PLANT SCIENCE TODAY
Vol x(x): xx–xx
https://doi.org/10.14719/pst.7737

eISSN 2348-1900

RESEARCH ARTICLE

Impact of Euphrates River level decline on agriculture in Fallujah district

Hussein Adnan Neame[1], Mayada Safaa Jasm[1], Sanaa Rashid Awad[2], Abdul Majid Mohamed Awad[3] & Bilal Muayad Abdulrahem Alalosy[3*]

[1]Center of Desert Studies, University of Anbar, Ramadi 31001, Iraq
[2]General Directorate of Anbar Education, Anbar Province, Ramadi 31001, Iraq
[3]Upper Euphrates Centre for sustainable Development Research, University of Anbar, Ramadi 31001, Iraq

*Correspondence email - bilal.m.a@uoanbar.edu.iq

Received: 14 February 2025; Accepted: 30 June 2025; Available online: Version 1.0: 25 August 2025

Cite this article: Hussein AN, Mayada SJ, Sanaa RA, Abdul Majid MA, Bilal MAA. Impact of Euphrates River level decline on agriculture in Fallujah district. Plant Science Today (Early Access). https:/doi.org/10.14719/pst.7737

Abstract

Water scarcity in Iraq, particularly in the agricultural sector, has emerged as a pressing concern. This study examines the impact of declining Euphrates River flow on agricultural productivity in a region where the river traverses approximately 103 km, starting from the north of Al-Saqlawiyah (in the Sen al-Dhaban region) to the outskirts of the district. The highest annual discharge rate of the Euphrates River was recorded in 2005-2006 at 680 m^3/s, while the lowest discharge was recorded during 2010-2020, at 290 m^3/s. This decline has negatively impacted the water levels of its tributary streams due to several factors, including climate change, global warming, political tensions with Turkey and Turkey's non-compliance with international laws and treaties signed with Iraq. These factors have had a direct impact on agricultural productivity in terms of cultivated areas and production volumes during the period (2010-2020). This period witnessed a negative change in cultivated areas, which decreased to 25818 dunums, with cereal crops being the most affected. The area cultivated with cereals decreased by 39597 dunums, with a corresponding drop in production by 2449 tons. Industrial crops were next, experiencing a reduction in cultivated area by 982 dunums and a decline in production by 275 tons. Finally, horticultural crops saw a production decrease of 103 tons.

Keywords: agricultural productivity; district; Euphrates River; Fallujah; water levels

Introduction

Water resources in Iraq in general and in the study area in particular, are of great importance, especially since this geographical region relies on a single water source represented by the Euphrates River which made Iraq and the study area vulnerable to transboundary water politics, where upstream countries exert control by manipulating river flow.

The decline in Euphrates River water levels has become a significant concern through the decrease in Iraq's total water supply, which was reflected in the decrease in the Euphrates River, which caused a decrease in the water quantities of the agricultural sector. The process of declining the levels of the Euphrates River is known as the water crisis or water scarcity as an imbalance between available and renewable water resources and the increasing demand for them, which represents a deficit in the water balance that is constantly increasing, which hinders development, including agricultural development (1). The water scarcity of the Euphrates River has worsened, especially recently, human reasons related to Turkish water policy through the construction of dams to decrease the water supply of the Euphrates River in the study area, The highest annual discharge was in 2005-2006, reaching (680 m^3/s), while the lowest discharge was recorded in 2010-2011, reaching (290 m^3/s) this is according to reports issued by the Iraqi Ministry of Irrigation which gives a serious indication of water scarcity. It resulted in problems reflected in the agricultural productivity in the agricultural area through the high costs of agricultural production, especially when the irrigation methods changed from surface irrigation to sprinkler irrigation, drip irrigation and intermediary irrigation methods. The problem of the study lies in addressing the impact of the decline in the Euphrates River's water levels on agricultural productivity in the Fallujah district.

