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Ecological drought consequences on sustainable development in Iraq

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Abstract

This study is aimed to analyze the spatiotemporal changes of drought in Iraq . Drought is one of the dangerous ecological phenomenon .That earth planet has been suffering since ancient times from ecological challenges such as drought , which have adverse effect on mankind activities and its damages are reflected on sustainable development ; economically , socially and ecologically, where its severity has recently increased. Iraq is considered the fifth country in the world in suffering of drought consequences , therefore, this research was prepared to analyze the ecosystem factors which related with drought, such as weather with a historical dimension at over the past and currently in Iraq through verification about of the weather features such as a temperatures and rainfall over half a century, for the period between 1970 -2020 . Where is proved from spatial analyze , it was the southwest and south region of Iraq are severely affected by drought due to the lack of rainfall and the temperatures rising . This study showed through temporal analyze of weather through the monitoring data in Iraq according to the (SPI), that is referred the warming is rising +2.1°C through 50 past years . Where this rise continues from 1998 until 2020, , with a linear regression of R2 = 0.7084.And there was an anomaly in the average of annual rain fall between 1970–2020. As The results is revealed the reduction of rainfall by −84 mm through the past of 50 years ,that precipitation began in decreasing continuously from 1998 until 2020 , with linear regression R2 = 0.1957. This is considering an indicators of climate change , where the drought is one of its repercussion ,which requires adapting with it ,by creating the solutions ,including changing of the mankind systems activities for reducing greenhouse gas emissions by resorting to renewable energies.

Keywords:Drought, (SPI), Sustainable development, consequences ,Iraq.

Introduction

The ecosystem is undergoing many climate changes such as drought , it is a recurring global environmental status occurs in different periods represented by temperature rising and less rainfall than its average, which causes a shortage of water resources. Drought is the lack and fluctuation of rainfall in temporally analyses , and it is an ecological al phenomenon that occurs in certain areas rather than others in spatially analysis , the falling rainwater is the main source of all types of water resources, that scarcity of water resources in the biosphere are reflecting on all types of water sources, whether surface or groundwater and others . Drought has consequences on the ecosystem and on all human activities, including agriculture, which harms the local and national economy. And that the length of the cycles of heat waves is the main reason for the aggravation of drought conditions dramatically by accelerating the evaporation of water and the lack of condensation of clouds and the loss of thermal balance. One of the results of drought is the emergence of arid and semi-arid areas such as deserts and barren lands .That the prolonged of drought is causing a humane disaster and migrations . More arid regions are characterized by less productivity. The causes of the eco-drought phenomenon can be

explained in two cases as either a natural disaster or due to human activities [1]. The severe shortage of water resources which is getting by drought at the level of the biosphere due to the lack of rainfall, and its decreasing from natural precipitation rate during a certain period of time has great consequences for all human activities, which is reflected by fundamental form in causing great lose in agricultural production , and is generating poverty , famine and migration farmers . Iraq is geographically located in arid and semi-arid regions, and many researches have proven that Iraq is characterized by an extreme climate that is unstable and suffers from drought , and that this suffering is in constant increase, and its impact will be more in the future if the frequency of the decrease and fluctuation of annual rainfall and the temperature rising . Therefore, it requires activating the work of meteorology with modern techniques such as remote sensing technology ,working with international space agencies for monitor the drought situation in Iraq, to predict extreme weather , and opening a information bank registry for data related with weather , that to stand with the problem and adopt solutions to reduce its impact on sustainable development. In order to able the researchers for clarify the main factors and indicators causing it , classify the types of drought , formulate integrated management of water using to reduce their depletion, and interacting with global and regional academic institutions in implement scientific researches and benefit from previous researches and studies on each levels , globally ,regionally and nationally levels about drought [2,3]. In Iraq , nearly of 90% of the annual precipitation occurs during the November to April months , and more of the rainfall is getting during December - March in the winter months , as for the six months of the year remains suffering from drought during June - August [4]. The scarcity of rainfall and heat intense heat convert more of the land in Iraq to desert , semi-desert and barren from vegetation cover , so severe dust storms prevailed from the far north to the far south due to very high evaporation rates, where the land and plants lose the little moisture very quickly that is obtained from rainfall , and plants cannot In a dry weather withstand then complete their life cycle, so they will become extinct and biodiversity is affected . Although the valley of the Tigris and Euphrates rivers was the main source of water for all Iraqi human activities including agricultural production, where continuity their flowing directly is related by food ,security

where thy are currently suffering from their water scarcity due to the limitation of their flow by its upstream source countries (Turkey, Iran, Syria), which has become a major challenge in achieving .[agricultural development [5

