Din, Anbar) with an area of (30.3445, 16.9190, 14.9650) km2 respectively as shown in table (1), and the territory is astronomically located between two viewing circles (29 22 33) (52 22 37°) north, two length lines (34 1 41°) and (44 2 42°) east, seven climatic plants distributed over the study area reflecting their general climate data for the climate of the region are selected, see table (2) and map (1).

Table (1) Area of study area and percentage of each province (km2)

The province	the total area of the province	the area of the province within the study area	Percentage
Ninawah	**37.185**	**30.3445**	**48.8**
Salah Alden	**26.685**	**16.9190**	**27.2**
Al Anbar	**138.408**	**14.9650**	**24.0**
Total	**202.278**	**62.2285**	**100**

Source: Based on Arc GIs 10.4 program.

Table (2) Aerial monitoring stations studied

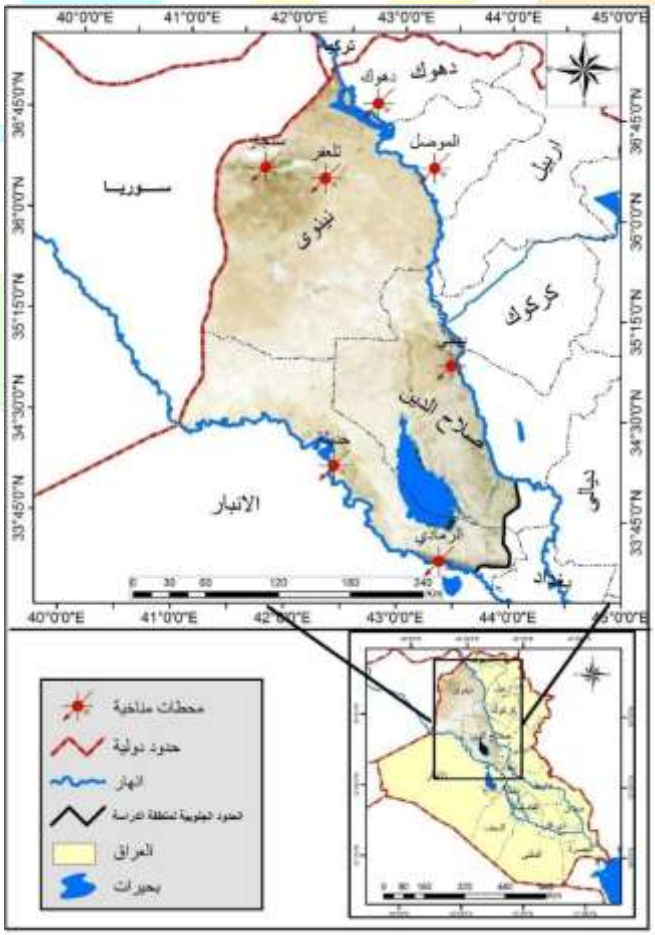
No	The climate station	cod station number	width circle (north degree) LAT	Longitude (eastward degree) LOG	Rise above sea level (m) ALT.	The province
1	Dohuk	**606**	**36 52**	**43 00**	**276**	Dohuk
2	Musial	**608**	**36 19**	**43 09**	**223**	Ninawa
3	Singar	**604**	**36 19**	**41 50**	**550**	Ninawa
4	TalAfar	**603**	**36 22**	**42 29**	**400**	Ninawa
5	Peggy	**631**	**34 54**	**43 32**	**115**	Salahaldean
6	Alramady	**645**	**33 27**	**43 19**	**48**	Alanbar
7	Hadith	**634**	**34 08**	**42 21**	**108**	Alanbar

Reference: Relying on the General Authority for Iraqi Air Force General And Seismic Monitoring, Iraq Climate Atlas (1961-1990), Baghdad.

2. The Temporal Dimension

The temporal dimension of the period (1980-2017) is the choice of this period to integrate the climatic data of the selected stations, as the climatic data of the rain element from September were adopted as a rainy season so as not to interrupt the season.