The study assumes that the discharge of the Euphrates River is in constant fluctuation and is unable to meet the water needs of agricultural land. It aims to reveal the extent to which the low water of the Euphrates River affects agricultural productivity. As for the boundaries of the study area, it is located astronomically between the longitudes (29-43 55-34) east and latitudes (10-33 45-33) north.

The Euphrates River flows within the study area and is (103 km) long from the north of the city of Saqlawiya (Sin al-Dhiban area) to the outskirts of the district as shown in Fig. 1, the study aims to reveal the extent of the impact of the decline in the Euphrates River water on the agricultural productivity.

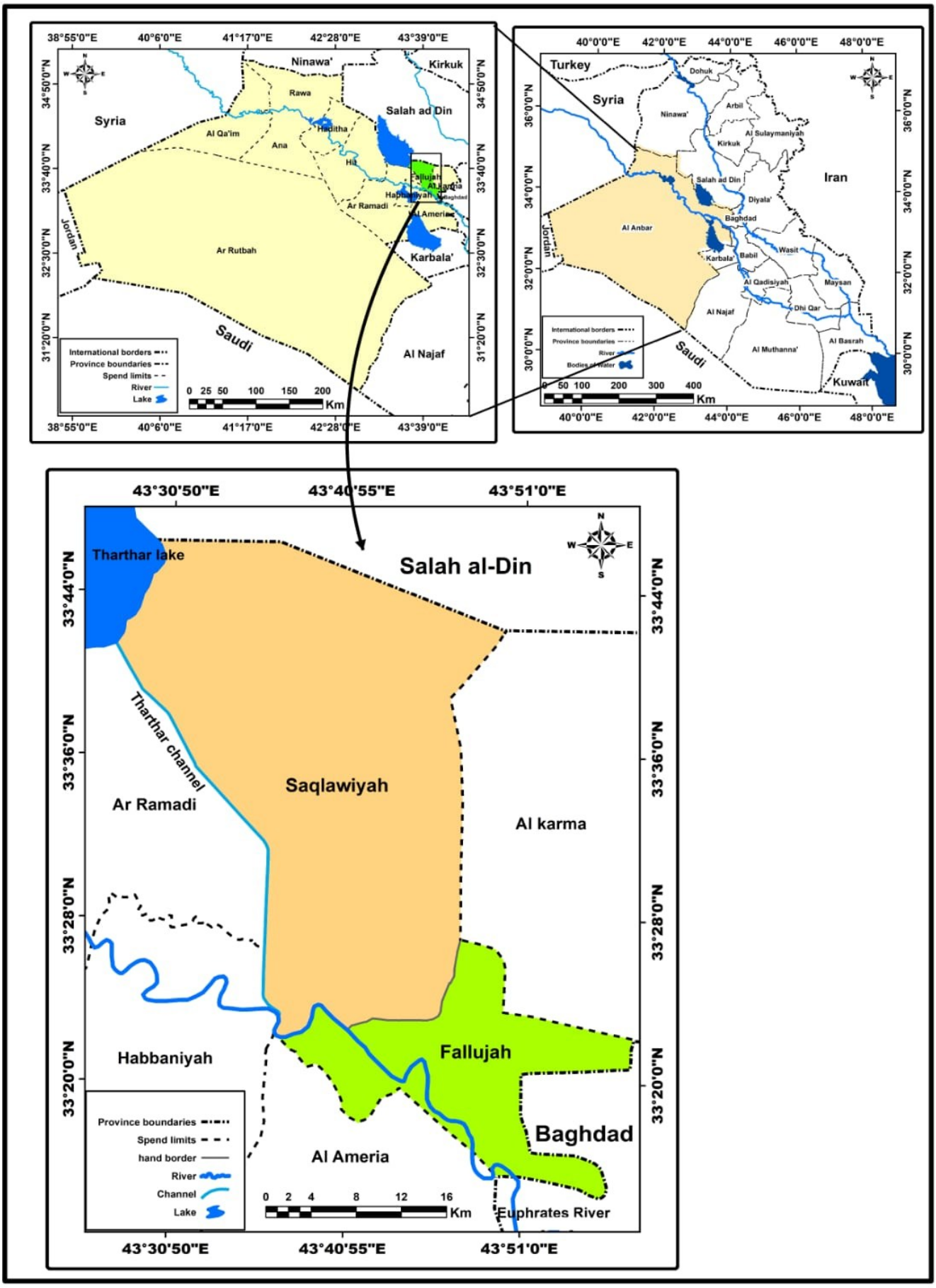

Fig. 1. Administrative boundaries of the study area.

Source: Ministry of Water Resources, General Authority for Surveying, Index of Anbar Governorate Districts, Scale 1:100000.

Surface water resources

Surface water resources are one of the basic elements of sustainable development. However, water scarcity has become a major challenge due to the growing imbalance between water supply and regional demand. Estimates suggest that approximately (67 %) of the world's population lives in areas suffering from water scarcity (2). No comprehensive development planning can be carried out without considering the importance of studying water resources. The surface water resources are one of the most prominent natural components in the study area, represented by the Euphrates River and its channels and streams because the study area is located in a dry desert climate, which is characterized by low rainfall and irregularity, which made it not to rely on it in carrying out any agricultural activity, which made reliance on surface and groundwater in the establishment of any agricultural activity.

The surface water in the study area is represented by the Euphrates River and its channels and streams as shown in Fig. 1. They are addressed as follows:

The Euphrates River

The Euphrates River is one of the most important water sources, but it is the lifeline in the study area, as it depends on it to meet water needs for agricultural and non-agricultural purposes. It is conducted within the study area and is 103 km in length from the north of the city of Saqlawiya (Sin Al-Dhuban area) to the outskirts of the district (3). The Euphrates River is