

Environmental Degradation in Iraq Due to Climate Change and Human Activity (Remote Sensing Study)

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Abstract According to the World Bank, Iraq is one of the countries that are considered a sufferer of climate change in the world. Climate change was clearly reflected in the rate of surface water in Iraq. Which showed significant degradation in vegetation cover and green areas. Then, it was Influence in the environmental and economic situations in Iraq. On the other hand, many studies do not consider climate change to be the main cause of environmental degradation in Iraq. But rather, human activity is the most influential factor and the main cause of environmental degradation over there. This research aims to determine the effects of climate change and human activity on environmental degradation in the study area. The other aim is to identify the most influential factor in this problem. This study relies on data and satellite images using remote sensing to display the most important environmental problems and impacts in Iraq.

Key words: Environmental degradation, remote sensing, Climate change, Iraq

التدهور البيئي في العراق بسبب التغير المناخي والنشاط البشري دراسة بالتحسس النائي

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الملخص: حسب تقديرات البنك الدولي ان العراق من الدول التي تعتبر ضحية لتغير المناخ الحاصل في العالم. التغير المناخي انعكس بشكل واضح على نسبة المياه السطحية بالعراق. مما اظهر تدهور كبير في الغطاء النباتي والمساحات الخضراء. وهذا بطبيعة الحال انعكس وينعكس على الظروف البنية والاقتصادية في العراق. الكثير من الدراسات لا تعتبر التغير المناخي هو السبب الرئيس في التدهور البيئي في العراق وان النشاط البشري هو العامل الاكثر تاثير. يهدف هذا البحث الى تحديد الاثار الناجمة من التغير المناخي والنشاط البشري في التدهور البيئي في منطقة الدراسة. والهدف الاخر هو تحديد العامل الاكثر تاثير في هذه المشكلة. وتعتمد هذه الدراسة على البيانات والصور الفضائية باستخدام الاستشعار عن بعد لعرض اهم المشاكل والاثار البيئية في العراق.

1- Introduction

Environmental degradation is a process in which the natural environment is harmed in some way, resulting in a reduction in biological variety and overall environmental health. It effects by climate change and human activities (Xu, Duanyang, et al. 2011). Climate change is happening in several parts of the world. Its effects began to manifest themselves in an obvious and quick manner. Global natural disasters are caused by climate change. Climate change, drought, and water scarcity are among the most significant. Direct consequences on agriculture, food, food security, and human health are among them (Hannah, L. 2021). On another hand, since 2018, the concentration of carbon dioxide in the Earth's atmosphere has reached 407.8 parts per million, according to the World Meteorological Organization (WMO). It is roughly 47% higher than in the pre-industrial era, shattering all previous records in human history (Merlone, Andrea, et al.2019).

According to Iraq's Ministry of Agriculture, the degradation of agricultural land and environmental degradation in Iraq is because of (natural causes): drought, desertification, water scarcity, and high temperatures due to climate changes. On the other hand, human factors include inappropriate land management and irrigation systems, the construction of dams on the Tigris and Euphrates rivers, and the abandoning of farmers for agriculture due to government policies.

Many previous studies have attempted to explain why Iraq's agriculture and vegetation cover have deteriorated. As (Al-Timimi, Y. K., & Al-Jiboori, M. H., 2013) Drought frequency in Iraq from 1980 to 2010 was explored in this study. The remotely sensed Drought Severity Index (DSI) was used to assess drought trends in Iraq and determine the most vulnerable areas to these phenomena (Jawad, T. K., Al-Taai, O. T., & Al-Timimi, Y. K. 2018). Also, (Price, R., 2018) The strength of evidence in regard to environmental concerns in Iraq is uneven, according to this study, which employed a mixture of peer-reviewed and unreviewed sources. The study's objectives are as follows:

- a. What are Iraq's environmental issues?
- b. How can remote sensing be used to study environmental degradation in Iraq?
- c. How may environmental deterioration in Iraq be influenced by climate extremism and negative human activity?

2- Study area

Iraq is an Arab Asian country that was once known as Mesopotamia. Administratively, Iraq is divided into eighteen governorates and one region known as the Kurdistan Region (see Figure. 1, Table 1). Iraq has a total area of 438,317 km². Iraq is situated between latitudes of 29.5 and 37.22 degrees north of the equator, and longitudes of 38.45 and 48.45 degrees east of the Greenwich line, astronomically. Iraq borders the Turkey on the north, the Syrian on the west, the Jordan on the east, Saudi Arabia and Kuwait on the south, and Iran on the east.

Iraq is a country rich in natural resources and natural gas, with large amounts of oil, particularly in the cities of Basra and Kirkuk. This country has only one port on the coast, which is the Persian Gulf port of Basra. The Tigris and Euphrates rivers are the most important in it, with the world's most important civilizations, such as Sumerian, Assyrian, and Babylonian, located on their banks.

The desert climate has an impact on Iraq. In the months of July and August, temperatures can reach 48 degrees Celsius. Furthermore, its summer is distinguished by high temperatures. Between the months of December and April, the country receives rain. The country receives 100-180 millimeters of precipitation per year on average. Iraq's mountain regions receive the most rainfall of any region. The country is divided into three climate zones, which are as follows:

- a. The Mediterranean climate: it affects the mountainous areas of Iraq's northeastern region. The coldness and accumulation of snow on the peaks of these mountains are the most distinguishing features of the weather in these areas. The annual rainfall ranges from 400 to 1000 mm. Its summer is known as moderation, with temperatures not exceeding 35 degrees Celsius.

Figure (1): Study area .