A study, in Iraq for analyze the characteristics of drought according to the information which is documented of climatic data for 10 by meteorological stations for period 1980-2011

by using the method of SPI for 9 and 12 month of time scales to study then analyze the drought , where concluded that each of following years 1999 and 2008 then 2009 were characterized by the most dry years in all parts of Iraq at different period scales. Whereas, a results of the SPI index for a period of 9 months showed that the station of Mosul is experienced more severe drought . Also northern Iraq is subjected to severe drought during a period of 9 months by comparison with other areas . While Baghdad and Al-Diwaniyah cities are experienced the drought by highest degree depending up on to the SPI index for a period of 12 months, the drought in these areas reached more severe stages with the two types of agricultural and hydrological droughts respectively [6]. Studying drought characteristics helps to assessment of all water types management where it will give an explanatory dimension to the potential effects in changing of climate in the future. For this reason, numerous studies and research are presented on indicators of drought analysis and assessment depending on its factors, causes and consequences, in the United States the Palmer Drought Severity Index(PDSI) is used widely, in the China is used the Z-Index(CZI) by the Center of the National Meteorological , That utilized in this study the Standard Precipitation Index(SPI) , for its simplicity

and according to the type of data available needed for analysis [7]. A study in Portugal for comparison between (SPI) and (SPEI)I in period for months 9 and 12 between semi-arid, semi-humid and humid sites ,where observed that the two indicators have given similar results for the same period scales about .[occurrence of drought and its seriousness [8

Drought is considering an impactful ecological event on agricultural, economic especially , after a long period the drought is appearance without rainfall , but it is not possible to determine its onset and extent then the end. So , it is not easy to determine its characteristics in terms of ; magnitude, intensity, duration, and spatiotemporal range. For these reasons, require to developing techniques for drought analysis and its monitoring [9.10].The (SPI) currently is one of the better drought indicators which are more applied than others in estimates of drought cases within the spatial and temporal range. The chief advantage of the (SPI) its enables to the determination of drought conditions on variance period scales and in any place. Therefore, the monitoring of the different types of drought is considering one of the first efforts in ecosystem under different environmental conditions at a time when the demand for water increased by calculating its values through testing drought indicator by temporal and spatial scales. [11].

Materials and Methods

This study was carried out in the Department of Water Resources - Technical Institute / Mosul - Northern Technical University . for the purpose of studying the drought situation in Iraq , that its study depends on different indicators which can be evaluated through its applications , all of which depend on rainfall rates that are the most different among other variables such as temperature, evapo-transpiration, hydrological drought, agricultural drought and others. That was used the indicator of standard precipitation Index (SPI) to study the drought based on the difference in the amount of rainfall. As for the Palmer drought index, it is used to determine the lack of water in surface water as rivers …etc. for a long time scale . The (SPI), designed by researcher (McKee et al, 1993) at the University of Colorado, is one of the important method which is more using as indicator for the drought in the world. It has been designed on the basis that every part of the water resource systems is affected by the lack of rainfall, so, it is relied on the temporal change of the rainfall. This allows evaluating and studying drought cases then benefiting from them in developing plans to manage water resources and devise solutions for adaptation and limiting its damage. Where the time series of rainfall and temperature in Iraq for a period of half a century for between (1970-2020) was used to calculate (SPI) and drought indictor(index) (DI) by using as the following equations :

1-SPI = Xi - x̄ /s
x

Where :**SPI** represent of Standard Precipitation Index**. X i** :Total rain during the month (ml), **x̄**: The arithmetic mean ,**sx**: Standard deviation , the equation as mentioned by **[12]**.