characterized by irregular flow, it varies from season to season and from year to year according to the quantities received from upstream countries and that the large fluctuation in the discharge of the Euphrates River in the study area is one of the most prominent problems related to water and it was shown from Table 1 that the quantities of river discharge are in continuous decline by observing the table data, it was found that the highest annual discharge was (680 m^3/s) in 2005-2006, while the lowest discharge was (290 m^3/s) in 2010-2011. That led to the reluctance of many farmers to agriculture and limited to the winter season only because winter crops do not need many quantities of water and that the exacerbation of the problem of water shortage forced the government to use the system of sprinkling in the study area, which stops the operation of water pumps from eight in the morning to eight in the evening with the aim of addressing the water scarcity experienced in the study area, as shown in Fig. 2.

1. Irrigation ditches and canals: The study area is characterized by the presence of a network of irrigation ditches and projects., which are the main means of transporting water from the Euphrates River to areas far from the river to provide the requirements of various human uses, but did not cover them completely, as some areas depend on groundwater to irrigate agricultural lands. Ditches and canals are divided into the following:

Fig. 2. Turning off pumps in the study area.

Table 1. Average annual discharge (m^3/s) of the Euphrates river and irrigation ditches and canals for the period (2000-2020)

Desalination Canal (m^3/s)	Tharthar Canal (m^3/s)	Saqlawiya hlrrigation ditches (m^3/s)	Dhiraa dijla canal (m^3/s)	Abughraib Irrigation ditches (m^3/s)ı	Euphrates River(m^3/s)	Water years
27	34	17	33	62.3	268	2000- 2001
32	26	17	22	64	344	2001-2002
44	42	17	44	66	419	2002-2003
68	87	16	86	70	558	2003-2004
123	123	17	122	76	589	2005- 2004
119	109	16	113	74	680	2005-2006
153	162	15	189	70	652	2007-2006
67	74	16	85	71	319	2008-2007
35	32	16	33	54	348	2009-2008
82	72	18	82	62	328	2009-2010
82	72	19	82	67	290	2010-2011
64	85	21	79	72	307	2011-2012
73	74	21	70	69	415	2012-2013
47	42	14	46	32	436	2013-2014
42	37	14	38	0	426	2014-2015
61	63	16	64	0	415	2015-2016
108	119	13	121	28	319	2016-2017
70	64	18	86	62	328	2017-2018
157	168	22	169	24	443	2018-2019
263	270	20	303	32	451	2019-2020