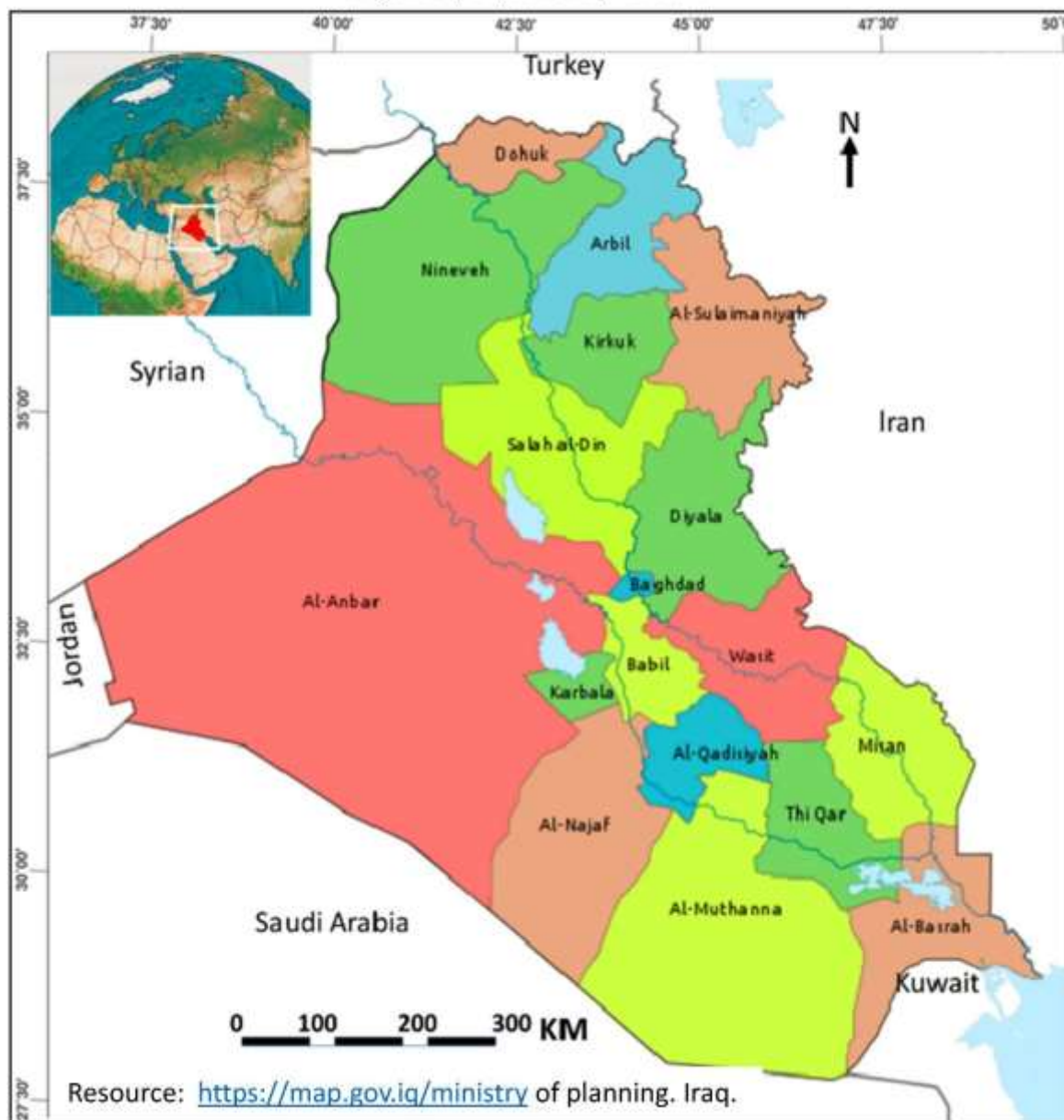


Table (1) The governorates of Iraq with their area

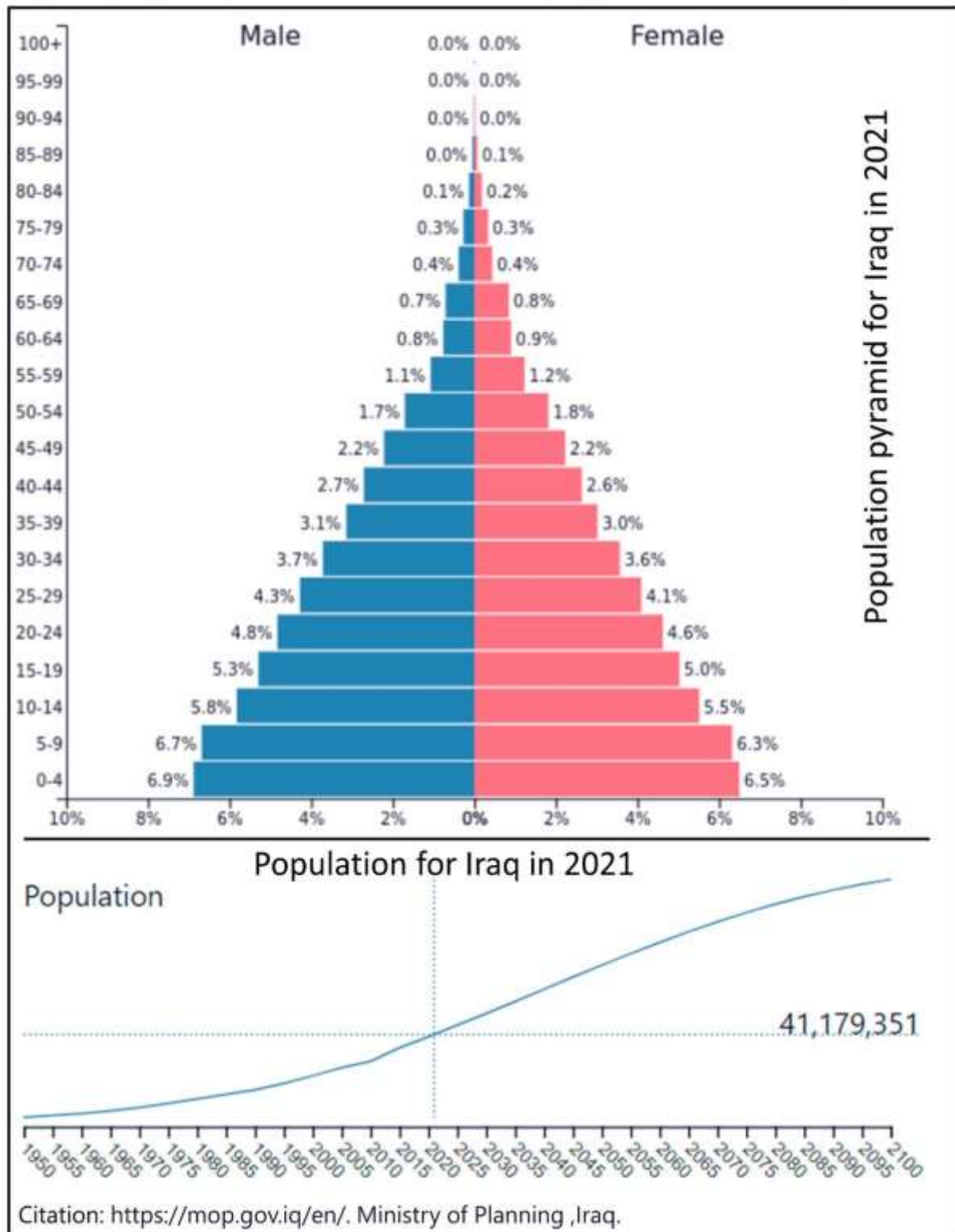
	Governorate	Population	Area km2	Districts
1	Baghdad	9,465,000	4,555	Karkh, Rusafa, madinat al-Sadr, Adhamiya, Kadhimiya, Abu Ghraib, Tarmiya, cities Husseiniya
2	Mosul	5,034,000	37,323	Baaj, Sinjar, Makhmour, Sheikhan, Hatra, Hamdaniya, Tal Afar, Tel Kaif
3	Basra	3,896,000	19,070	Qurna, Shatt Al-Arab, Al-Faw, Abu Al-Khasib, Al-Zubayr, Medina, Umm Qasr
4	Sulaymaniyah	2,492,000	17,023	Chamchamal, Dukan, Rania, Bashdr
5	Dhi Qar	2,459,000	12,900	Shatra, Rifai, suq alshuyukh, Chabaish
6	Babylon	2,364,700	5,119	Mahaweel, Musayyib, Hashemite.
7	Erbil	2,187,700	15,074	Erbil, Koysanjak, Soran, Shaqlawa, Choman
8	Anbar	2,091,000	138,501	Anah , Haditha , Hit , Fallujah , wet - Rawah , Amiriya , The Karma , Khalidiya
9	Diyala	1,848,000	17,685	Baquba , Khalis , Muqdadiya , Khanaqin , Baladruz , Kifri
10	Kirkuk	1,715,600	9,679	Daquq , Dibs , Hawija
11	Salahaddin	1,689,000	24,751	Samarra , Shirqat , Baiji , Al- Dur , Balad , Tuz Khurmatu , Dujail
12	Najaf	1,496,000	28,824	Kufa , Manathira , Mashkhab
13	Karbala	1,390,300	5,034	Tuwairej , Ain Al-Tamr, Husseiniya
14	Wasit	1,360,000	17,153	Hay , Essaouira , Badra , Numaniyah , Aziziyah
15	Qadisiyah	1,320,000	8,153	Shamiya , Afak , Hamza, Ghamaas, Al bidir
16	Dohuk	1,258,700	6,553	Amadiyah , Aqrah , Simeel , Zakho
17	Maysan	1,079,644	16,072	Ali algharbi, Almaymuna, Almajar, Qaleat salih, Alkahla
18	Samawa	875,900	51,740	Alrumaytha, Alkhudar, Alwarka', Alsalman
19	Halabja	186,000	3,060	Shahrazour, Penjwen, Sayed Sadiq , Harparaz

