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The Impact of Climate Change on the Increase in the Frequency of Drought in the Eastern Region of Iraq

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Abstract

Aim: This abstract aims to highlight the critical nature of climate change as a pressing challenge facing humanity in the 21st century. It underscores the severe consequences it poses to essential facets of human existence, including water and energy resources, agricultural production, and the broader environmental systems.

Method: The abstract primarily utilizes a descriptive approach to emphasize the impact of climate change on the Middle East, particularly the Arab region. It relies on a review of existing knowledge and data related to climate change and its effects on ecosystems and drought patterns.

Results: The abstract outlines the direct and indirect repercussions of climate change on human life and the environment. It draws attention to the escalating intensity, frequency, and persistence of drought, a pressing issue exacerbated by shifting environmental patterns.

Conclusion: In conclusion, climate change presents a formidable challenge that imperils various aspects of human life, particularly in regions like the Middle East. The observed changes in temperature and their cascading effects demand urgent attention and concerted global efforts to mitigate the consequences and adapt to the new realities of our changing environment. Addressing climate change is not only an environmental imperative but also a critical factor for ensuring the well-being and sustainability of future generations.

Keywords: *Climate change, drought, vegetation, water resources.*

Introduction

The problem of the study :(Does climate change have an impact on the increase in the frequency of drought in the eastern region of Iraq?)

Study hypothesis: (Climate change has an impact on the increase in the frequency of drought in the eastern region of Iraq)

Objective of the study: To prove the reality of climate change in the eastern region of Iraq, and to clarify the role of that change In increasing the frequency of the drought phenomenon by studying the drought variables represented by (frequency, intensity,

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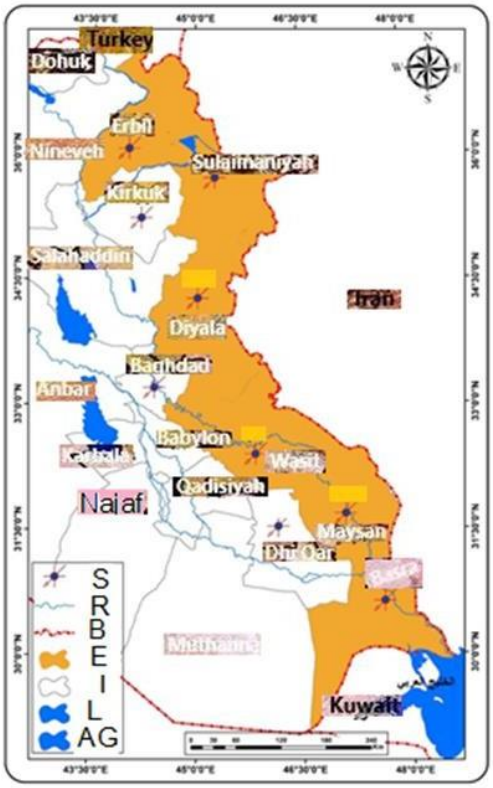
sustainability), and studying the environmental effects resulting from climate change and drought in the study area by analyzing satellite visuals and calculating the area and percentage of dry land through drought indicators represented by (vegetation, water cover).

Boundaries of the study area: The study area is geographically determined by the eastern part of Iraq, which includes six governorates represented by (Erbil, Sulaymaniyah, Diyala, Wasit, Maysan, Basra), and the study will rely on nine climatic stations: (Erbil, Sulaymaniyah, Kirkuk, Khanaqin, Baghdad, Al-Hay, Nasiriyah, Amara and Basra), while astronomically it is located between latitudes (36° and 31°) north, and longitudes (43 and 47) east, map (1).



