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ENVIRONMENTAL AND ECONOMIC IMPACTS OF DROUGHT IN IRAQ

Abstract

The phenomenon of drought is one of the serious environmental problems faced by large areas of the world, especially in dry and semi-dry environments and even semi-humid lands. In Iraq droughts have serious economic consequences as the post-war economy is struggling hard to ensure supplies of food.

Iraq has suffered in recent years from droughts, especially in terms of climate and hydrology alike, due to the lack of rainfall at the sources of rivers. This was caused by climate change, as well as the control exerted by the neighbouring countries (Turkey, Syria, Iran) in the supply of water flowing into Iraq, without taking into account international conventions and treaties that govern the water right.[1]

The amount of rainfall in the country was lower in 2007 than its average level in the period of 1978–2007 by 29.6% in the dry climate, and 40.1% in the semi-dry climate. With respect to drought in terms of hydrology, the annual supply of water in the Tigris and Euphrates in the 2008–2009 season was 75.8% lower than in 2004. Similarly, the supply of water in the Shatt al-Arab in the summer of 2008 was on average 79.2% lower. This had environmental and economic impacts in the form of the increased salinity of river water and reduced irrigation output, lower agricultural production and decreased density of natural vegetation, and the exacerbation of desertification and declining per capita consumption of water by the

[1] D. Kadhim, *Geostrategic importance of Iraq's geographical location in the light of new international changes: a study in political geography*, MA thesis, University of Kufa, Iraq, 2005, pp. 85–89. See also H. Al-Obeidi, *Iraq and non-Arab neighboring countries*, Baitul Hikmah, Bagdad 1997, pp. 36–37.

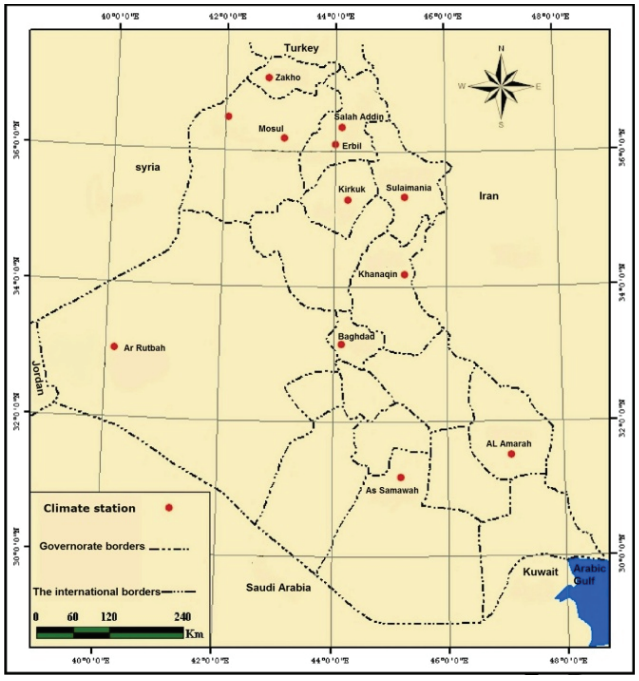
Iraqi population, which required certain procedures to alleviate these problems in the short and long term.

Keywords: drought, environment, impact of drought, economic impact of drought, drought in Iraq.

Introduction

This study research aims to analyze the intensifying drought that has occurred in Iraq, especially in the last few years, together with some of its environmental and economic implications, and the strategies needed to address it in the near and long term. This study relied on a descriptive, analytical and applied approach based on collecting data on rainfall from twelve climatic stations (Figure 1) distributed over the different climatic regions of Iraq: dry, semi-dry and semi-humid, with four sta-

Figure 1. The spatial distribution of climate stations surveyed in Iraq



Source: General Authority for Iraqi Meteorology, *Atlas of Iraq Climate*, Baghdad 1999, p. 1.

tions for each climatic region, and in the period from 1978 to 2007, as well as the application of data and other types of relevant information. The analysis focuses on the following issues:

– the nature and patterns of drought,
– the phenomenon of drought in Iraq,
– environmental and economic impacts of droughts and ways to alleviate them.