Map (1): The astronomical and geographical location of the island region and the climatic stations studied



Reference: Based on the General Authority for Space, the map of Iraq is 1:1000, 000, and arc map 10.4.

Wind Erosion

Erosion is defined as a mechanical displacement of earth materials that can be transported from their places to new locations due to multiple factors including running water on the surface, wind, moving ice, waves, coastal water currents and gravity [2],and Wind erosion is a type of degradation that is reflected in the loss of the surface layer of soil through sand creeping and sand clusters in the form of sand dunes, in addition to the impact of sand creeping, movement, movement and fall on residential areas and transportation routes as well as their impact on public health [3].

In 1962 Schippel has proposed an equation with climatic requirements to estimate the average annual loss of soil by wind and a total of other climatic factors, and has indicated that the amount of erosion varies by varying wind speed and soil moisture in the upper surface layer, which is an influential and important factor as the relationship of erosion is ejective with wind speed and reverse with soil moisture), and to extract annual wind erosion at the island's stations The mathematical formula is used as follows:

$$C = 386\ \frac{u^{-3}}{(PE)^2}$$

The:

C= Climatic susceptibility to wind erosion

386= Fixed amount indicating the factor of conditions in Cardin City, Kansas.

u-3 = wind speed rate (mph)

PE = Effective rain in thornthwiat method extracted by the following equation:

$$^{10}PE = 115\ \left(\frac{P}{T-10}\right)^{/9}$$

p = precipitation (Ang)

T= Temperature (P)

Chepil divided wind erosion into five categories, as shown in table 3.

Table (3) Degree of climatic susceptibility to wind erosion according to the Schippel equation

The amount of erosion	The degree of erosion
17-5	Very few
36-18	Few
71-37	Medium
150-72	High
151 And more	Very high

Reference: E. L. Skidmore, Wind Erosion Climatic Erosivity, ARS, USDA, Kansas State University, Manhattan, 1986, p;195-196.

[2] Ibrahim Ibrahim Sharif, Ali Hussein al-Shalish, Soil Geography, Ministry of Higher Education and Scientific Research, University of Baghdad, Faculty of Arts, 1985, p. 85.

[3] Mushtaq Ahmed Gharbi, Study of Land Degradation and Desertification Control in Al-Rutbah/Anbar Province using remote sensing and geographic information systems, PhD thesis (unpublished), Faculty of Education for the Humanities, Anbar University, 2012, p. 163.

It is noted through the application of the wind erosion equation and the results shown in table (4) and map (2) that the first period of the study during which the values of erosion were very high in all study stations except Mosul station were very low stripping, and although erosion is very high in most study stations, it varies in values in Ramadi station recorded the highest erosion values by (2680.3) This is due to the low amount of rain that has already been shown to have recorded the lowest amount of rain among the study stations, but the lowest value of the very high nudity recorded at Dohuk station as it reached (167.5) and here the difference between them is large but they fall within the same category, while the Mosul station, which recorded the least nudity and was very few Reached (8.6) due to the decrease in erosion in that station compared to the station Dohuk, which recorded higher rains that are supposed to work on soil stability, but the opposite happened because the Mosul station was characterized by a lack of rain, high temperatures and increased wind speed as well as a small amount of effective rain unlike the Dohuk station, which was characterized by higher rain, lower temperature, greater wind speed and effective rain Higher here shows the significant difference in wind speed of (4.4) mph.