Citation: Iraq Population", www.worldometers.info, Retrieved 11-4-2021

- b. The Semi-arid/steppe climate: It is a climate that exists between the Mediterranean and desert climates. It has an impact on the country's northern and southern regions. Its effect on areas with ripples is highlighted. The annual precipitation ranges from 200 to 400 mm.
- c. Arid/desert climate: this climate affects the sedimentary plain and western plateau regions. It covers 70% of the total land area of the country. It becomes extremely hot; where summer and winter are mild. However, freezing temperatures have been recorded on some winter nights.

Iraqi society is regarded as one of the young societies. According to the population pyramid of Iraq (see Figure. 2) indicating that people under the age of 15 accounts for 40.5 percent of the total population. The pyramid shows the age group (15-29) in Iraq, and they are the young population according to the national definition of the population in Iraq. They constitute the second group in the number of people, which reached 40.27% of the total population. The working-age population, or those aged between 30 and 44, made up 17.8% of the total population in 2021, down from 11.2% in 2021, according to the most recent official estimates. The people of the age group (15-64) constitute 2.11% of the total population, up from 2.01% in 2021, according to the most recent official (see Figure. 2).

Figure (2): Population distribution by age and sex for Iraq in 2021.



3- Method and data:

The inductive approach was used in the study. The analytical approach is based on some Arab and international references. The United Nations, the United States Geological Survey, and the Food and Agriculture Organization all publish international reports. In addition, data from the Iraqi Ministry of Planning and the Central Statistical Organization, as well as data from the Ministry of Environment, are available. The data I use:

a. **Moderate Resolution Imaging Spectroradiometer (MODIS)**

Since the engineering model (EM) was finished in mid-1995, the MODIS instrument has been designed and developed. Two spaceflight units, the Protoflight Model (PFM) and the Flight Model 1 (FM1), have been completed and launched since then. Aqua was launched on May 4, 2002, and before that, Terra was launched on December 18, 1999. The MODIS instruments, which (Santa Barbara Remote Sensing) built to NASA specifications, represent the pinnacle of spaceflight hardware engineering for remote sensing. Monitors 36 spectral bands between 0.4 μm and 14.4 μm (see Figure.3) and Images entire earth every 1-2 days at 1 km resolution.

MODIS products that are relevant are: MOD11 - Surface temperature and emissivity; MOD43 - Albedo; MOD15 - Leaf Area Index (LAI); MOD13 - NDVI; Mod07 - Atmospheric stability, temperature, and vapor pressure at 20 vertical levels; MOD03 - Latitude, longitude, ground elevation, solar zenith angle, satellite zenith angle, and azimuth angle (MODIS Components, 2021).