1. The nature and patterns of drought

Aridity means an imbalance between the amount of rainfall and amount of evaporation and transpiration in a certain region. It prevails in places where the amount of annual precipitation is less than the amount of evaporation. Hydrological drought is related to diminished water discharge for rivers, such that it does not provide the water needed for crops and other uses. Agricultural drought denotes insufficient rainfall and soil moisture to meet the water requirements for the growth of agricultural crops.[2] A drought can occur in different forms, as described in the following:

1. **Permanent drought.** This prevails in areas with dry weather and severe drought where the annual precipitation ranges between 25–200 mm, which are called areas of water shortage. There is insufficient water and these regions are not suitable for agriculture unless artificial irrigation is introduced, as is the case in the region of the dry climate in Iraq. This region occupies about 80% of the total area of Iraq.

2. **Seasonal drought.** This prevails in areas with a semi-dry or semi-humid climate. A surplus of water occurs for a number of months, with water shortages during other months. The duration of water deficit in the semi-dry climate is longer than in the semi-humid climate, which is located in northern Iraq (Figure 2), and the opposite occurs with the duration of the water surplus, which is longer in the semi-humid climate, lasting from December until the end of April. By contrast, the water surplus in the semi-dry region is confined to the winter months (December, January and Feb-

[2] A. Granger, *Desertification Threat and Confrontation* (trans. M. Atef, S. Amal), Supreme Council for Culture, Cairo 2002, p. 60.

ruary).[3] Agriculture that depends on rainwater is possible in both regions during the winter season, but it depends on using irrigation water in the summer season.[4]

3. **Dry spells.** These are caused by climate change and are limited to areas with humid and semi-humid climates, where they endure for a period of time, up to a number of years, when the amount of rainfall is reduced, as is the case with the drought experienced by the semi-humid region in northern Iraq and neighbouring countries over the past three years.

2. The phenomenon of drought in Iraq

Dry and semi-dry areas in Iraq extend over an area of 409,600 km^2 (94.4% of total area),[5] while the semi-humid region extends over the remaining 5.6% of the total (Figure 2). The region suffers from seasonal drought during the months of June to the end of September due to rain deficit.[6] The lack of rain in most of the territory of Iraq has prompted the overuse of surface water and groundwater to meet the water needs of agricultural, industrial and domestic activities,[7] which are constantly growing due to the rapid expansion of the population,[8] at a time where the increase in water demand is not matched by any increase in water resources. Parts of Iraq in recent years have been exposed to a dry climate owing to lack of rainfall and drought caused by low water levels in the rivers Tigris, Euphrates, and Shatt al-Arab.

With respect to the lack of rainfall, there is a general trend towards lower precipitation in the feeding areas of rivers due to climate change resulting from global warming[9] and a similar situation exists in Iraq.[10] Table 1 shows the average total

[3] A.S. Al-Maliki, A.N. Derry, *Estimate of The Water Budget Climate in Iraq*, "Basra Arts Journal" 2005, No. 38, p. 186.

[4] *Ibidem*.

[5] *Ibidem*, p. 180.

[6] Republic of Iraq, Ministry of Planning, *Environmental Statistics in Iraq Report 2009*, December 2010, pp. 6, 12.

[7] *Ibidem*, p. 3.

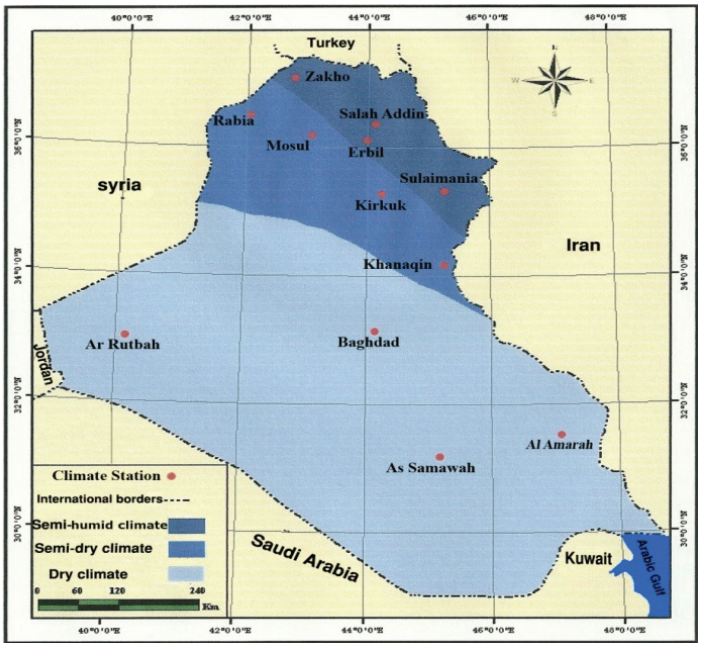
[8] A. Salih, A. Falih, *Management of corn irrigation to increase water use efficiency in middle of Iraq*, "Diyala Agricultural Sciences Journal" 2012, Vol. 4, Iss. 1, p. 63.