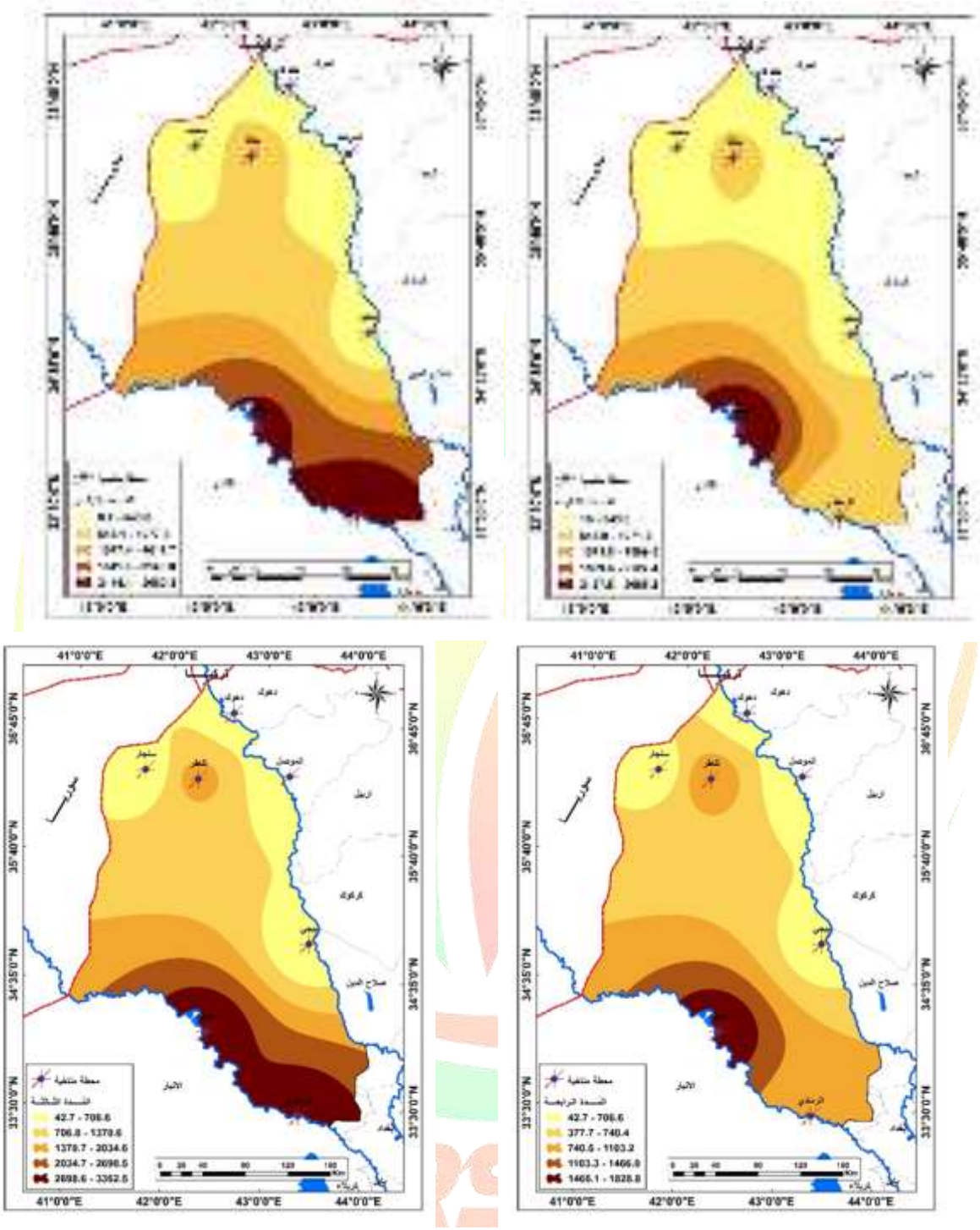
The second period of the study was different from the first period, as erosion was very high in four stations (Tal Afar, Baiji, Ramadi, and Haditha) and the highest value was in a modern station (2655.2) While the lowest high erosion values were at the Baiji station amounted to (332.4) and the difference between them is very large mostly due to the speed of the wind that rose at the station Modern, the Singar station was highly striped at (135.7), a value very close to the category of very high erosion, The Mosul station recorded very little nudity of (16) as in map (2), and for the third period recorded very high nudity in five stations (Dohuk, Singar, Tal Afar, Ramadi, Haditha) ranging from its highest value (3362.5) in a modern station and the lowest stripping value amounted to (233.5) in Dohuk station and here the difference

Table (4) Requirements and values of wind erosion in the island region during the four study periods