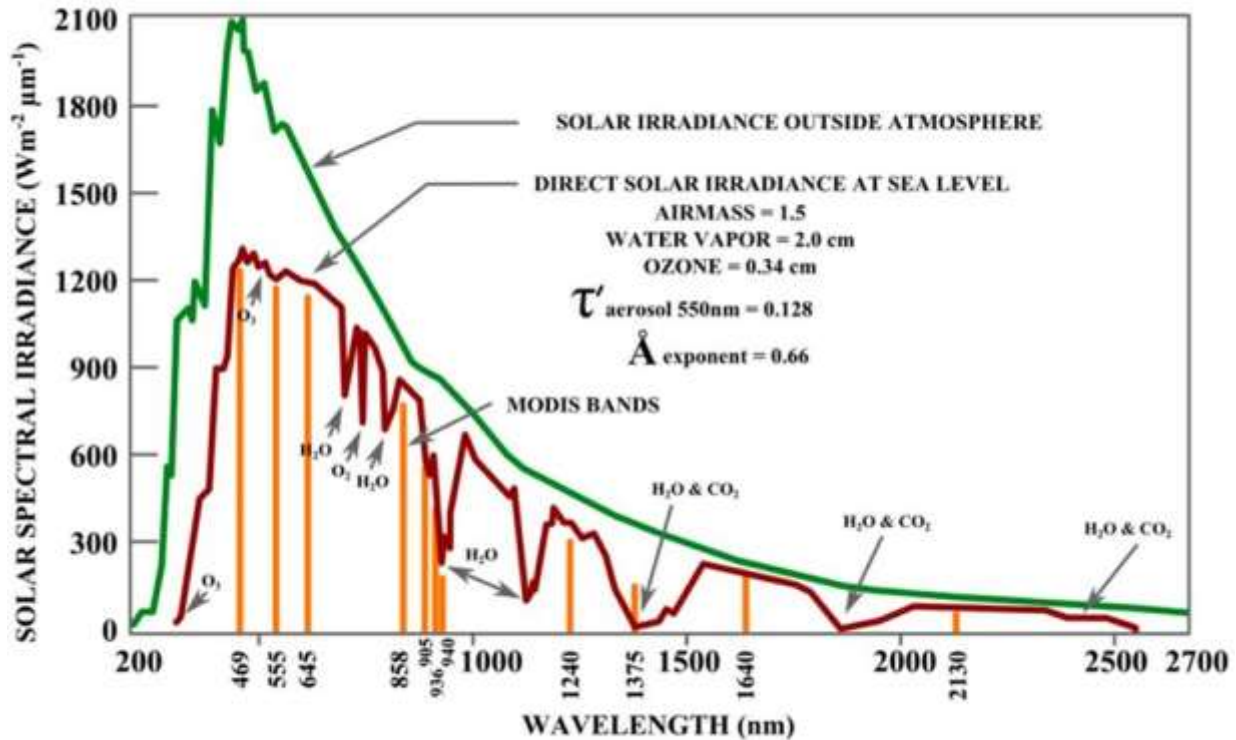
b. **POWER Data Access Viewer v2.0.0 (DAV)**

I downloaded free climate data from 1981 to 2020 from DAV. I got temperature, precipitation, humidity, wind, and many other data from 1981-2020 for Iraq. DAV is Web Mapping Application includes cloud related parameters, meteorological, and geospatially enabled solar that can be used to evaluate and develop renewable energy systems.

c. **Normalized Difference Vegetation Index (NDVI)**

We should observe the distinct colors (wavelengths) of visible and near-infrared sunlight reflected by the plants to determine the density of green on a patch of land. It helps to differentiate vegetation from other types of land cover (Eastman, J. Ronald, et al.2013).

Figure (3): Solar irradiance spectrum and MODIS bands.



Citation: MODIS Imagery, <https://modis.gsfc.nasa.gov/>

The NDVI is calculated using the following formula: $NDVI = (NIR - Red) / (NIR + Red)$, where NIR is near-infrared light and Red is visible red light (Pettorelli, N.2013).

- d. EVI : The Enhanced Vegetation Index (EVI) was designed to correct NDVI results for atmospheric influences as well as soil background signals, particularly in dense canopy areas. Healthy vegetation has a value range of

0.2 to 0.8. and EVI has a value range of -1 to 1 (Waring, R. H., et al.2006).

Formula of EVI:

$$\text{EVI} = 2.5 * ((\text{NIR} - \text{Red}) / ((\text{NIR}) + (\text{C1} * \text{Red}) - (\text{C2} * \text{Blue}) + \text{L}))$$

where NIR/red/blue are atmospherically corrected and partially atmosphere corrected (Rayleigh and ozone absorption) surface reflectances, L is the canopy background adjustment that addresses non-linear, differential NIR and red radiant transfer through a canopy, and C1, C2 are the coefficients of the aerosol resistance term, which uses the blue band to correct for aerosol influences in the red band. The MODIS-EVI algorithm employs the following coefficients: L=1, C1 = 6, C2 = 7.5, and G (gain factor) = 2.5. (Waring, R. H., et al. 2006).

- e. The vegetation Health Indicator (VHI): Drought of Iraq was studied using the Vegetation Health Indicator (VHI), a remote sensing index. VHI=

$a * \text{VCI} + (1 - a) * \text{TCI}$, where a is the coefficient that determines the contribution of the two indices. VHI is a measure for vegetative health or a combined estimate of moisture and temperature. VHI can be calculated using both the NDVI and Land Temperature Surface (LST) (Masitoh, F., Rusydi, A. N. 2019).

4. Results

4-1. Climate changes in Iraq

Iraq's environmental, economic, political, and security issues are being exacerbated as a result of climate change. Iraq's agricultural industry has been weakened by rising temperatures, declining precipitation, desertification, severe droughts, salinization, and the growing frequency of dust storms (Hassan, K., Born, C; Nordqvist, P. (2018).

Furthermore, climate change, such as rising temperatures, less precipitation, and increased water scarcity, will almost certainly have long-term consequences for Iraq's state. In this study, I focus on rising temperatures as well as declining precipitation.

- Rising temperatures: Iraq's winters are also brief and cold, and summers are long, hot, and dry. The hottest months of the year are June, July, and August. the coldest

months of the year December, January, and February. In Iraq, average temperatures range from 29 degrees Celsius in July and August to below 4.4 degrees Celsius in January and February (Table 2, see Figure. 4). Central Iraq's July temperatures exceed making it one of the world's fastest-warming locations. It presents a dismal picture of global climate change in the future (world bank. 2019).

Even though temperatures in neighboring countries are similar, they are the highest in Iraq. Because the infrastructure has been destroyed and is no longer capable of absorbing all of the climate extremism. Iraq is one of the most vulnerable countries to climate change.