[9] A. Al-Maliki, K. Abdulameer, *Computerized model for the amount of rainfall in Iran for the period of 1971–2030*, "Journal of Arts College" 2011, No. 58, pp. 85–101.

[10] *Ibidem*.

annual rainfall at climatic stations that lie in the region of semi-humid climate in the north of Iraq and at plants in Zakho, Salah al-Din, Erbil, and Sulaymaniyah, in the period from 1978–2007. In 1978, it amounted to 606.3 mm, which decreased to 394.4 mm in 2007, down by 211.9 mm and a decrease of 34.9%.

Figure 2. Climatic regions in Iraq, according to the classification by Thornthwaite



Source: A.S. Abdullah, *Viability of wind to erosion in the dry and semi dry areas in Iraq*, "Basra Arts Journal" 2001, Iss. 30, p. 183.

At the climatic stations that are located in the region of semi-dry climate (Rabia, Mosul, Kirkuk, and Khanaqin), the total annual rainfall for the same period was 353.2 mm, falling to 211.5 mm in 2007, a decrease of 40.1%. For the region of the dry climate, which is represented by the stations at Rutbaa, Baghdad, Samawah and Amarah, the annual total was 122.5 mm and fell to 86.2 mm in 2007, a decline of 29.6%.

Table 1. Total annual rainfall (mm) in the period 1978–2007 and in the year 2007 in the climatic stations included in the study

Climatic regions	Climatic stations	Average rainfall in 1978–2007	Rainfall in 2007
Semi-humid	Zakho	662.9	273.5
	Salahuddin	605.4	444.4
	Arbil	429.0	272.0
	Sulaymaniyah	728.1	587.7
	Average	606.3	394.4
Semi-dry	Rabia	356.4	223.0
	Mosul	396.4	192.9
	Kirkuk	353.5	173.1
	Khanaqin	306.7	257.1
	Average	353.2	211.5
Dry	Al Rutba	112.5	58.4
	Baghdad	112.6	99.2
	Samawah	97.9	62.3
	Umara	167.1	125.1
	Average	122.5	86.2

Source: data based on the General Authority for Meteorology and Seismology of Iraq, Department of Climate, Baghdad 2007 (unpublished data).

Less rain results in a smaller water surplus during the wet season, which leads to a diminished surface runoff and insufficient replenishment of the tributaries of the Tigris and Euphrates.

With regard to the drought caused by low water levels in the Tigris and Euphrates, Iraq has suffered recently from a significant shortfall in the amount of water flowing in rivers, and some of its territories. Table 2 shows that the total supply of water of the Tigris and Euphrates in 2004 was 64.9 billion m^3, which dropped in 2005 to 54.6 billion m^3, and to a mean of 24.2 billion m^3 per hydrological year over the period of 2007–2008, then falling to 15.7 billion m^3 by April of the hydrological year 2008–2009. This indicates that the decline in water supply of the rivers amounted to 49.2 billion m^3, a decline of 75.8% compared to 2004. Because of the scarcity of water in the Euphrates River in 2009, 5.4 billion m^3 of water stored in the Hadsitha Dam have been transferred to the river in order to meet some of the water requirements of agricultural activities in the basin.[11] The decrease in the amount of

[11] Ministry of Water Resources, *Dams and Reservoirs*, Baghdad 2009 (unpublished data).

water flowing into the rivers Tigris and Euphrates is due not only to the lack of precipitation, but also to regulation by the headwaters states of the two rivers (Turkey, Syria, and Iran) of the amount of water flowing into Iraq. Turkey has established a series of dams and reservoirs on the Tigris and Euphrates, the most prominent of which are the dams at Keban and Kara, Kaya and Ataaturk, as well as the Southeastern Anatolia Project (GAP), which includes 13 projects for irrigation and power generation.[12] The total storage capacity of these projects is 138 billion m^3 of water from the Tigris and Euphrates.[13] Syria has established dams on the Euphrates River at Tabaqa, Tishreen, and Al Tandeemi, with a storage capacity of 14.1 billion m^3,[14] and these projects have led to a decline in the supply of water to Iraq.