The duration	The station	The rain (Ang)	Temperature (p)	wind speed (mile/hour)	Effective rain (Thornthwiat)	wind erosion (Schippel)	described the severity of erosion
First Term	Dohuk	**15.9**	**67.6**	**6.9**	**27.5**	**167.5**	Very high
	Musial	**15.3**	**67.7**	**2.5**	**26.3**	**8.7**	Very few
	Singar	**15.5**	**67.3**	**7.2**	**26.9**	**199.1**	Very high
	TalAfar	**13.6**	**68.5**	**10.5**	**22.7**	**864.6**	Very high
	Peggy	**8.3**	**71.6**	**4.9**	**12.4**	**295.3**	Very high
	Alramady	**3.6**	**70.2**	**5.6**	**6.9**	**2680.3**	Very high
	Hadith	**6.4**	**69**	**8.3**	**9.7**	**2323.5**	Very high
Second Term	Dohuk	**15.4**	**69.4**	**6.3**	**25.7**	**146.6**	High
	Musial	**15.7**	**68.2**	**3.1**	**26.8**	**16**	Very few
	Singar	**16.6**	**69.3**	**6.5**	**27.9**	**135.7**	High
	TalAfar	**14.7**	**68.9**	**10.5**	**24.6**	**738.4**	Very high
	Peggy	**8.4**	**72.3**	**5.1**	**12.4**	**332.4**	Very high
	Alramady	**5.6**	**71**	**4.9**	**8.1**	**692.7**	Very high
	Hadith	**5.9**	**70.7**	**8**	**8.6**	**2655.2**	Very high
Third Term	Dohuk	**12.3**	**68.5**	**6.3**	**20.3**	**233.5**	Very high
	Musial	**11.7**	**69.6**	**3.4**	**18.8**	**42.7**	Medium
	Singar	**11.5**	**71**	**6**	**18**	**257**	Very high
	TalAfar	**9.4**	**69.4**	**9.8**	**14.8**	**1652.4**	Very high
	Peggy	**6.9**	**73.7**	**2.9**	**9.7**	**99.4**	High
	Alramady	**3.3**	**72.7**	**5.4**	**4.4**	**3191.9**	Very high
	Hadith	**4.1**	**69.6**	**6.7**	**5.9**	**3362.5**	Very high
Fourth Term	Dohuk	**14.4**	**68.7**	**5.8**	**24.1**	**129.3**	High
	Musial	**12.4**	**69.4**	**2.5**	**20.2**	**14.8**	Very few
	Singar	**13.3**	**71.2**	**5.6**	**21.1**	**152.4**	Very high
	TalAfar	**10.6**	**71.6**	**9**	**16.3**	**1062.4**	Very high
	Peggy	**6.4**	**74.7**	**2.9**	**8.8**	**121.6**	Very high
	Alramady	**4.6**	**73.4**	**4.5**	**6.2**	**905.1**	Very high
	Hadith	**3.9**	**72.3**	**5.1**	**5.3**	**1828.8**	Very high

Reference: Relying on the General Authority for Iraqi Air Force and Seismic Monitoring Authority, Climate Section, Unpublished Data, 2021.

Map (2) Temporal and spatial modelling of wind erosion ranges in the island region during the four study periods



Reference: Based on data of table (4) and ArcGIS 10.5.

Is also very large which means that the north of the island region is experiencing nudity Wind less than its southern part, map (2), and for the fourth period of study it was less naked than the previous periods in general where it recorded very high nudity in four stations (Singar, Tal Afar, Ramadi, Haditha) the highest value was in a modern station reached (182) 8.8) And the lowest at Singar station (152.4) also by a wide margin, and recorded the stations Dohuk and Baiji high nudity amounted to (129.3, 121.6) each, respectively, while the Mosul station was stripped naked Very few (14.8) as shown in map (2).