Source: Ministry of Water Resources, Directorate of Water Resources in Anbar Governorate, Fallujah Irrigation Division (Unpublished Data) 2000 -2020)

2. Tigris canal or 'Dhira'a Dijla': This canal comes in second place after the Euphrates River, as it branches off from the main canal (Tharthar Canal - Euphrates) and is located in the northern part of the study area Fig. 3 and the discharge capacity is (10 m^3/s) and to give information and a clear and accurate picture of this canal, it must be noted to its discharge rates because it gives an important hydrological significance. The canal is characterized by the difference in the amount of annual discharge because of its dependence on the Tharthar - Euphrates canal, which is governed by the state's policy, which determines the amount of water for both the Euphrates and Tigris Canal or "Dhira'a Dijla" and the analysis of the data of Table 1 showed a showed significant year-to-year variation in the annual discharge rates. The highest discharge rate in (2019-2020) was (303 m^3/s) and the lowest annual discharge rate in (2001-2002) was (22 m^3/s) and this is due to the state's policy and the extent of its control over raising and lowering the discharge of this channel as it is a water carrier from Lake Tharthar towards the Tigris River.

3. Saqlawiya irrigation project: This project is located (12 km) northwest of the city of Fallujah, Fig. 2 and branches off from the left side of the Euphrates River and is (18 km) long and has great importance in saving water, especially after the construction of the Fallujah Barrage, which raised the water level at the top of the table. This project is one of the most important projects that transfer water and deliver it to agricultural fields, as water increases, agricultural areas increase, meaning that it is directly related to the available amount of water. It is clear from Table 1 that the water discharges differ from year to year, as the highest discharge rate for the water year (2018-2019) of (22 m^3/s) while the lowest discharge rate for the water year (2016-2017) and the rate of (13 m^3/s) and this decrease in the annual discharge rates of the project is associated with the decline of the water levels of the Euphrates River. Hence, the shortage of Project Water Inflows, which reflected negatively on the project's expenses in a manner that is not commensurate with the requirements of the region to achieve agricultural development considering the increasing water demand.

4. Desalination canal: The Desalination canal, measuring 99 km in length and 40-42 meters in width, has a discharge capacity of 250 (m^3/s). This project flows into the Tigris canal and the aim of establishing this project is to irrigate large areas of land that the project passes. The analysis of the data in Table 1 showed a discrepancy in the annual discharge rates, as the highest discharge rate in (2019-2020) was (263 m^3/s) and the lowest annual discharge rate in (2000-2001) was (27 m^3/s) and this is due to the state policy and the extent of its control over raising and lowering the discharge of this canal.

5. Abu Ghraib Irrigation Project: This project is located south of the city of Fallujah, Fig. 2 and its length is 23 km and a drainage capacity of 28 m^3/s, as the irrigated area of this project, is 170288 dunums. Through the data of Table 1, a clear decline appears in the annual rate of discharge, as the highest annual rate was recorded in the water year (2004-2005) of (76 m^3/s) and the lowest annual rate in the water year (2018-2019) of (24 m^3/s). This decrease is related to quantities related to the discharge of the Euphrates River, which reflected negatively on the discharges of this project and the interruption of water discharge in the water year (2014-2015 and 2015-2016) due to the ISIS militants cutting off water from this project during the control of those groups on the Fallujah Barrage, which led to a significant decline in water availability and groundwater was relied on for various purposes and irrigation of agricultural fields.