Table 2. Water supply of the Tigris and Euphrates in Iraq (billion m^3) in the period from 2004 to April 2009

Years	Tigris	Euphrates	Total
2004	44.4	20.5	64.9
2005	37.0	17.6	54.6
2007–2008	15.9	8.3	24.2
2008–April 2009	10.7	5.0	15.7

Source: Ministry of Water Resources, *Dams and Reservoirs*, Baghdad, 2009 (unpublished data).

Iran has also created a series of dams on the headwaters of the rivers Zab Al-Sakhir and Diyala, as well as dams erected on the river Karun and Karkheh. It has furthermore diverted a number of streams of rivers close to its border, as in the cases of the Sirwan, and Qurato, Al Wind, Kenjang, Al Teeb, Dwiridj, and Karkheh rivers, as well as diverting the course of the Karun river towards the Bahmanshir canal, which ends up in the Arabian Gulf after it pours into the Shatt al-Arab, and provides it with water at a rate of about 15 billion m^3 per year.[15] The result was a decline in

[12] A.I. Bagls, *GAP, Southern Anatolia project*, Istanbul 1989, pp. 50–60.

[13] H. Al-Obeidi, *Iraq and non-Arab neighboring countries*, Baitul Hikmah, Bagdad 1997, pp. 36–37.

[14] S. Mukhaimar, H. Khaled, *The water crisis in the Arab region*, Series of World of Knowledge, No. 209, Kuwait 1996, p. 27.

[15] S.I. Kubba, *Iraq's water-the reality and treatments, the Ministry of Planning and Cooperation Development*, Baghdad 2008, p. 2.

the supply of water for the Tigris River Shatt al-Arab: the rate of water supply of the Shatt al-Arab in the period from 1990 to 2000 was 643 m^3/s but this decreased by the summer of 2008 to 133.7 m^3/s.[16] In other words, the annual average supply of water of this river in the period from 1990 to 2000 was 20.2 billion m^3 and fell by the summer of 2008 to 4.2 billion m^3, which meant the decrease of 79.2%.

3. Environmental and economic impacts of droughts and the ways to alleviate them

The phenomenon of drought in Iraq has led to environmental and economic effects as follows:

1. **Increased water salinity.** The reduced supply of water in the rivers of Iraq has led to an increase in their salinity: the salinity of the waters of the Tigris and Euphrates in 2007 was 1.5 times greater than its value in 2002,[17] while the average salinity in the Shatt al-Arab increased from 3.5 Ds/m in 2005[18] to 5.4 Ds/m in the summer of 2008[19] due to the lack of supply of fresh water and the penetration of salty tidal water from the Arabian Gulf. Its influence reached as far as the sub-district of Al Deer, located about 40 km to the north of the centre of Basra Governorate. The Shatt al-Arab has become unsuitable for domestic use, as well as for agriculture and livestock.

2. **Reduction of agricultural areas and low agricultural production.** Agricultural areas that rely on rainwater for irrigation, as well as those irrigated by rivers, have seen their productivity reduced. As can be seen in Table 3, the acreage of wheat in 2002 was 3,436,400 acres, but shrank in 2007 to 2,250,400 acres, a decrease of 34.5%. Its production in the first of these years amounted to 989,400 tons but decreased by 2007 to 369,800 tons, a decline of 62.6%. Although the area planted with barley that depends on rainwater reduced only slightly in 2007 from 2002, production fell by 58%, and yields decreased by 56.9%. The agricultural areas that depend

[16] O.R. Al-Lami, *The influence of marine characteristics of the Arabian Gulf on the hydrology of Shatt al-Arab*, Master Thesis, Faculty of Arts, University of Basra, Basra 2009, pp. 113, 158.

[17] S.I. Kubba, *Iraq's water – the reality and treatments, the Ministry of Planning and Cooperation Development*, Baghdad 2008, p. 3.

[18] S. Hamza, *Seasonal and spatial variation of pollution in the Shatt al-Arab province of Basra*, PhD thesis, Faculty of Arts, University of Basra, Basra 2006, p. 75.