DROUGHT INDICATORS IN THE STUDY AREA:

Reconnaissance Drought Index (RDI)

The World Meteorological Organization (WMO) has issued the RDI index as part of the Integrated Drought Management Program (IDMP), which was calculated through the Drin C program, based on two main variables: Rain (P) and Evaporation/Evaporation/pet, which is a recent indicator based on the total differences between rain and evaporation/erosion, and can be calculated in accordance with the following formula [4]:

$$\alpha_k^{(i)} = \frac{\sum_{j=1}^{k} P_{ij}}{\sum_{j=1}^{k} PET_{ij}}, \; i = 1 \text{ to } N$$

The: Pij = Precipitation

PETij = Evaporation/Panman Monteith

N= Number of years of study

The values and degrees of drought in these plants vary according to their severity and strength to four degrees, ranging from the highest degree of drought (dry) to the lowest (semi-humid) as shown in table 5.

The Sub Humid Climate: Table 6 shows that this type of climate recorded very few repetitions on the study area as it is directly related to rain, the frequencies of this type of climate in only two stations, Dohuk and Mosul during the first and second periods of 1.1) per station and each period respectively, while it did not repeat it in the third and fourth period due to the lack of rainfall as well as rising temperatures and increasing the amount of Evaporation/Erosion possible.

[4] Drought Management Indicators and Indices Guide, Integrated Drought Management Program, World Meteorological Organization (WMO), National Drought Mitigation Center (NDMC) of Nebraska, Publications, 2016, p. 17.

Table (5) Drought and humidity by Survey Drought Coefficient RDI

The standard of drought	In the manner of Penman Monteith	In the manner of Harkravis
he Hyper Arid	Less than 0.03	Less than 0.05
The Arid	0.20-0.03	0.20-0.05
The Semi-Arid	0.50-0.20	0.50-0.20
The Sub Humid	0.75-0.50	65-0.50
Humid	Bigger than 0.65	Bigger than 0.65

Reference: G. Tsakirisand H. Vangelis, Establishing a Drought Index Incorporating Evapotranspiration, Lab. of Reclamation Works & Water Resources Management National Technical University of Athens, Iroon Polytechniou, Athens – Greece, 2005, P4.

Table (6) Frequency of reconnaissance drought coefficient in island region stations during the four study periods

The station	First Term 1989-1980				Second Term 1999-1990				Third Term 2009-2000				Fourth Term 2017-2010			
	Semi-humid	Semi-dry	Dry	Bigger Than Dry	Semi-humid	Semi-dry	Dry	Bigger Than Dry	Semi-humid	Semi-dry	Dry	Bigger Than Dry	Semi-humid	Semi-dry	Dry	Bigger than Dry
Dohuk	1	7	2	0	1	8	1	0	0	8	2	0	0	7	1	0
Musial	1	8	1	0	1	8	1	0	0	7	3	0	0	7	1	0
Singar	0	6	4	0	0	8	2	0	0	4	6	0	0	6	2	0
TalAfar	0	2	8	0	0	2	8	0	0	0	10	0	0	0	8	0
Peggy	0	0	10	0	0	1	9	0	0	2	8	0	0	0	8	0
Alramady	0	0	7	3	0	0	10	0	2	0	8	0	0	0	8	0
Hadith	0	0	10	0	0	0	8	2	0	0	10	0	0	0	8	0

Reference: Relying on the General Authority for Iraqi Air Force and Seismic Monitoring Authority, Climate Section, Unpublished Data, 2021.

SPATIAL MODELLING OF COEFFICIENT DROUGHT PLANTS

Drought values vary spatially at each climatic and temporal station in each of the four study periods, in spatial variation When we notes Table 7 it clear that all of them were in the dry and semi-dry climate [(5)], The Dohuk and Mosul stations had a semi-dry climate during the four consecutive study periods, but the value of the drought differed despite the fact that they had a single climate, which is semi-dry, with a drought value of 0.34,0.32, respectively, while during the second periods it recorded a drought value of 0.34, 0.32, respectively. The third was different values (0.24, 0.29), i.e. it moved

[5] Firas S Raheem , Ali A Kazem Al-Waeli, Osama kazal A Al-Sharifiy, Observation and monitoring in vegetation cover in Al – Qadisiyah Governorate, Iraq based on remote sensing and GIS, Materials Today, 2214-7853/_ 2021 Elsevier Ltd. All rights reserved. p.4.

away from the semi-dry category and approached the dry climate category, as did the Mosul plant, where drought values were recorded (0.30, 0.30, 0.21, 0.25) during the four consecutive study periods and those values also indicated an increase in the degree of drought during the third and fourth periods.