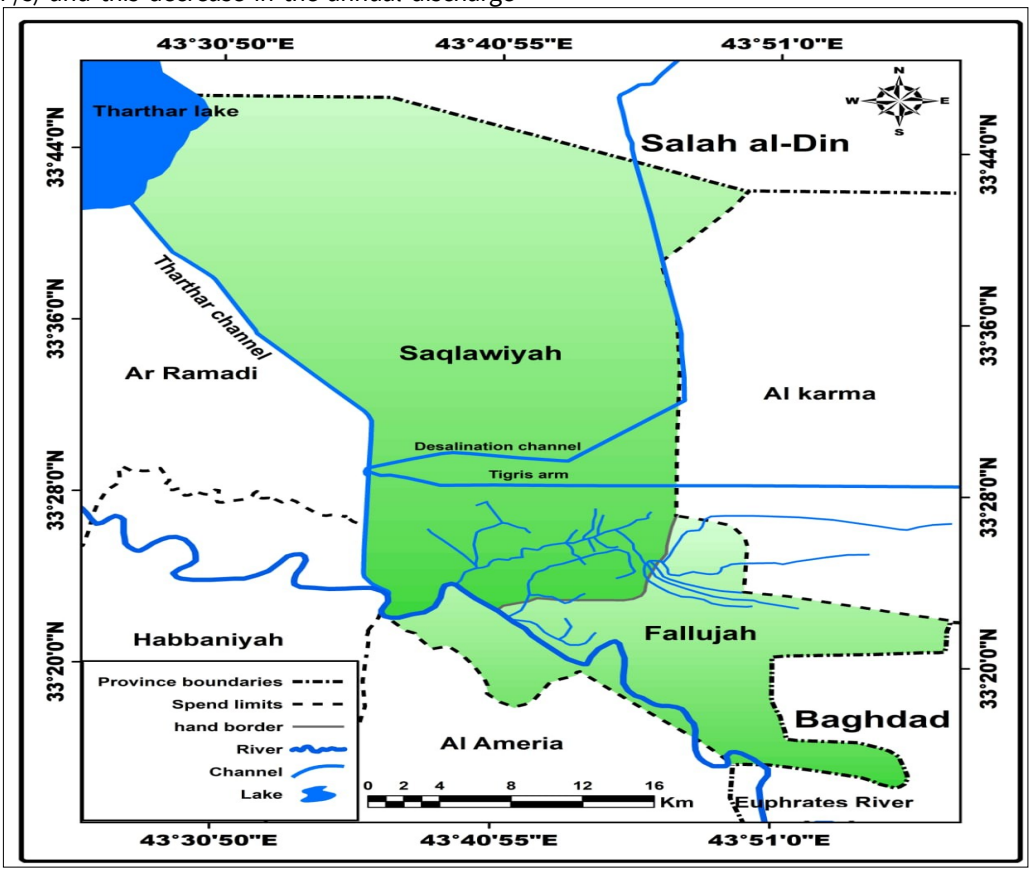

Fig. 3. Sources of surface water resources in the study area.

6. Tharthar canal: This canal is located 50 km north of Fallujah city and has a length of 37 km Fig. 2 and the design drainage capacity is 1100 m^3/s. Through the data of Table 1, a clear decline appears in the annual rate of discharge, as the highest annual rate was recorded in the water year (2019-2020) of (270 m^3/s) and the lowest annual rate in the water year (2001-2002) of (26 m^3/s) and this decrease is associated with the discharge of the Euphrates River, which reflected negatively on the discharges of this project, which controls the control of water from Tharthar lake to the Euphrates River.