[19] O.R. Al-Lami, *op.cit*., p. 158.

on river water for irrigation have seen the cultivated areas reduced by 60% during the agricultural season of 2008/2009,[20] leading to low agricultural production and increased imports from abroad to meet local needs.

3. **Decreased density of natural vegetation.** The density of natural vegetation and particularly natural plants, which constitute more than 75% of the total natural vegetation,[21] has decreased in Iraq. This is of great significance for grazing and the consistency of the surface layer of the soil to prevent erosion by wind. This has led to a deterioration of natural pastures and diminished fodder production.

4. **Low per capita share of the Iraqi water and increasing water deficit.** The per capita share of the Iraqi water was 1637 m^3 per year in 2000. The estimations per year for 2025 lie below the water poverty line.[22] By that year, Iraq will be suffering from a water deficit of 15.3 billion m^3.

Table 3. Agricultural areas (acres) that depend on rainwater for wheat and barley crops and production (tons) and yield (kg /m^2) in Iraq in the years 2002 and 2007

Year	Crops	Area planted (Hectares)	Production (tons)	Yield (kg/m^2)
2002	Wheat	3,436,400	989,400	287.9
	Barley	2,753,300	568,600	206.5
2007	Wheat	2,250,400	369,800	164.3
	Barley	2,682,200	238,500	88.9

Source: Ministry of Planning and Development Cooperation, the Central Agency for Statistics and Information Technology, Annual Statistical Group 2006-2007, Baghdad, pp. 71–72.

5. **Decreased production from hydropower plants.** Hydroelectric power plants represent 22% of all power stations in Iraq.[23] The most important plants are those at Qadisiyah, Samarra and Hamrin, Dukan and Darbandikhan, Al Hindia and Kufa and Bekhme. Low water levels in rivers and dams disrupt the functioning of these stations or decrease the production of electric power, so that Iraq suffers from power shortages and fails to meet the growing demand. To avoid this dangerous devel-

[20] Ministry of Agriculture, *Planning and Follow-up*, Baghdad 2009 (unpublished data).

[21] A. Al-Maliki, et al., *Geography of Iraq*, Ai Janoob Press, Iraq 2010, p. 87.

[22] An annual per capita share of fresh water of 1000 m^3 represents the water poverty line, and less than 500 m^3 per year equates to water scarcity.

[23] S.I. Kubba, *op.cit*., p. 6.

opment, which may be repeated in the future, the following recommendations should be followed, in both the short and long term. Perhaps the most important of those are:

- The need to activate the international conventions and treaties and agreements with the neighbouring countries (Turkey, Syria, Iran) to safeguard Iraq's water rights.
- Improve the applied technologies, for instance rain stimulation from cumulus clouds in the atmosphere, including seeding iodine silver, which can be launched from aircraft. In Iraq, non-precipitating clouds are occasionally present, in which case this technology could be applied. Many experiments have been conducted in this regard in a number of countries, including Syria and Jordan, and have achieved great success without great expense.[24] In Syria, this technology resulted in an increase in the amount of rain during the months of March and April of 1992, and provided an amount of water ranging between 2.5–5 billion m^3.[25] The cost per cubic meter of rain by human intervention in Jordan was 1.5 fils.[26] This technology could also be applied in Iraq to increase the amount of rain.
- Desalination of salt water, which requires large amounts of energy, can be achieved instead by using solar energy, and other energy sources available in Iraq. This method is used in a large number of countries, including the countries of the Arabian Gulf, whose production of desalinated water in 2003 reached approximately 2.7 billion m^3. A number of desalination plants could be created in the district of Basra, which lies at the head of the Arabian Gulf, where sources of energy are available. Other stations could be established further downstream in the districts of Baghdad, Babylon, Qadisiyah, Muthanna, Thi Qar, and Basra, which could provide about 4 billion m^3 per year of fresh water suitable for drinking in those districts.[27]
- The use of non-conventional water from drainage water and sewage water after treatment in agricultural and industrial plants. The Arab Republic of Egypt and Syria in 2004 used about 7.5, and 2.2 billion m^3 respectively of drainage water to irrigate crops. Drainage water can be blended with fresh-

[24] A. Musa, *Artificial Rain*, Dar Al-Fikr, Damascus 1993, p. 167.

[25] *Ibidem*, pp. 155–170.

[26] *Ibidem*, pp. 155–170; S. Mukhaimar, H. Khaled, *op.cit*., p. 27.