Table (7): Rate of exploratory drought factors in the island region during the four study periods

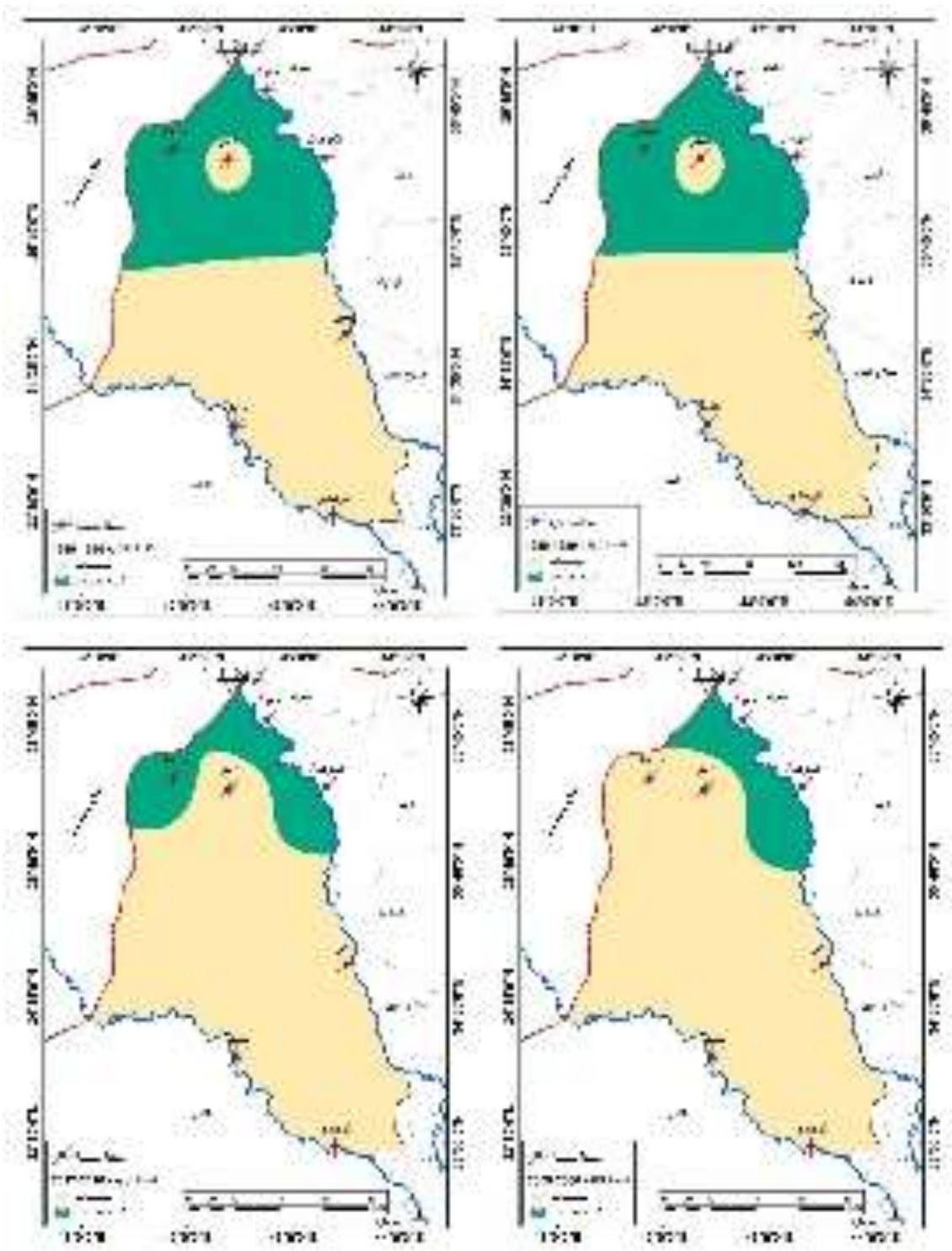
The station	**First Term 1989-1980**		**Second Term 1999-1990**		**Third Term 2009-2000**		**Fourth Term 2017-2010**	
	value	Climate type	value	Climate type	value	Climate type	value	Climate type
Dohuk	**0.34**	**Semi-dry**	**0.32**	**Semi-dry**	**0.24**	**Semi-dry**	**0.29**	**Semi-dry**
Musial	**0.30**	**Semi-dry**	**0.30**	**Semi-dry**	**0.21**	**Semi-dry**	**0.25**	**Semi-dry**
Singar	**0.22**	**Semi-dry**	**0.24**	**Semi-dry**	**0.16**	**Dry**	**0.22**	**Semi-dry**
TalAfar	**0.17**	**Dry**	**0.17**	**Dry**	**0.12**	**Dry**	**0.15**	**Dry**
Peggy	**0.12**	**Dry**	**0.12**	**Dry**	**0.13**	**Dry**	**0.11**	**Dry**
Alramady	**0.05**	**Dry**	**0.08**	**Dry**	**0.05**	**Dry**	**0.07**	**Dry**
Hadith	**0.07**	**Dry**	**0.07**	**Dry**	**0.05**	**Dry**	**0.06**	**Dry**