Causes of the decline in Euphrates River water levels

The global water problem results from the rapid increase in demand for water, which exceeded the quantities of water available, which caused a water crisis, which is defined as an imbalance between available and renewable water resources and the increasing demand for them, which represents a deficit in the water balance and this deficit is called (water gap) and then the deficit reaches a degree that leads to economic and social damage that threatens the structure of the state. These causes are classified as follows:

1. Natural causes

The problem of global warming in recent times and the resulting rise in temperatures and the occurrence of weather changes and pressures and then the movement of winds, led to more drought and lack of rainfall. The study area is in the dry desert climate area and the annual rate of rain does not exceed 200 mm. This led to a decrease in the surface runoff volumes of the Euphrates River because rainfall is the main feeder for this river (4). Climate change has a significant impact on the hydrological characteristics of the course of the Euphrates River directly and indirectly. It leads to a decrease in the amount of rainfall, whether in the humid or semi-humid ranges, such as the climate of the State of Turkey, from which the Euphrates River originates, or in Syria or Iraq with a dry climate. This was reflected during the Euphrates River in the study area and put it in a state of fluctuation in running water, which reflected negatively on the agricultural and industrial sectors and tourism in the study area (5).

2. Human causes

Water is an economic commodity employed to serve politics and whoever owns water resources influences the absence of international organizations and laws, which prompted Iraq to make many treaties and agreements with the riparian countries, but the failure to activate these agreements and international treaties according to charters led to non-implementation and disruption (6). Since the Tigris and Euphrates river system benefits all countries in the region, Turkey claims that the local dam is beneficial to Iraq, assuming that increasing the orderly flow of water, Turkey has established many irrigation projects compared to Iraq, which is still suffering from the effects of the American invasion and the instability and certainty faced by farmers about their crops, as it has become subject to Ankara's whims. (7) Iraq was one of the few countries in the region that was considered a grain exporter, but it has now turned into a grain importer, reflecting the agricultural result of the current water situation (8). As a result of the decrease in the quantities of water in the Tigris and Euphrates Rivers, the agricultural areas in Iraq in general and the study area in particular have shrunk and agricultural costs per dunam have increased. Farmers have left their agricultural fields for years and some have migrated to cities to pursue non-agricultural work with greater economic returns compared to the agricultural sector (9). Not only that, but other reasons led to the low levels of the Euphrates River and the formation of the water crisis in the study area, including the lack of lining the waterways, the absence of water guidance and the weakness of the administrative systems responsible for addressing the water crisis.

Results and Discussion

Water needs

Assessing water needs is an important step in planning effective water resources management, as the development of the agricultural sector depends mainly on the optimal exploitation of water resources and determining how to use water to irrigate crops as one of the important factors in achieving economic and social development (10). The increase in water losses exceeds water needs, especially in the agricultural aspect, which requires the provision of water equipment and appropriate irrigation methods in the process of irrigation for the growth of crops. The irrigation system is the main way to provide sufficient and appropriate quantities of water for irrigation and the lack of good management of irrigation water leads to the loss of large amounts of water, high groundwater levels, salinization and forestation of agricultural lands and then low productivity of crops and destruction.

Studies show that one dunum of land needs about 3250 m^3 of water when using modern irrigation methods. In contrast, traditional irrigation uses up to 6600 m^3 per dunum. This means that about 50 % of the water used in traditional irrigation is more than what is needed (11, 12). It is clear from Table 2 that the need for crops in the study area by traditional methods totalled for the years 2010-2020 (815944800 m^3 per year) (645546000 m^3 per year) respectively, while the need in the light of modern methods reaches (401791000 m^3 per year) (317882500 m^3 per year) respectively, which means providing water up to (414153800 m^3 per year) (327663500 m^3 per year) respectively and many methods are used in the study area, including surface irrigation, as the irrigated areas by surface

Table 2. Water requirements of agricultural crops (m^3/dunum) according to irrigation methods (traditional and modern)

Amount of Water that Can Be Saved (m^3/year)	Water Requirement According to Modern Irrigation (m^3/year) **	Water Requirement According to Traditional Irrigation (m^3/year)*	Area (Dunum)	Years
414153800	401791000	815944800	123628	2010
327663500	317882500	645546000	97810	2020

Source: Directorate of Agriculture in Anbar, Fallujah Agriculture Division, Planning and Follow-up Department, Unpublished Data (2010-2020).