Map (1) Astronomical and geographical location of the study area

Source: Researchers based on Arc GIS 10.7

First: Climate Change: Climate change is defined by the International Panel on Climate Change (IPCC) as any change in the state of the climate over time and contributed by natural causes such as changes in the solar cycle, volcanic eruptions and human causes resulting from human activities in the atmosphere, Second: Drought: There is no specific concept of drought because of the difficulty of determining a specific definition of it, so it is in fact a phenomenon associated in its inception with very complex and diverse factors and conditions that have their nature in spreading and crawling towards an area and have their ability to solve somewhere in a certain way, and drought can be defined as meaning a decrease in the effectiveness of rain and not in its quantity, that is, drought in this concept is represented in metrological drought.

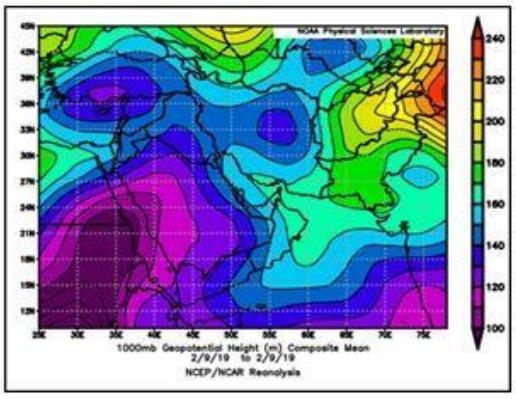
Environmental impacts of climate change: The edge of climate change threat is the arrival of rising global temperatures, Five types of multiplier risks can be identified for the setback to human development in the event of a rise in temperatures to 2 °C, namely a decrease in agricultural productivity due to the decline in rains in large parts of the world, especially parts of sub-Saharan Africa and Southeast Asia, and water insecurity in many regions of the world, as it will lead to increased floodingCoastal and extreme weather

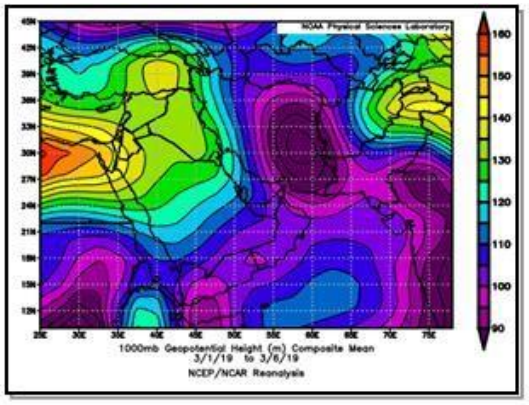
events, ecosystem collapse and extinction of many species of organisms Coral reefs already degraded will be subject to significant shrinkage in their areas, affecting biodiversity losses in those areas.

Environmental effects of drought: Drought has serious effects that can be summarized as follows: the formation of sand dunes and their encroachment towards agricultural fields, the increased frequency of dust and dust storms, wind erosion, soil salinization as a result of high temperatures, which cause high rates of evaporation of water and the leave of salts on the soil causing an increase in its alkalinity, lack or absence of natural plant cover, limited agricultural areas according to the abundance of water used for irrigation, whether from rivers, fresh lakes or ground water, The migration of animals and many birds from drought-prone areas to wetter areas, lack of natural pastures.

Pressure systems affecting the study area: depressions A - Mediterranean Low In winter, the Mediterranean Sea becomes a major center of low atmospheric pressure, which is surrounded from almost all directions by centers of high atmospheric pressure, to the north and east of it extend huge outcrops From the Siberian air altitude over Eastern Europe, the Anatolian Plateau, Iraq and the interior of the Levant, as a result, the Mediterranean Sea will be exposed throughout the winter to the influence of cold continental polar air masses (cP) and warm continental tropical air masses (cT)Map (2).

B- Sudanese depression: This depression arises from the confluence of tropical northeastern trade winds coming from the Sahara Desert, which is characterized by high temperatures and dryness, with the southeastern trade winds coming from the subtropical high pressure area south of the African continent, which is characterized byAfter it arises over Sudanese territory, it heads towards the Red Sea, it is provided with moisture and reaches Iraq and the study area through two paths, it moves north until it reaches the Sinai Peninsula and then heads east towards Iraq, and moves in the northeastern direction passing through the Arabian Peninsula until it reaches Iraq, Map (3).