2- D I = P / T+10

Where :D I represent of Drought indicator , P: Average of annual rainfall ,T: Average of annual temperature ,the equation as mentioned by **[13]**.

Results and discussion

Environmental disasters such as drought are a transboundary phenomenon which has an impacts on planet in different places and times, but drought frequency has increased in recently due to natural and anthropogenic reasons where obtained the lack of surface run-off , and the depletion of many wells & springs .That the prevalence of dry weather for a long or short period impacted on the human, animal, and plant needs for water. However, its sudden and unusual occurrence in non-desert areas attracts attention because of its dire consequences on sustainable development, so it calls for studying and identifying its causes and consequences resulting from it to devise solutions to limit its damage. Where drought is a concept that indicates the prevalence of dry weather for a certain long or short period of time in different parts of the globe, so that the continuation of this condition leads to the failure of human activities to meet the need for water, and among its signs the land appears yellow and dry with no runoff and the depletion of many wells and springs. And the expansion of aridity and desertification. The aridity (permanent drought), which is purely climatic criteria resulting from the great water deficit or its depletion, can be considered as the prevailing situation in the desert areas .While climatic drought means that the amounts of rain falling on a particular area are less than the normal amounts, as this is linked to high temperatures and the rate of evaporation, and climatic drought can turn into a form of permanent drought, such as what occurs in desert and semi-tropical areas in the winter, or It can be occasional dryness at intervals .While hydrological drought is a severe shortage in water resources, as a result of the lack of rain, in which a significant decrease in the flow of valleys and in the level of underground water is noted from the normal level, and it ends with the drying out and depletion of wells and springs , and this type of drought is closely related with the climatic drought. , because a large deficit in the amount of precipitation results in a decrease in the surface and groundwater resources. While agricultural drought is the result of the scarcity of rainfall or fluctuation due to a heterogeneous distribution between the seasons of the year, that agricultural drought is not determined by the quantity of rain falling , but by the seasonal distribution of rainwater , agricultural drought also has a close relation with climatic drought, the decrease in the amounts of rain for a long time leads to depletion in the water stock , The land is lose its water then the soil dries up over time, which causes to plants wilting and die, the severity of agricultural drought and its effects on agricultural crops is happening according to the type of climate and according to the season of occurrence of drought , but its greater impact is getting on the winter crops which are sowing in the rain-fed way in northern of Iraq, as happened in Iraq during the past two years 2020/2021 & 2021/2022 without any crop harvesting and production, which has an impact on Iraqi food security for one reason is represented by drought, so it is necessary to adapt to the drought situation and formulate solutions to reduce its negative effects. Among the causes of drought are the scarcity of rain that falls during a certain period of time, the increase in evaporation rate, the increase in the coldness of the Earth in the northern hemisphere, the rise in temperatures as a result of recurring heating waves in the sites of hurricanes or high pressure systems. The consequences of drought as follows ; failure to achieve food security by low yield of agricultural production in both plant and animal side , soil erosion, poverty and famines , Destruction of the original habitat of animals and plants, which affects the ecosystems on land and in water resources , causing the extinction of biodiversity, malnutrition and the spread of some human diseases . mass immigration and fires erupting in forests due to temperatures rising .The issue of climate change is considering a global challenge and a transboundary phenomenon in the ecosystem [14]. Where measurements of air temperature and precipitation rates are among the most important criteria for assessing atmospheric variables, which can be used to understand the climate of any region and assess the effects of climate change [15,16]. So drought is the occurrence of an emergency event of a deficit in water resources in general in a certain area and during a specific period of time, which leads to water scarcity , and a significant decrease in its quantity in various sources of water resources ,which has