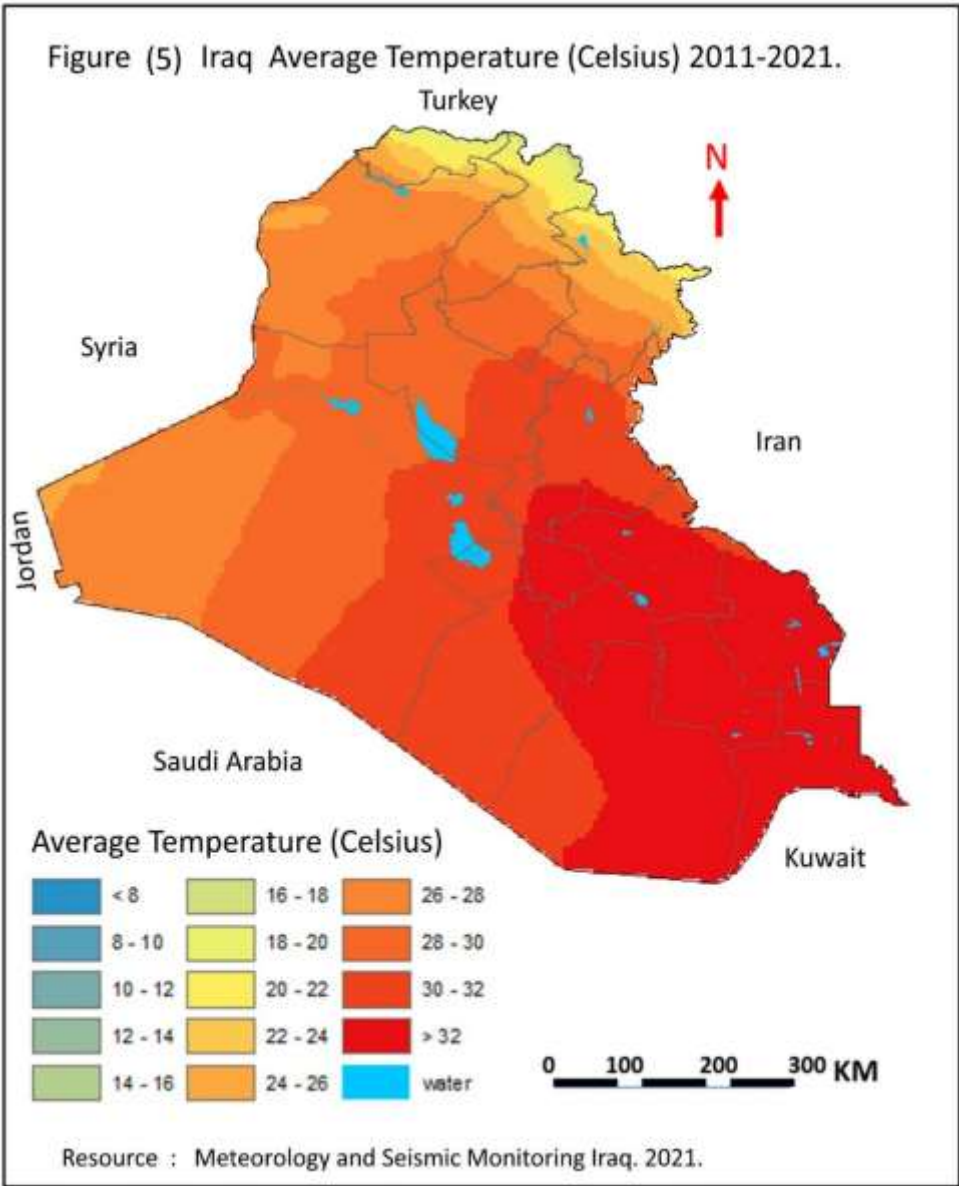
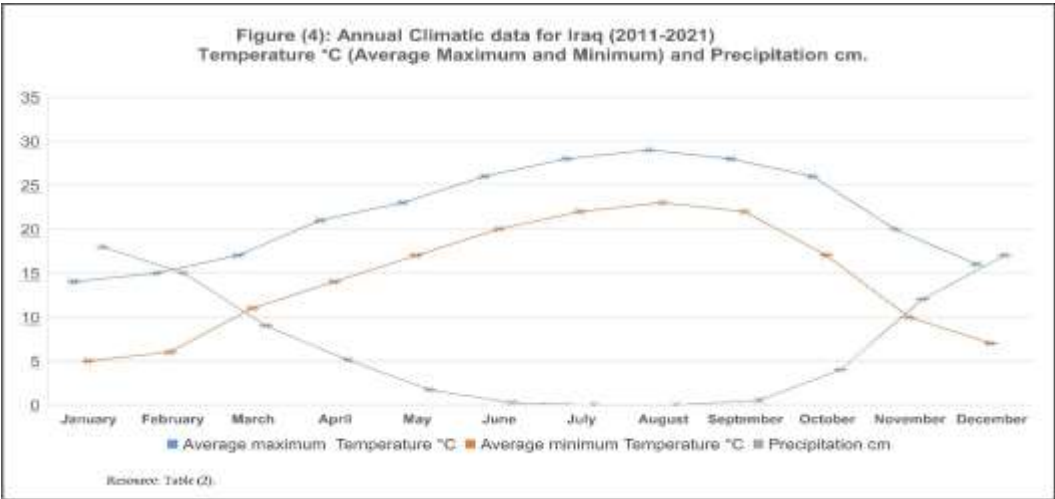
The drought is severe and prolonged, with higher-than-average temperatures, fluctuating rainfall. All of this resulted in the annihilation of agricultural crops and the drying up of vast swaths of land.