Map (2) Impact of the Mediterranean Depression on Iraq on 1/3/2019

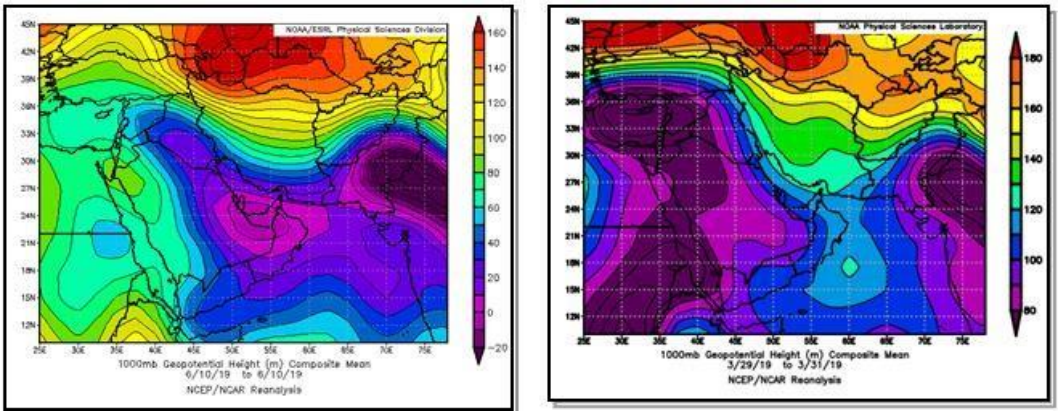
Map (3) Impact of the Sudanese Depression on Iraq on 19/2/2019

Source: https://www.esrl.noaa.gov/gmd/news/7074.html

Merged depression: This type of depression is formed as a result of the merger of the Sudan depression with one of the Mediterranean depressions, when the first moves north over the Red Sea until it reaches the northeastern region of it, as it meets with the Mediterranean depression and takes its direction towards the east or southeast, and the merger process occurs either outside Iraq when the northern Sudan depressions meet the directionWith one of the Mediterranean depressions passing in the eastern and southeastern directions or deepening over the Mediterranean Sea, which helps to integrate them into the eastern or southeastern Mediterranean, or it occurs over the airspace of Iraq and this happens when the arrival of the Mediterranean depressions and the depressions

of Sudan correspond to Iraq or precedes it, or the depressions of Sudan precede the Mediterranean depressions sometimes, so they merge when they arrive in Iraq, Map (4).

D - Indian seasonal depression: It is a thermal depression formed in summer over the Indian subcontinent and southeast Asia, this depression expands to include large areas of Asian land and extends in the southwestern direction of the continent of Asia, and its impact sometimes reaches the north of the Sahara Desert, and helps to raise the minimum and maximum temperatures and increases the speed of the winds in summer, and is the main reason for the generation of the dust phenomenon during the summer, map (5).