adverse effect on the needs of various mankind activities. The United Nations Environment Program is classified Iraq as the fifth vulnerable country in the world due to a decrease in water and rising of temperature , which has a negative impact on achieving the sustainable development ; ecologically, socially , economically (UNEP 2017). This is confirmed by this study. The results revealed that the average of annual temperature which recorded in Iraq for the period 1970-2020 it is trait by fluctuations through the second half of the twentieth century and was less than the general average. Since the mid-nineties until now, the average of temperature began is rising high of the general average in Iraq, which . On the other hand, the average of rainfall has decreased in Iraq, and this has been evident since 1998 . The present study is an step towards understanding of weather assessment through scientific analysis of temperature and precipitation in Iraq . Which is important in analyzing the causes, types and consequences of drought, whether it is a climatic, hydrological or agricultural drought. Moreover, in Iraq the adaptation and mitigation plans which will be implemented under the Paris Agreement have therefore been prepared. The study results can help to implementation of scientific approaches derived from research in identifying trends and contexts and warding off risks in developing solutions to reduce drought damage. As the study of temperature and precipitation based on scenarios over the years contributes to preparing approach to assess drought . We conclude from the research that climate change and drought are a global characteristic in general and the Middle East region in especially form including Iraq , it was found that drought is one of the intense ecological status that often occur periodically by a decrease in rainfall due to the varying climatic conditions such as heat, wind, relative humidity and variance in dates of rain due to global warming and climatic changes that have recently occurred on the earth planet. There is a prediction that the consequences of drought will worsen. However, the assessment of drought has become a complex practical and scientific matter because of the interrelationship of its intertwining factors . The study showed, as a result of monitoring the weather conditions in Iraq, that there was an exacerbation of the climate change situation for the years (1998/1999, 2007/2008) due to the drought which is covering about 85% from area of Iraq , as the results is referred that the drought was more severe in central and southwestern Iraq by the comparison with southeastern and northern Iraq **[7,17]**.

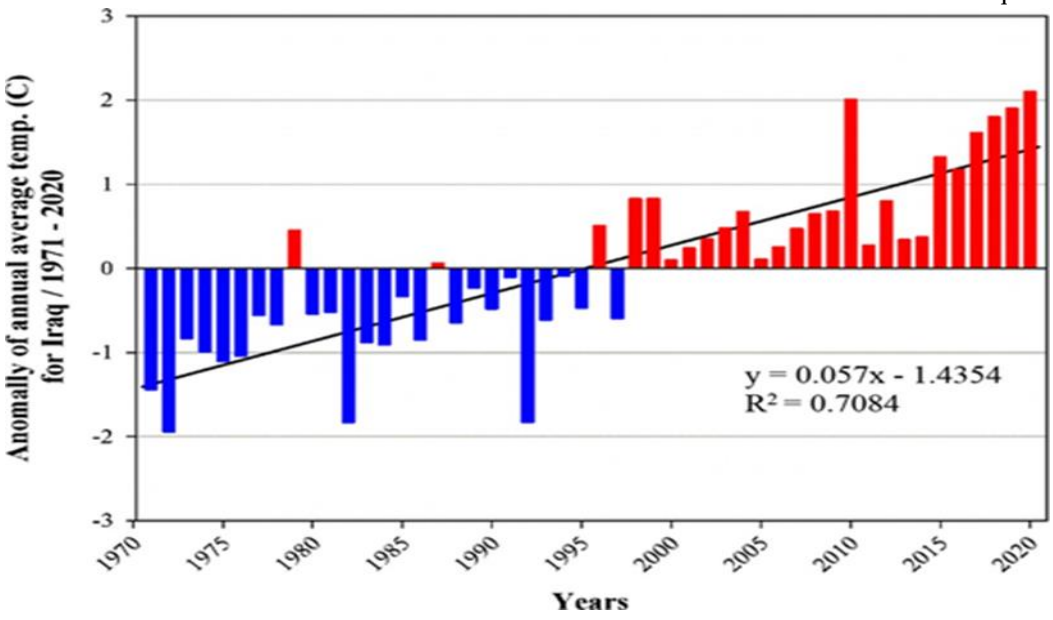


Fig.(1) Anomaly of annual average temperature during 1970–2020 Source / General Authority for Meteorology and Seismic Monitoring / Iraq

Fig. (1), is indicating to the anomaly of annual average temperature in Iraq for period 1970 - 2020. That is getting an increasing in temperature by +2.1°C through the past 50 years , the heat rose

began in continuously from 1998 - 2020, by comparison with the climatic during 1970 - 1995, with a linear regression of R2 = 0.7084.