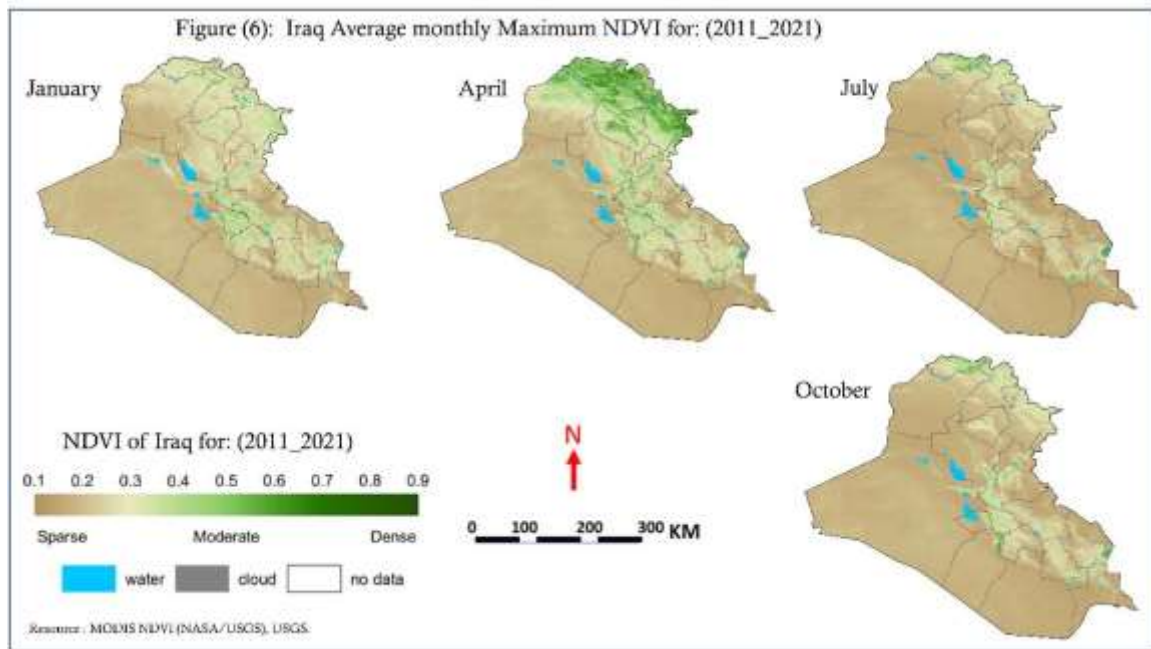
Temperatures gradually rise as vegetation declines. In figures 4 and 5, show the spatial and temporal temperature distribution in Iraq, and figure 6 shows the spatial and temporal vegetation distribution in Iraq which has an extremely high correlation. We see that vegetation grows at the same season of the year when temperatures are low or moderate, which is normally be in Iraq's northeastern regions. On the other hand, in locations with high temperatures throughout the year, such as the south-southwest, we find that vegetation cover declines. Finally, we discover that temperatures have a significant impact on the regional and temporal distribution of vegetation cover. This means that the climate in Iraq is harsh, particularly in terms of high temperatures, and that solar radiation plays a significant role in environmental degradation.

Table (2): Annual Climatic data for Iraq (2011-2021)
Temperature °C (Average Maximum and Minimum) and Precipitation cm.

The month	January	February	March	April	May	June	July	August	September	October	November	December	Annual rate
Average maximum Temperature °C	14	15	17	21	23	26	28	29	28	26	20	16	22
Average minimum Temperature °C	5	6	11	14	17	20	22	23	22	17	10	7	15
Precipitation cm	18	15	9	5.1	1.7	0.25	0	0	0.5	4	12	17	82.55

Resource : General Authority for Meteorology and Seismic Monitoring Iraq, 2021.





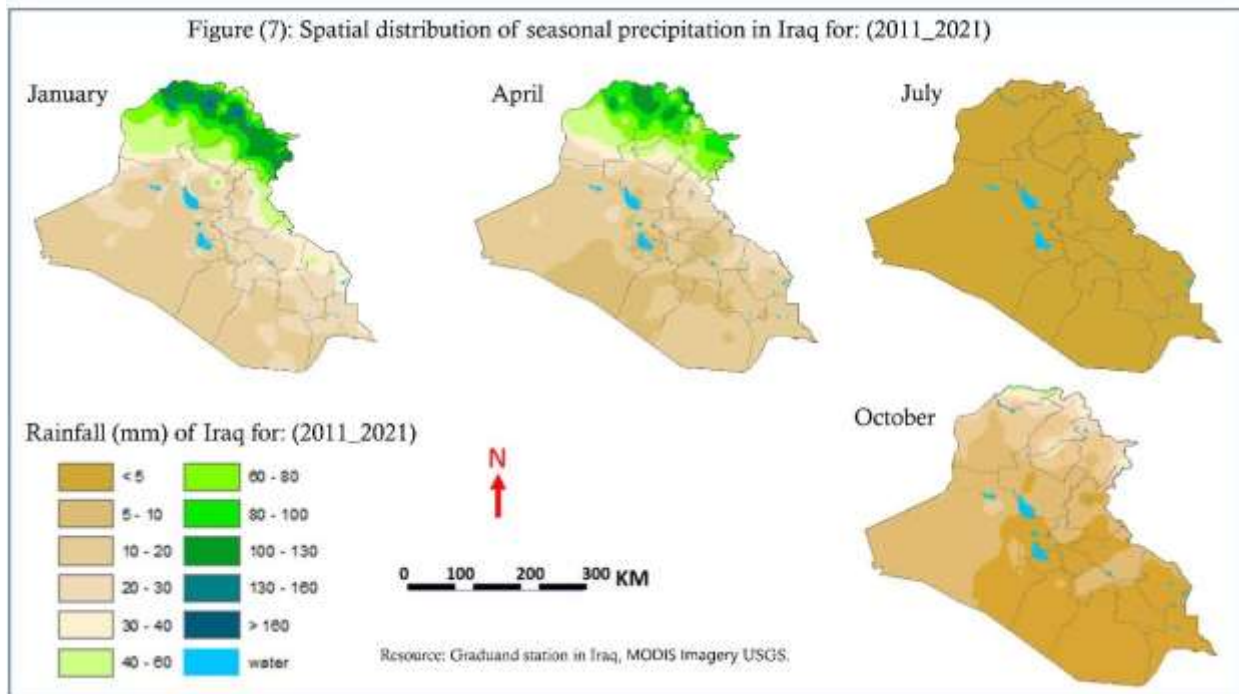
4.1 Declining precipitation.

Between November and April, and December and March, nearly 90 percent of the annual rainfall falls. Rain is uncommon in the remaining months, particularly those with high temperatures, such as June, July, and August. Except for the north and north-east, data from stations in the foothills of the mountains, the plains of the south, and the south-west of the mountains indicate that the average annual precipitation for that region ranges between 1500- and 2000-mm. Precipitation is more abundant in the mountains, possibly up to 2,600 mm per year in some places, but the terrain prevents extensive cultivation. Agriculture is limited to unirrigated land, primarily in mountain valleys, foothills, and steppes that receive 700 millimeters of rain or more

per year. Even in this region, only one crop can be grown per year, and increased rainfall frequently causes crop failure.