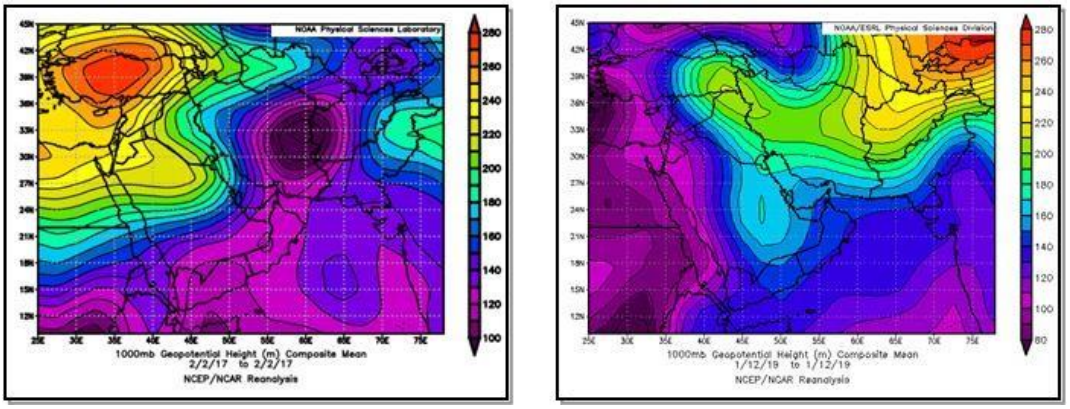


Map (4) Impact of the Merged Depression on Iraq on 29/3/2019

Map (5) Impact of Indian Monsoon Depression on Iraq on 10/6/2019

Source: https://www.esrl.noaa.gov/gmd/news/7074.html

Air heights: A- Siberian Air Height: The arrival of winter in the northern hemisphere is accompanied by a decrease in temperatures, which results in an extension of the Siberian High towards the south and its stability over the plateau of Armenia, Anatolia and northern Iraq, Iraq is under the influence of the extension of the Siberian air altitude (the main) from the eastern and northeastern sides of western Iran and from the northern side through the Anatolian Plateau Note map (6),It affects the study area in all seasons except the summer, as it begins to appear during the autumn during the period from October to May, and this type of Hypertension is accompanied by a cold polar air mass (cP) originating from Siberia, and due to the great distance traveled by this mass and its passage over a vast land, its thermal properties modify and reach Iraq modified, the Siberian high enters the study area from the northern, eastern and northeastern parts and works on the occurrence and frequency of cold waves and falling Rain Map(7)



Map (6) Influence of the Siberian Hypertension on Iraq on 12/1/2019

Map (7) Impact of European Hypertension on Iraq on 2/2/2017

Source: https://www.esrl.noaa.gov/gmd/news/7074.html

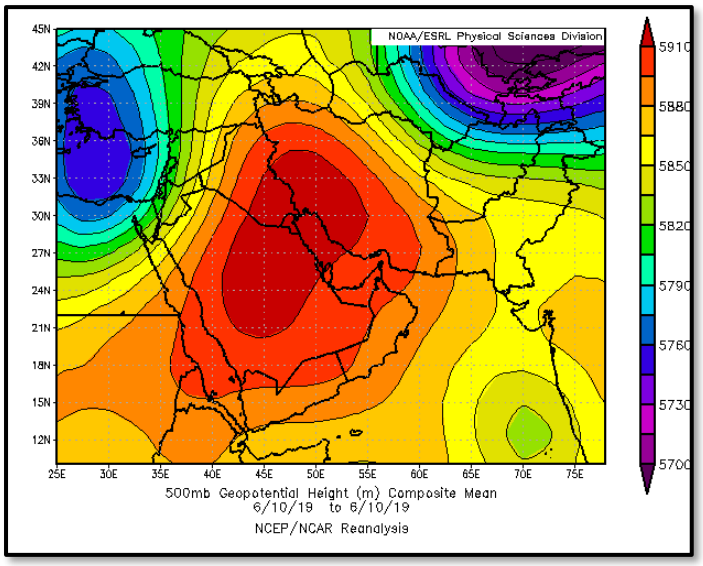
European high: One of the cold thermal air heights seasonal effect, as its frequency is limited during the rainy season, it is formed over the snow-covered Alps and over the plateaus of Armenia and Anatolia, this air altitude is centered in central Europe and covers most of the area of Europe and reaches the breadth of the areas covered by (2000) km2, as it extends from southern France to England in the north and to the eastern Mediterranean in the south, and is characterized by its slow movement and remains stable forseveral days and then gradually decays and is called the temporary air altitude, Map(7).