[27] A. Al-Maliki et al., *Geography of Iraq*..., p. 103.

water at specific rates and used for irrigation, as is the case in Syria and Saudi Arabia. In addition, waste water can be used after treatment to become an important source used for agricultural and industrial purposes, as is the case in the Gulf Cooperation Council (GCC), which used 752 million m^3 of water obtained in this way in 2004.[28] Those methods can be used in Iraq instead of the discharge of such water to streams and rivers, leading to the saving of large amounts of water for agricultural and industrial purposes, as well as alleviating pollution of rivers.

– Establishing a number of other storage projects on the rivers in Iraq, especially in locations south of Baghdad, to store surplus water during wet years, thus contributing to the provision of large quantities of water during years with low precipitation.
– Expanding the use of modern methods of irrigation such as spray irrigation and drip irrigation, which can achieve high-efficiency irrigation of up to 90%, reducing the loss in water and waste water.
– Crossbreeding of plant progeny that is better suited to dry conditions, needs only small quantities of water, and produces high yields.
– Rationalization of water consumption for various purposes and avoiding the pollution of surface water and groundwater.
– Conducting studies to reveal new water reservoirs, groundwater, and provide a database to be made available to decision-makers to perform maintenance and pollution control.

Conclusions

The study reveals that Iraq suffers from the phenomenon of both climatological and hydrological drought, where the amount of rainfall in 2007 was lower than the average for the period 1978–2007 by between 29.6% in the dry zones and 40.1% in the semi-dry zones. The revenue of annual water from the rivers Tigris and Euphrates in the hydrological year of 2008–2009 decreased by 75.8% compared to the year 2004. The revenue of water of the Shatt al-Arab decreased over the same period by about by 79.2%. This phenomenon has had environmental and economic impacts, including an increase in the salinity of the water, a shrinking area of arable land, low

[28] *Ibidem*, p. 24.

agricultural production, decreased density of natural vegetation, expansion of desertification and declining water share per person. These consequences require action to reduce this problem in the short and long term.

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WPŁYW SUSZY NA ŚRODOWISKO I GOSPODARKĘ IRAKU

Streszczenie

Zjawisko suszy stanowi jeden z poważnych problemów środowiskowych, z jakim spotyka się wiele obszarów na świecie, zwłaszcza w klimacie suchym i półsuchym, jak i w klimacie półwilgotnym. W Iraku susze przynoszą także poważne konsekwencje gospodarcze, jako że powojenna gospodarka kraju boryka się z zapewnieniem zapasów żywności.

W ostatnich latach Irak cierpiał z powodu susz, powodowanych zwłaszcza kwestiami klimatycznymi i hydrologicznymi. Susze wynikały z braku opadów u źródeł rzek. Powyższa sytuacja była spowodowana zmianą klimatu, jak również kontrolowaniem wód wpływających do Iraku przez państwa sąsiadujące (Turcję, Syrię, Iran), które nie uwzględniały postanowień międzynarodowych konwencji i traktatów regulujących prawo do wody.[29]

Ilość opadów w kraju zmniejszyła się w roku 2007 w stosunku do średniego poziomu w latach 1978–2007 o 29,6% w suchym klimacie i 40,1% w klimacie półsuchym. Omawiając kwestie suszy w kategoriach hydrologii, roczny przepływ wód rzek Tygrys i Eufrat w latach 2008–2009 wyniósł o 75,8% mniej niż w roku 2004. Podobnie, przepływ wód rzeki Shatt al-Arab latem 2008 roku był średnio o 79,2% niższy. Sytuacja ta wywiera wpływ na środowisko i gospodarkę powodując zwiększone zasolenie rzek oraz zmniejszone możliwości w zakresie nawadniania, niższą produkcję rolną oraz zmniejszoną gęstość roślinności naturalnej, jak również skutkuje przyspieszeniem procesu pustynnienia przyczyniając się do zmniejszenia konsumpcji wody przypadającej na mieszkańca Iraku. Sytuacja taka wymagać będzie podjęcia pewnych procedur w krótszej i dłuższej perspektywie w celu złagodzenia skutków występujących problemów.

Słowa kluczowe: susza, środowisko, wpływ suszy, gospodarcze skutki suszy, susza w Iraku

[29] D. Kadhim, *op.cit.*, pp. 85–89. See also H. Al-Obeidi, *op.cit.*, pp. 36–37.