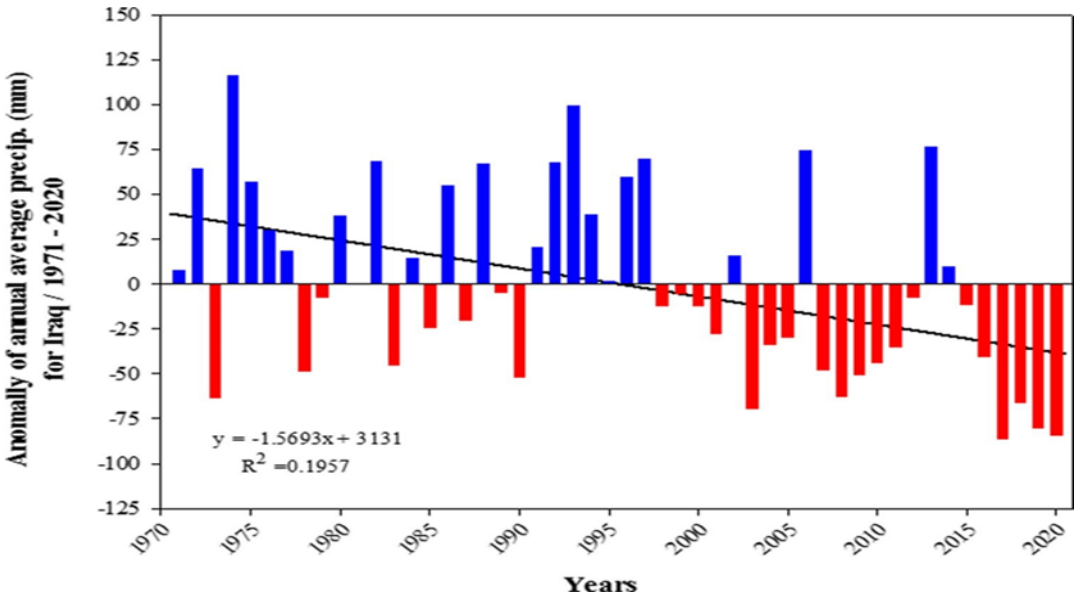


Fig. (2) Anomaly of annual average precipitation during 1970-2020 Source / General Authority for Meteorology and Seismic Monitoring / Iraq

Fig. (2), revealed to the anomaly of annual average of rainfall through 1970–2020 ,which referred to the rainfall reducing by −84 mm at the past of 50 years , the rainfall started to lowing continuously from 1998 until 2020, by comparison with the wet period (1970–1997),by linear regression R2=0.1957.