* water requirement for the crop using traditional irrigation was calculated by multiplying the crop area by 6600 m^3/dunum.

irrigation reached in the study area (1449 dunums) As for the type of Supplementary irrigation, it prevails in lands high above the river level and areas far from the river to which water cannot be delivered to surface irrigation. As for the methods of modern irrigation, such as sprinkler irrigation, the areas irrigated in this way in the study area reached (11675 dunums). Excessive irrigation leads to confusion in the process of water quota management of agricultural land by wasting large amounts of drainage rates of the Euphrates River and its branching streams, through field experience with the ignorance of the farmer and his lack of knowledge of the water needs of each crop and then the negative practices associated with each method of irrigation, which causes an imbalance between the amount of water available and the amount of water needed by agricultural lands.

The impact of the decline in Euphrates River levels on agricultural productivity

Concerning water, there is a variation in the rates of discharge of the Euphrates River and the agricultural land and the crops grown in it in the study area depend on the available surface water, especially provided by the Euphrates River and its branching streams, which are the main source of water and lifeline in the study area. It is clear from Table 3 that the cultivated areas in the study area vary according to the available water, which was reflected in the variation in the cultivated areas and the quantities of production in the study area, during the period (2010-2020), as this period witnessed a negative change in the cultivated areas, which amounted to a decrease of -25818 dunums, foremost of which are grain crops, as their areas decreased by a negative amount of (-39597 dunums) and with negative production quantities also amounting to (-2449 tons), followed by industrial crops, as they witnessed a negative change in the cultivated areas. It amounted to (-982 dunums) with negative production quantities amounting to (-275 tons) and comes after horticultural crops, as the production quantities decreased by (-103 tons).

Since the study area is located within the characteristics of the hot dry climate, represented by the lack of rainfall, the prevalence of drought, the increase in the amounts of evaporation and the decline in water levels of the Euphrates River and its fluctuation, which was reflected in the decrease in cultivated areas and it is clear from the above that the agricultural situation in the study area is affected by the decline of water levels represented by the Euphrates River and its branching streams, which was reflected on the decline in cultivated areas and the deterioration of production quantities. It was noted through the field study and due to the low surface water levels, farmers were prompted to use poor quality water such as drainage Water and groundwater represented by wells, which amounted to (6628 wells) with high salinity, especially in areas relatively far from the Euphrates River and its branching streams, which was reflected in the shrinking of cultivated areas through the high percentage of salts in them. The decline in water levels has also pushed farmers to leave their agricultural land.

Conclusion

The study reveals that the Fallujah district is situated within a hot arid climate zone characterized by low rainfall, making it highly dependent on surface water resources, which are marked by fluctuations and instability. This variability has had a negative impact on agricultural activities, leading to the transformation of vast agricultural lands into barren areas. Data also indicate a significant decline in the annual inflows of the Euphrates River, with the highest discharge recorded in the 2005-2006 season at 680 m^3/s, while the lowest was in 2010-2011 at 290 m^3/s. This decline is attributed to various factors, including climate change, global warming, political tensions with Turkey and its non-compliance with international treaties and agreements signed with Iraq.

The study also highlights the continued reliance on traditional irrigation methods, which consume much more water than modern techniques. Between 2010 and 2020, total water usage reached 815944800 m^3/year and 645546000 m^3/year, respectively. However, if modern irrigation systems had been used, water requirements would have dropped to 401791000 m^3/year and 317882500 m^3/year, resulting in annual savings of over 400 million cubic meters. This excessive water consumption has negatively affected cultivated areas, with a reduction of 25818 dunams during the same period. Field crops experienced the largest decline-39597 dunams-with a production loss of 2449 tons. Industrial crops saw a decrease of 982 dunams and a loss of 275 tons in production, while horticultural crops recorded a production drop of 103 tons.