Reference: Relying on the General Authority for Iraqi Air Force and Seismic Monitoring Authority, Climate Section, Unpublished Data, 2021.

Tal Afar recorded a clear anomaly in drought values, as although it occurred in the north of the study area, which is supposed to be less dry than plants south of the study area, it recorded (0.17, 0.17, 0.12, 0.15) for the four consecutive periods of study due to high wind speeds, which in turn led to higher evaporation/erosion and thus increased drought.

The mapping of drought varieties is observed through map (3) and table 8 that the dry climate category reached the area covered (41,604, 40,344, 54,818, 5203) 1) Km2 by 66.8, 64.8, 88, 83.5% of this we conclude that these areas are increasing over and over again, which means that the degree of drought in the study area has increased very significantly.

Map (3): Temporal and spatial modelling of reconnaissance drought plants in the island region during the four study periods



Reference: Based on table 8 and ArcGIS 10.5.

Table (8): Area areas of drought plants in the island region and their percentages of duration (1980-2017)

Drought plants regions	First Term 1989-1980		Second Term 1999-1990		Third Term 2009-2000		Fourth Term 2017-2010	
	Area of region	Ratio	Area of region	Ratio	Area of region	Ratio	Area of region	Ratio
Dry	41604	66.8	40344	64.8	54818	88.0	52031	83.5
Semi-dry	20681	33.2	21942	35.2	7467	12.0	10255	16.5
Total	62286	%100	62286	%100	62286	%100	62286	%100

Reference: Based on table data (7) and ArcGIS 10.5.

CONCLUSIONS:

1. The semi-wet climate category recorded very few repetitions of the study area as it was directly associated with rain, the frequency of which increased at Dohuk and Mosul stations during the first and second period by (1,1) per station and for a period respectively, while it was not repeated in the third and fourth period due to lack of rainfall as well as high temperatures and increased evaporation/erosion.

2. The recurrence of the semi-dry climate within the Dohuk and Mosul stations began to decline and the emergence of a more severe category represented in the dry climate category, while the lowest frequency of this species was at the Baiji station at (1,2) a repetition during the second and third period while disappearing during the first and fourth period.

3. The dry climate recorded varying frequencies in the study area, but in general the highest frequencies were at stations south of the study area, including a modern one, with (10, 8, 10, 8) recorded repeats during the four consecutive study periods.

RECOMMENDATIONS:

1- Activating the work of the ministries of water resources, environment and agriculture by identifying drought regions and creating the right conditions to reduce drought and desertification.

2- Adopt the classification derived from this study to determine the aforementioned drought regions, the level and limits of exploratory drought and the ways in which it is treated and reduced.

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