C- Subtropical high: Iraq's climate is affected by the subtropical high, whose influence prevails throughout the months of the year, and it is one of the warm kinetic heights concentrated in the upper layers of the atmosphere, specifically at the pressure level (500 millibar), and it is one of the air heights represented in the upper and weak layers of the atmosphere at the surface because it is a descending upper air, the impact of which reaches and extends over the eastern Mediterranean regions, which hinders the formation of Mediterranean depressions and their passage towards the east and southeast, Map (8).

d. Al-Jazeera Anticyclone : It is one of the warm continental air heights, and its extensions cover a large area of the Arabian Gulf region, and when Iraq is under the influence of this air altitude, it covers its entire area, including thestudy, this high is active during the two seasons of transition, and its incursion is longitudinally adjacent to the east of the Arabian Peninsula, pushed by the introduction of the Sudanese depression towards the east, and its extension towards the east leads to pushing the pressure depression formed on Iran towards the north, which leads to a large pressure gradient and then an increase in wind speed.

Environmental repercussions of drought in the eastern region of Iraq :

The focus will be on studying and monitoring changes in the various drought spectral indicators and then building a model to know the accumulated drought risks as a result of the decline of vegetation cover, decrease in water cover area, increase soil salinity, erosion and low moisture, Therefore, some indicators of dehydration will be addressed as follows:



Map (8) The impact of the subtropical high on Iraq on 10/6/2019

Source: https://www.esrl.noaa.gov/gmd/news/7074.html

1- Vegetation

Vegetation cover can be defined as the natural cover produced through the interaction between the appropriate climatic conditions and the soil factor that it comes out of the plant on its own, and the vegetation cover works as a protective cover to protect the soil from erosion and maintenance, and it is also subject to natural factors that control the distribution of its quality, density and survival, and the most important of these factors are some elements of climate, soil type, location, and terrain, The greater the density of vegetation cover, the more cohesive the soil grains and the greater their resistance to wind erosion and vice versa, so the Normalized Difference Vegetation Index will be calculated, as it refers to the density of vegetation cover in its various degrees, and this indicator (NDVI) is calculated through the following equation.

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}}$$

Whereas:

NDVI=vegetation coefficient of variation index, NIR = is a high reflection within the range of infrared, RED= is a low reflection that falls within the red-ray range of the spectrum, In the case of Landsat (8) satellite data Land4 and Land5, (B3) refers to the part of the red spectrum, while (B4) refers to the part of the near-infrared spectrum, using the following equation.

$$\mathrm{NDVI} = \frac{(\mathrm{Band4} - \mathrm{Band3})}{(\mathrm{Band4} + \mathrm{Band3})}$$

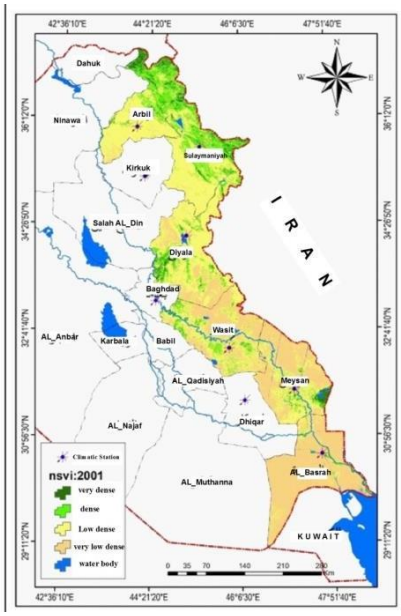
As for the theoretical aspect, it takes the values of (NDVI) that range between (+1, -1), and generally positive values indicate the presence of dense vegetation cover, while negative values indicate the absence of vegetation cover, and these areas within these values include barren lands, human settlements and water bodies.