Table 3. Cultivated area and agricultural production and amount of change for the period (2010-2020)

The Variation Between 2010 and 2020		2020		2010		Crop
Production (Ton)	Area (Dunum)	Production (Ton)	Area (Dunum)	Production (Ton)	Area (Dunum)	
-2449	-39597	14807	44544	17256	84141	Grains
17587	12082	223427	42570	205840	30488	Vegetables
-275	-982	255	975	530	1957	Industrial crops
6806	1007	21076	3750	14270	2743	Forage crops
-103	1672	7202	5971	7305	4299	Horticulture
21566	-25818	266767	97810	245201	123628	Total

Considering these challenges, the study recommends pursuing fair and scientifically based water-sharing agreements with upstream countries, taking into account climatic differences and geographic distances. For instance, producing a crop in Turkey requires less water than in Iraq's hot and arid environment. It also recommends adopting modern irrigation technologies such as drip and sprinkler systems, lining irrigation canals and removing obstructions to ensure efficient water delivery during the summer growing season. Finally, the study stresses the importance of supporting scientific research and promoting collaboration with universities and research centers to develop practical studies that can inform effective water resource management strategies in Iraq.

Acknowledgements

We would like to thank Dr. Essam Khudair, a specialist in agricultural sciences, for providing assistance and valuable advice during the preparation of this study. We also extend our gratitude to Dr. Ali Suleiman and Dr. Mahmoud Ibrahim for providing the necessary facilities to obtain the data that greatly contributed to conducting the current study.

Authors' contributions

HAN prepared the draft and structure of the manuscript and MSJ collected the agricultural data on which the study is based. SRA coordinated the manuscript and performed the scientific translation. AMMA collected and analyzed the water resources data in detail. BMAA prepared and designed the maps for this study. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

References

1. Khallaf HA. Agricultural land ownership and its investments in Baghdad Governorate. 1st ed. Baghdad: Al-Irshad Press; 1976.
2. Petruzzello M. Water scarcity. In: Encyclopedia Britannica. 2023. https://www.britannica.com/science/water-scarcity
3. Al-Dulaimi RMMG. Agricultural development in Fallujah District. Ramadi: University of Anbar, College of Arts; 2023.
4. Assi NA, Abdulaziz RAH. The role of strategic planning in managing the water crisis: A field study on the opinions of the Directorate of Water Resources in the Middle Euphrates. J Coll Adm Econ Econ Adm Financ Stud. 2020;12(2).
5. Al-Fahdawi LMKA. Climate change and its impact on the hydrological characteristics of water reservoirs on the Euphrates River. Ramadi: University of Anbar, College of Education for Human Sciences; 2017.
6. Al-Ta'i AO. Water scarcity in the Middle Euphrates region and its impact on agricultural reality. J Coll Educ Univ Misan. 2024;56(1).
7. Zarei M. The water-energy-food nexus: A holistic approach for resource security in Iran, Iraq and Turkey. Water-Energy Nexus. 2020;3:81–94. https://doi.org/10.1016/j.wen.2020.05.004
8. Ewaid SH, Abed SA, Chabut A, Al-Ansari N. Water footprint of rice in Iraq. IOP Conf Ser Earth Environ Sci. 2021;722:012008. https://doi.org/10.1088/1755-1315/722/1/012008
9. Giovanis E, Özdamar Ö. The transboundary effects of climate change and global adaptation: The case of the Euphrates-Tigris water basin in Turkey and Iraq. SSRN Electron J. 2023. https://doi.org/10.2139/ssrn.4320746
10. Al-Saadi DAHA. Optimal investment of water resources and its impact on grain crop productivity in Muqdadiyah District. J Univ Anbar Hum Sci. 2023;20(1).
11. Alalosy BMA, Daood ST, Mohamed MR, Al-Karbouli ASE, Ahmad JM, Ghani ETA. Effect of climate on variation of oil crop production in Anbar Governorate. Plant Sci Today. 2024;11(3). https://doi.org/10.14719/pst.4098
12. Al-Jughayfi MIMA. Future prospects for rationalizing and investing surface water resources in Anbar Province. J Univ Anbar Hum Sci. 2013;2(4).

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.