

Evaluating the Potential of Agricultural Drainage Water Reuse to Alleviate Water Scarcity in Al-Anbar, Iraq: A WEAP Model ApproachAmeen M. Noon^{1*} – Ayad Sleibi Mustafa¹ – Anas M. Elmolla^{2,3} – Mohamed Ibrahim Mohamed²¹Department of Civil Engineering, Faculty of Engineering, University of Anbar, Ramadi 31001, Iraq²Department of Civil Engineering, Faculty of Engineering, Al-Azhar University, Cairo 4450113, Egypt³Department of Civil Engineering, Faculty of Engineering, Galala University, Suez 43552, Egypt

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Abstract. The scarcity of water resources in Iraq and particularly in AL-Anbar Province is expected to worsen in the future, due to the decline in imports of the Euphrates River as a result of water policies pursued by the upstream countries as well as due to climate changes. Water resources are the main determinant of agricultural production and expansion and achieving food security for the country. The agricultural sector in Iraq is considered one of the most consuming sectors of available water resources and consumes more than 80% of the already dwindling amount of available water revenues, which restricts the agricultural production process and the expansion of the exploitation of new agricultural lands. Due to the low efficiency of irrigation in general, a large proportion of irrigation water is collected by drainage to be transported to the general outlet and then to the Arabian Gulf in the south of Iraq, and the other part of it is exposed to evaporation and other losses. In this study, the Water Planning and Assessment (WEAP) model was applied to the scenario reference and scenario of reuse of agricultural drainage water for agriculture in order to provide water for the purpose of establishing new agricultural areas or to meet the needs of the current agricultural sector in times of scarcity where agricultural drainage water is treated according to environmental determinants before reuse for agriculture. The study will have a timeframe of 2008 as the base year, 2009-2025 as the reference scenario, and 2026-2040 as the future forecast for water needs in the agricultural sector. The results obtained through the web form indicate the provision of large quantities of water amounting to 20% of the total water demand for the agricultural sector. This is the expected percentage of water used in the agricultural wastewater treatment scenario to be considered supplementary water for the agricultural sector. They can be considered as additional water resources that can be utilized to provide part of the required needs in this sector. In addition, the water tests proved that the water of most of the drainages in the study area has physical and chemical properties that allow it to be easily and cheaply treated and reused in the agricultural sector.

Keywords: WEAP Model; Water Resources Management; Drainage water; Sustainability; Water demand**INTRODUCTION**

Iraq is currently facing a set of water-related challenges, as the growing population and raising the standard of living of the individual are among the main challenges that lead to an increase in the demand for water for all sectors of the user. The problem of saving water is one of the most complex problems at the international and local levels. Achieving water security is a guarantee for achieving and continuing food security as a guarantee for sustainable agricultural development. This study focuses exclusively on surface water as the primary source, with wastewater reuse being a supplementary water source. Where the subject of the scarcity of water resources allocated to the agricultural sector has become a critical issue, especially since the irrigated agricultural sector in Iraq withdraws 85% of the water resources allocated to the agricultural sector, with a decrease in the total water resources available to Iraq from the Tigris and Euphrates rivers (Badri & Muhammad, 2007). Several studies have been conducted on water scarcity and high water consumption in agriculture. The results of this study indicate that in 2010, Anbar's share of the Euphrates River water was about 2200 million m³/year, and by 2020 it had declined to 1700 million m³/year a decrease of about 23% compared to 2010 (Formatting Citation). This makes it necessary to avoid future danger and to look for solutions and alternatives. Iraqi irrigated agriculture depends on the method of surface irrigation and irrigation in intermediary, where we find that the percentage of agricultural land irrigated surface 60% and 40% through the intermediary (Resources, 1996). The use of drainage water for the purposes of irrigation of agricultural crops is one of the matters proposed to solve the water crisis that afflicts agricultural land in Iraq in general and in Anbar province in particular, as it is possible to benefit from the water that is surplus to the needs of the plant by reusing the drainage water in the irrigation of agricultural areas. We can consider the objective of this study to be "evaluating the possibility of reusing wastewater as a solution to alleviate future agricultural water shortages and analyzing its feasibility."