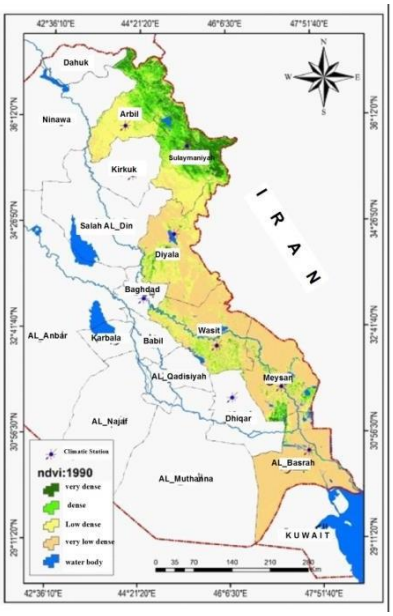
It is clear through the analysis of maps (9)(10)(11)(12) and Table (1) that there is a clear spatial and temporal variation in the varieties of vegetation cover in the study area during the study years, as the dense vegetation category recorded an area of 7818.4 and a rate of 7.03% in 1990, while this area decreased during the year 2001, where the area reached 6834.7 km2 and a rate of 6.4%, This decrease continued during the third year of the study in 2008, as the area reached 5663.9 km2 and 5.3%, while the increase returned again during the last year during 2017 with an area of 9526.2 and by 6.09%, and the reason for this decrease and increase is due to the variation in the amount of rain falling in the study area, As for the type of vegetation cover, which was concentrated in different parts of the northern, central and southern part of the study area, it recorded an area of 13887.3 and a percentage of 13% during the year 1990, and this area decreased during the year 2001, reaching 12605.2 km2 and by 11.8%, then it rose again as its area during the year 2008 amounted to approximately 14852.8km2 and a percentage of 13.9%, then decreased again during the last year of study during the year 2017 again, as the area of this variety reached 9762 km2 and a percentage of 9.2%, As for the third category of the second vegetation cover, which is the weak vegetation cover,

Table (1) Area and percentage of vegetation cover in the study area during the study years

Vegetation	1990	%	2001	%	2008	%	2017	%
Very dense	7818.4	7.3	6834.7	6.4	5663.9	5.3	9526.2	8.9
dense	13887.3	13.0	12605.2	11.8	14852.8	13.9	9762.0	9.2
Weak	28065.8	26.3	52028.5	48.8	29754.8	27.9	43661.9	40.9
Very weak	54147.6	50.8	33551.9	31.5	53511.5	50.2	42108.4	39.5
Water	2756.6	2.6	1655.4	1.6	2892.7	2.7	1617.2	1.5
Total	106675.7	100	106675.7	100	106675.7	100	106675.7	100

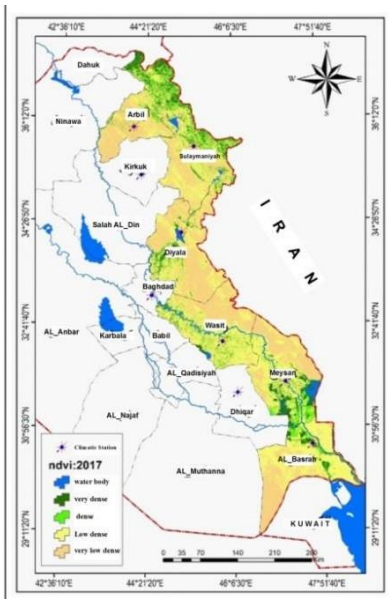
Source: Researchers based on Landsat satellite visualizations (5, 7, 8)

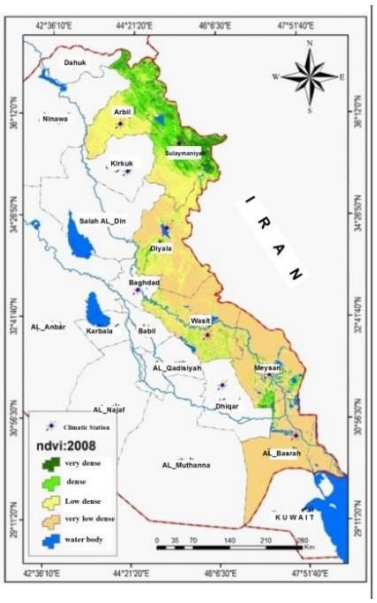




Map (9) Vegetation Index (NDVI) in Map (10) Vegetation Index (NDVI) in Area study within a year (1990) Area study within a year (2001)