There is a spatial correlation between precipitation (as shown in Figure 7) and vegetation cover (as shown in Figure 6). We can see an increase in vegetation cover in the northeastern regions of Iraq, which receive a lot of rain, as well as around riverbanks that rely on rain and snow in the Tigris and Euphrates basins. On the other hand, in the arid areas, as in the western and northern regions, we see a decrease in

vegetation cover. As a result, we discover that droughts have a significant impact on the regional and temporal distribution of vegetation cover. This indicates that drought, as a manifestation of climatic extremism in Iraq, plays a significant influence on ecological degradation.

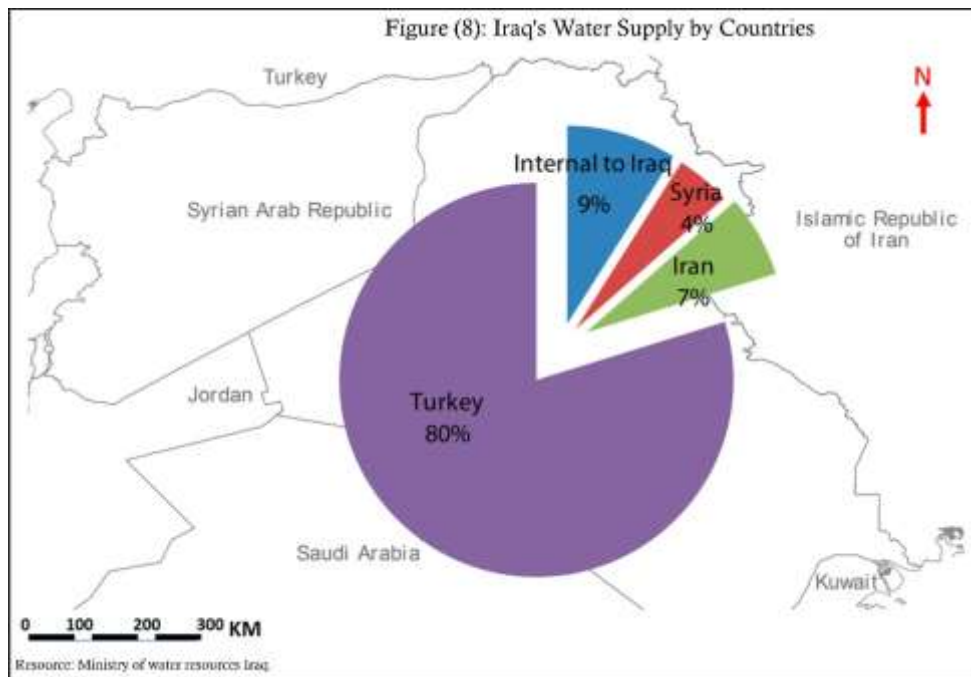


4.2- Human actives impact

First and foremost, we must realize that climate change is one of the most difficult and intractable concerns we face today, and it continues to be a puzzling subject. The Intergovernmental Panel on Climate Change (IPCC, 2014), a collection of 1,300 independent scientific experts from around the world, stated in its 5th Edition that there is a more than 95% possibility that human activities during the last 50 years caused global warming (IPCC, 2021). True, better water, land, food, and energy management will reduce costs and increase benefits for humans and the environment; however, we still need to learn more about the complex dynamics of these systems and their feedback mechanisms. Human-made greenhouse gases including (CO_2 , CH_4 , and N_2O) have contributed significantly to the observed increase in Earth's temperatures during the last 50 years (IPCC, 2021). Iraq's environmental degradation is being exacerbated by two major human-caused issues:

1- water scarcity: Climate change, while not the only cause of water shortage, causes less rain for agriculture and deterioration of the quality of freshwater reserves due to the inflow of saline water from the Gulf into freshwater aquifers and higher pollutant concentrations. Iraq's water security is predicated on the Tigris–Euphrates Rivers system, which is deteriorating. The 2020-2021 rainy season in Iraq was the second driest in the last 40 years, resulting in a 29% and 73% decline in water flow in the Tigris and Euphrates, respectively. Unsustainable resource construction projects (such as hydroelectricity, dams, and water diversion systems among river basins) have a direct impact on Iraq's hydrological systems. Additionally, excessive decrease and improper use of water from natural sources in traditional agriculture in Iraq have led to the destruction of various streams and wetlands.

Turkey, Iran, Syria, and Iraq all share the Euphrates-Tigris Basin. Unilateral irrigation plans that affect river flows, dam construction, and political disputes between countries have strained relations in the basin. Disputes have made it impossible for the three countries to successfully co-manage the basin's rivers. Despite increasing cooperative efforts in the 2000s, no official agreement on basin water management has been reached (climate-diplomacy.org, 2021), (as shown in Figure 8).



2- Iraq's political and governmental achievements:

The following are examples of government performance issues in Iraq, as well as their impact to environmental degradation (World Bank,2019):

1- The difficulties of policies and legislation, exemplified by a high volume of imports at the expense of domestic products and a lack of investment in the agricultural sector, particularly infrastructure projects.

2- Qualitative issues are illustrated by the use of rudimentary agricultural technologies and the lack of rivalry between local food commodities and their imported counterparts.

3- Wars: Iraq is remarkable in the number of wars that have ravaged it, and this has had a noticeable impact on the environment. These wars were:

- Iraq & Iran War (1980–1988)
- Gulf War (1990–1991)
- Iraq War (2003–2011)
- War in Iraq (2013–2017)

The Iraq wars have had an impact on the environment in:

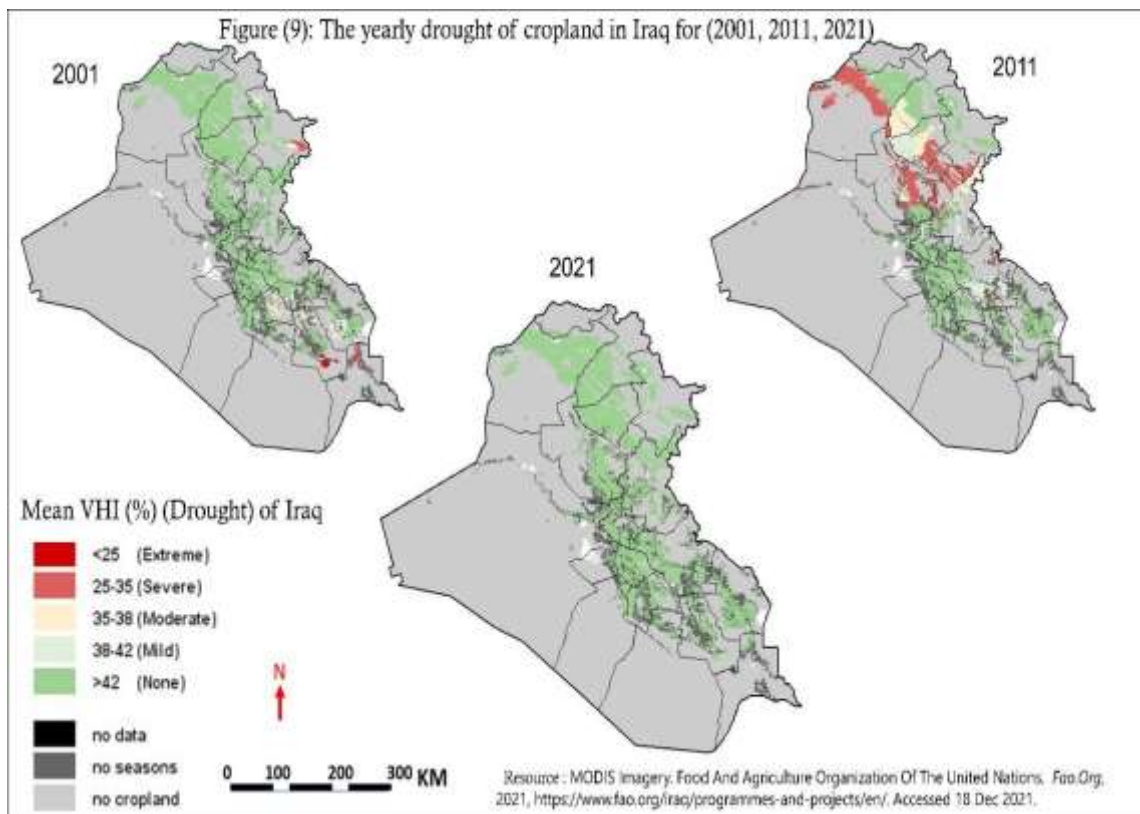
1- Oil, sulfur, soot, and acid rain rained down from as far as 1,900 kilometers (1,200 miles), poisoning the animals and vegetation, contaminating the water, and choking the people. Nearly half a billion tons of carbon dioxide were emitted by burning oil fields (Dixon, M., & Fitz-Gibbon, S. 2011).

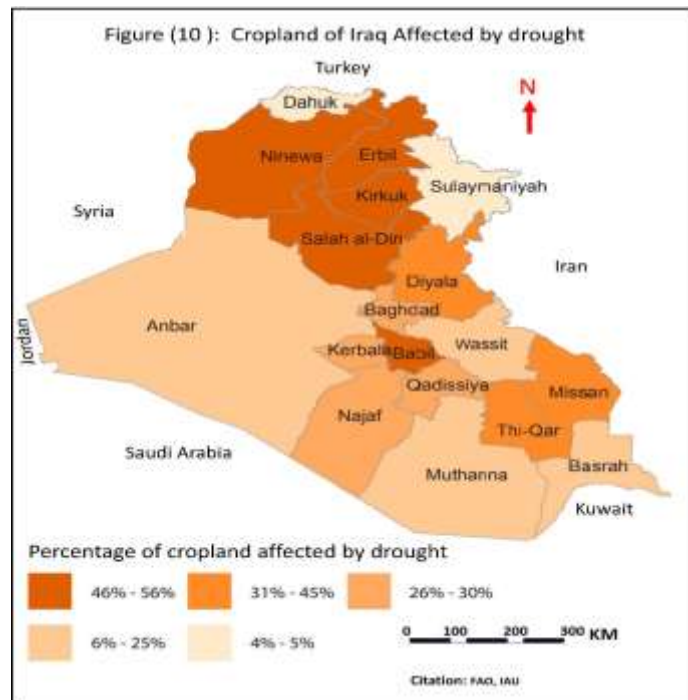
2- Wars have an impact on the environment because the weapons and military equipment employed in hostilities leave environmental legacies. Land mines, cluster munitions, and other explosive remains of war can restrict access to agricultural land and damage soils and water supplies with metals and harmful energetic elements, limiting access to agricultural land (CEOBS, 2020).

5-Discussion and conclusion

The degradation of Iraq's environment and agricultural land is caused by a combination of natural and human factors, including drought, retreating water, high temperatures, climate shifts, and bad land management. The deterioration of Iraq's habitat is the result of land degradation in a semi-arid climate zone. According to recent studies, degradation has reached 39% of Iraq's area, with the remaining 54% under threat.

Climate change mitigation and transnational water management will be difficult due to national and regional political uncertainties. In figures 9 and 10, show the spatial and temporal environment degradation in Iraq. The agricultural areas that were harmed by 56 to 46 percent are those where agriculture and vegetation rely on rainfall, or what is known as rainfed agriculture in Iraq. The incidence of damage in places that rely on irrigation agriculture on the banks of the Tigris and Euphrates rivers ranges from 46 to 31 percent. That means climate change, human activity, and water management all play a role in the deterioration of the environment in Iraq.





Iraq's environmental difficulties pose a serious threat to the country's Environment. Addressing them is the responsibility of all

executive and legislative state entities, not just the Ministry of Agriculture and Environment. The study conclusions are summarized as follows:

- 1- Remote sensing analysis, if properly utilized, has the potential to significantly improve human growth and environmental sustainability goals.
- 2- Environmental degradation is a symptom of global processes that endanger the globe, such as desertification and drought caused by global warming and climate change.
- 3- Iraq's rising population expansion has put a strain on natural resources and the environment.
- 4- Exacerbation of the salinity and water scarcity problem as a result of neighboring countries' policy, particularly Turkey's, of constructing massive dams in contravention of international law.
- 5- Environmental degradation is the result of current and prior regime practices such as draining

marshes and water bodies, chopping down millions of palm trees, and burning oil wells in the south.

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