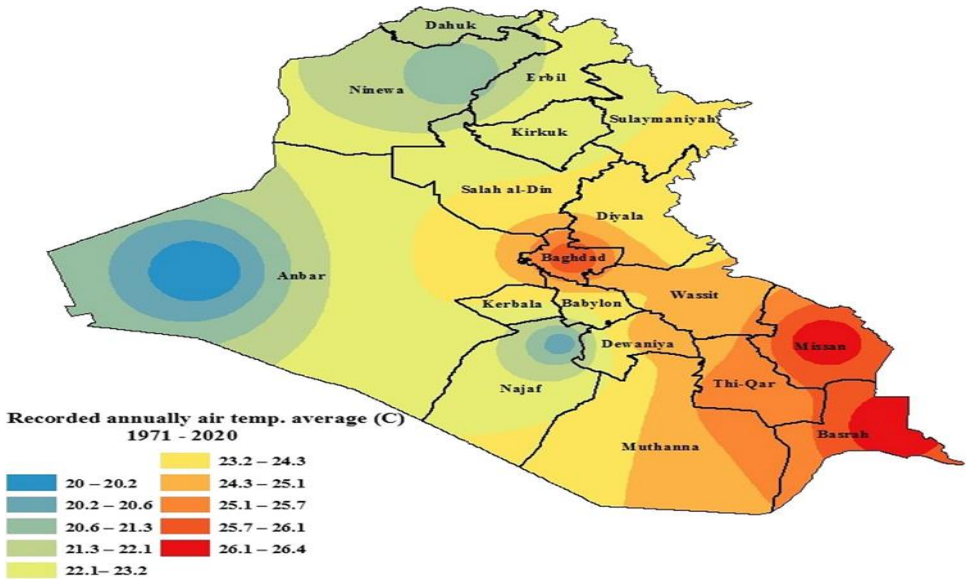
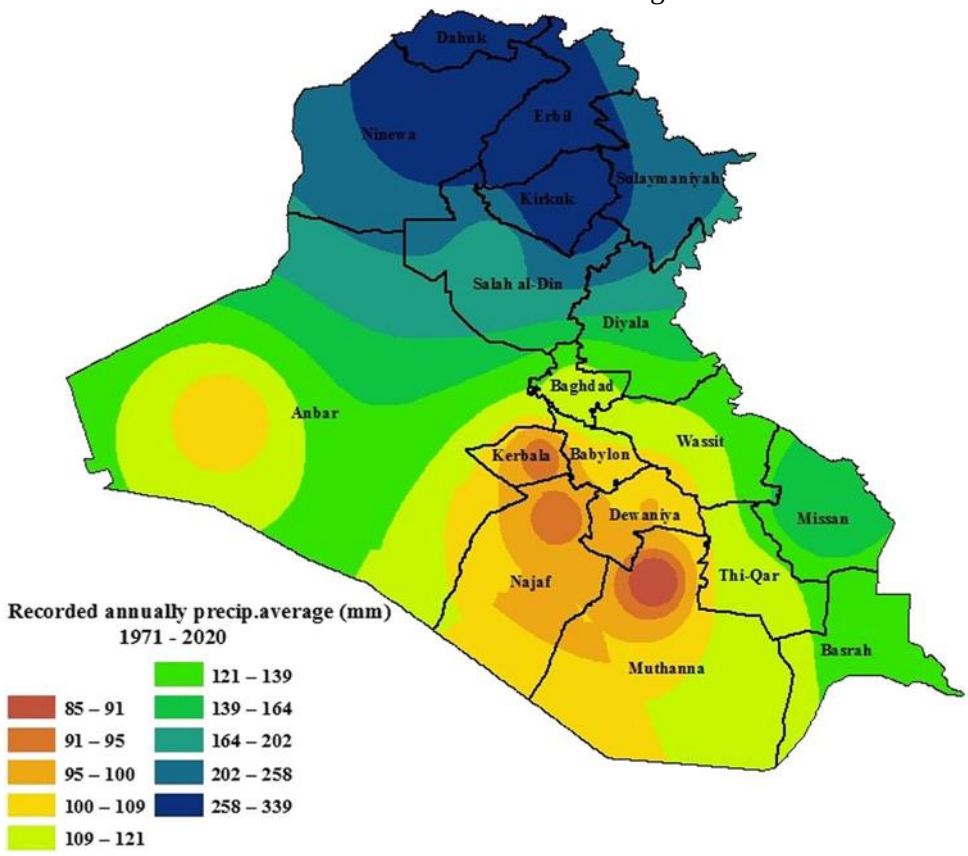


Fig.(3) Annually average of temperature in Iraqi meteorological stations from 1970 to 2020 Source / General Authority for Meteorology and Seismic Monitoring / Iraq

Fig.(3), represents the period of the years between 1970-2020 to determine the behavior of temperature. It was found that the average of annual temperature recorded in meteorological stations of Iraq ranges

between 20 and 26.4 degrees Celsius.