Source: Researcher based on satellite visual Landsat (5) and Landsat (7)





Map (11) Vegetation Index (NDVI) in Map (12) Vegetation Index (NDVI) in area study within a year (2008) Area study within a year (2017)

Source: Researcher based on satellite visual Landsat (5) and Landsat (7)

which was concentrated in different parts of Erbil, Sulaymaniyah, Diyala, Maysan and Wasit, which came in second place after the very weak vegetation, as its area during the year 1990 amounted to approximately 28065.8 and a rate of 26.3%, then this area increased during the year 2001, reaching 552028.5 km2 and a rate of 48.8%, As for the last variety of vegetation varieties, which is very weak, which is concentrated within the central and southern part of the study area, as it extends from Diyala down to Basra and is very concentrated in Basra.

1- Water cover (water resources

It includes rainwater, surface water, groundwater,, so there was a need to practice irrigation agriculture based on the Tigris River and irrigation projects as well as groundwater, and the Normalized Difference Water Index (NDWI) will be applied, which proposed the Water Bodies Index for the first time by the researcher (Mc Feeters) to detect water bodies in any area and indicate wet and dry areas, It's a sensitive indicatorof the change in the water content of the studied area The high values of this indicator (blue) indicate the highest water content, and the water bodies index shows the area of the water cover in the study area by increasing or decreasing it, based on the equation :

$$\mathrm{NDWI} = \frac{\mathrm{Green} - \mathrm{NIR}}{\mathrm{Green} + \mathrm{NIR}}$$

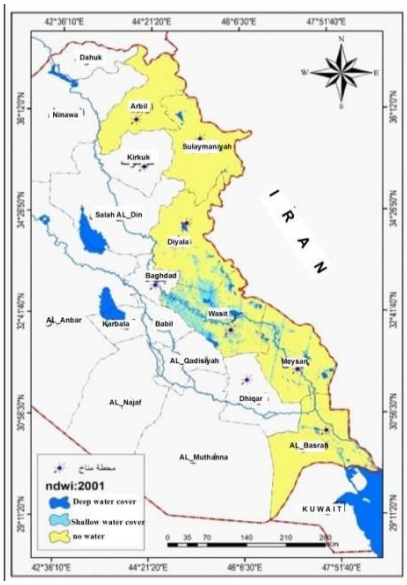
Whereas: NDWI= Water Bodies Indicator, Green=Green Wavelength, NIR= Infrared Wavelength

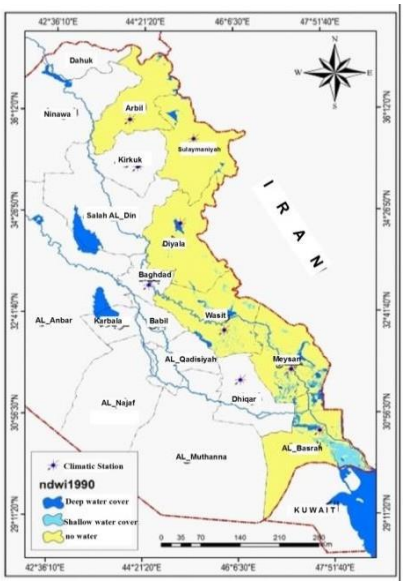
It is clear from Table (2) and maps (13), (14), (15), (16) that the category of dry cover recorded An area of 95997.9 km2 by 90% during the year 1990, while that area decreased to 91706.5 km2 and by 86% during the year 2001, and the decline continued during the years 2008-2017, where the area of each of them reached 88850.2 - 83818.4 km2 and by 83.3% and 78.6% respectively, while the shallow variety recorded an area of 6999.9 and a rate of 6.6% during the year 1990, It continued to rise during the years 2008-2017, where the area of each reached 13285.0 km2 and 17992.6 km2 and a percentage of 12.5 and 16.9 respectively, while the deep variety recorded an area of 3677.9 and a rate of 3.4% during the year 1990, and that area increased during the year 2017 where the area reached 4864.7 and a rate of 4.6%.

Table (2) Area and percentage of water cover in the study area during the study years

Water cover	**1990**	**%**	**2001**	**%**	**2008**	**%**	**2017**	**%**
Crusty	**95997.9**	**90.0**	**91706.5**	**86.0**	**88850.2**	**83.3**	**83818.4**	**78.6**
Shallow	**6999.9**	**6.6**	**13179.6**	**12.4**	**13285.0**	**12.5**	**17992.6**	**16.9**
Deep	**3677.9**	**3.4**	**1789.6**	**1.7**	**4540.5**	**4.3**	**4864.7**	**4.6**
Total	**106675.7**	**100**	**106675.7**	**100**	**106675.7**	**100**	**106675.7**	**100**

Source: Researchers based on Landsat satellite visualizations (5, 7, 8).





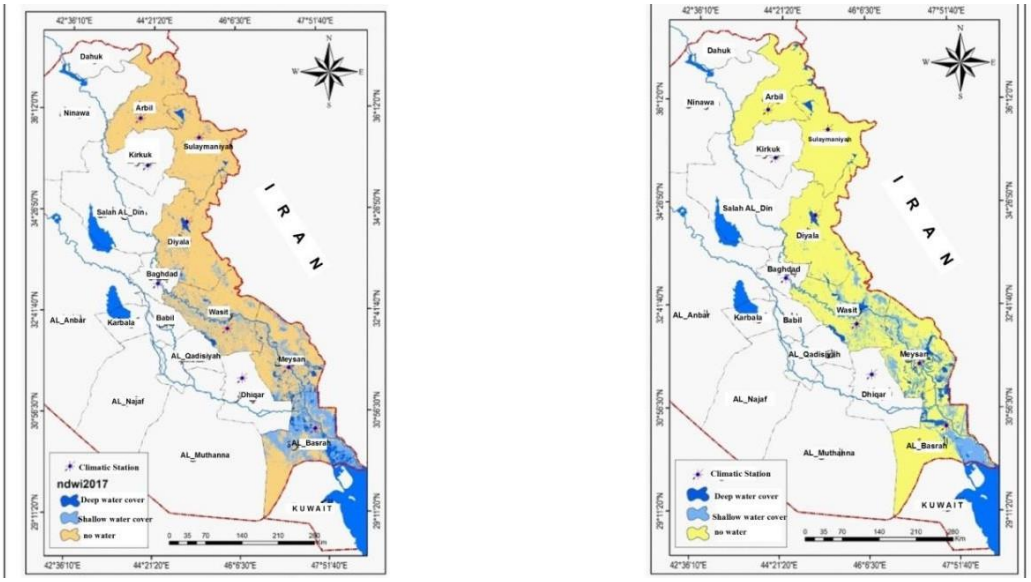
Map (13) Water Cover Index (NDWI) in the study area during the year (1990)

Map (14) Water Cover Index (NDWI) in the study area during the year (2001)

Source: Researchers based on satellite visual Landsat (5) and Landsat (7)

Results

Iraq environment is seriously in need for changing the Drought profile. The massive use of fossil fuels caused a very dangerous air pollution that impacts the health of people and plants. The excessive use of water resources in Iraq and the lack of rationing conducive to drought, and the distribution of vegetation cover and climate elements contributed to this.



Map (15) Water Cover Index (NDWI) in the study area during the year (2008)

Map (16) Water Cover Index (NDWI) in the study area during the year (2017)

Source: Researchers based on satellite visual Landsat (5) and Landsat (7).

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