Source / General Authority for Meteorology and Seismic Monitoring / Iraq

Fig. (4) Annually average of total precipitation in Iraqi meteorological stations from 1970 to 2020

Fig.(4) ,is indicating to the annual average of the total rainfall for the period (1970–2020) which was recorded in the 12 Iraqi meteorological sites which ranged between 85 and 339 mm. The highest average was recorded in the northern of Iraq, in Nineveh, Duhok, Erbil, and Kirkuk, while the lowest rainfall average was recorded in south-western and western parts of Iraq in Muthanna, Najaf, and Karbala region . The study shows in temporal analysis that most rainwater gets in Iraq between November and April , where coupled this period with middle – low atmospheric , and more than 50% falls in during winter season at November, December and January by the first rank , that March and April forms second rank ,while September and October is forming in the last rank .In spatial analysis for rainwater amount falling shows the northern region occupies the firs rank and the center region is the second .where the southern is the last region. The table (1) is explain the category of climate classification according to the rainfall .

Table (1)Category of global climate according to the rainfall

SPI Value	Drought category

More than ≥ 2	Exteremly wet
1.5 to 1.99	Very wet
1 to 1.49	Moderatly wet
0 to 0.99	Mild wet
- 0.99 to 0	Mild drought
-1.49 to -1	Moderatly drought
-1,99 to -1.5	Severly drought
Less than ≤-2	Extermely drought

Source ;The researchers (Mckee et al) for SPI classification

Conclusions

The drought causes great pressure on global water and food security then is hindering achieving sustainable development in general .Iraq which is more suffering from its consequences Therefore, the Iraq is classified as the fifth country in the world at risk due to drought by United Nations Environment Program . Which shows its impact on comprehensive in all aspects of life. This is proven by the results of our study. The results revealed that the average annual of temperature recorded in Iraq for the period 1970 - 2020 was distinguished by fluctuations through the second half of the twentieth century and it was more than the general average. Since the mid-nineties until now, the average temperature started to rise above the general average in Iraq, Also, that amount of rainfall has decreased in Iraq . It is expected the climate change will be continue through the twenty-first century. Drought has severe consequences for living organisms and the ecosystem directly. We are concluding that drought consequences as the following:

1. Disruption of the state of balance of sustainable development factors , without achieving the water ,food and healthy security.

2. Degradation of water quality due to the low level of water, which helps the occurrence of eutrophication and the high concentration of toxic and polluting substances, thus increasing the pollution rate in the rest of the water sources ecologically.

3.The extinction of biodiversity in the biosphere, especially the aquatic ones, due to the decrease in the level of surface water in rivers and seas.

4.Reduction of agrarian areas and the decrease in the density of agricultural crops, and consequently the decrease in production economically.

5.Deterioration of vegetation cover, natural pastures and faltering the development of plant and animal production.

6.Spreading of poverty , famine and immigrants because of the lack of water and foods .

7.Increasing of diseases by related to malnutrition is causing by drought.

8.Lowing of electricity production, due to a decrease in the level of water in hydroelectric dams.

9. Increasing of fires intensity in forests due to drought.

Recommendations

In view of the drought that occurred in the traditional water resources, which prevailed in the land of Iraq, it requires the following:

1.Requires compensation of the water deficit by activating non-traditional water resources by recycling its by technological manners , including domestic , agricultural and industrial water.
2 .Detecting alternative water sources to mitigate and reduce drought by desalinating saline water, as in the Shatt al-Arab water, for use in irrigation and drinking, and other consumptive purposes.

3.Activating artificial rain techniques by pollinating the clouds.

4.Rationalization of water consumption in general, in agriculture, industry, domestic consumptive.

5. Refrain to use traditional irrigation canals because of the loss of water.

6.Require, the use of modern techniques such as sprinkler , drip irrigation and irrigation robots to ration water for agricultural crops.

7 .Applying the ecological agriculture program and adapting to the prevailing climate in choosing the type of agricultural crop, by cultivating crops that do not need a large amount of water in a dry environment, as in rainfed agriculture applications.

8.Intensifying the vegetation cover ,the green belt and artificial lakes ,as they have a role in reducing the atmospheric temperature , bringing rain and lowing the drought .

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