LITERATURE REVIEW

Based on the scrutinized literature, it was apparent that many researchers attacked such problems numerically. Among them, for example, were the following:

- agricultural drainage water was used to irrigate the cotton crop economically and for a long time in Sardaria, south of Tashkent, capital of the Republic of Uzbekistan (USSR) (Falah, 2011).
- The WEAP system was previously used in a water management study in the same region, where the results indicate that the first and second scenarios could reduce unmet water demand by 36% and 84%, respectively, by 2040 compared to the baseline (Noon et al., 2024). The WEAP model was also used in Anbar Governorate to manage water and reduce water deficits. The results indicate a decrease in water demand from 5,846.59 million cubic meters to 4,232.29 million cubic meters in the first and second scenarios, respectively (i.e., by 38%) (Noon et al., 2022).
- An assessment of the quality of drainage water and the extent of its powers was conducted in the areas north of Baghdad. The results indicate the possibility of using tapped water to irrigate salt-resistant agricultural crops, with the need for agricultural lands in those areas to be washed when using that water (Husainiya, 2011).
- Some studies in Egypt indicate that agricultural drainage water is considered a strategic reserve for the increasing demand for water (Fleifle et al., 2013)
- The drainage water in Iraq is estimated at 6.6 billion cubic meters per year, and this water is suitable for growing agricultural crops according to the extent of its salt tolerance (Jaber, 2015).
- In irrigation and drainage projects, such as drainage projects in Wasit, Dhi Qar, and Basra governorates, the operating cost of simple treatment plants may be between \$0.3 and \$0.5/m³. Advanced treatment of drainage water for reuse in irrigation may cost between \$1 and \$1.5/m³ ("Iraq Ctry. Water Resour. Assist. Strateg. Addressing Major Threat. to People's Livelihoods," 2006).
- WEAP was implemented in the Djefara-Medenine shallow aquifer in Tunisia to evaluate the groundwater spatial management and management of its amount, where 3 scenarios were mimicked to simulate irrigation water, population growth rate, as well as industry growth rate. The results signposted a future decrease in reservoir water amount due to intensive exploitation under limited recharge (Ayed et al., 2022).
- A study was carried out to assess the Euphrates River in Ramadi City as well as the Al-Dhiban Canal for various purposes and to inspect the cations, anions, electrical conductivity, and TDS during 1992-1998. The results flagged out that Euphrates River water is suitable for drinking, irrigation, as well as for industrial purposes, in reference to Iraqi specifications (Mustafa et al., 2009).
- A study was conducted on samples from the Al-Warrar area of Ramadi City at different groundwater levels, where the results specified proportions of sulfate variations in water as well as soil physical as well as soil chemical properties (Abbood et al., 2023).
- A study was carried out in the Al-Warrar area of Ramadi to designate a water quality index for domestic as well as agricultural use, where the laboratory analysis flagged out that there are significant differences between wells and the water quality of the Al-Warrar Canal. This is evident in the measured parameters, in terms of the World Health Organization. This was attributed to human activities (i.e., urban expansion, agricultural flooding, as well as discharge of untreated sewage) (*The Unified Arab Economic Report*, 2003).
- A study conducted in Anbar Governorate to calculate water demand in 2021 indicates that the agricultural sector's water demand is 1,404.38 million cubic meters annually, based on the limited cultivated area. This represents 42.93% of the total available area of 221,250 hectares. Agricultural demand is projected to rise to 2,611 million cubic meters annually when all available land is utilized, resulting in a water deficit of 1,591 million cubic meters and 1,715 million cubic meters annually in 2030 and 2035, respectively (Sulaiman et al., 2021).
- A study analyzing climate change in the Euphrates River basin, focusing on rainfall, temperature, and surface runoff, indicates that rainfall is expected to decrease by up to 13% after 2021, and potentially by more than 40% by the end of the century, particularly in Turkey, the primary source of surface runoff. The flow of the Euphrates River could decrease by 23.5% by 2100, with surface runoff declining by 30% after 2040. Average winter temperatures are projected to rise by 1–5°C between 2021 and 2081. These changes pose a threat to Iraq's water resources, as the country already loses approximately 14.7% of its reserves annually due to drought, with 85% of its water used for agriculture (Hammadi Al- Shaabani, M. M., & Nashed, 2025).

THE STUDY AREA

1. Al-Anbar Province

Al-Anbar province is one of about the province that possess large areas and located in the west of Iraq with an area of 1/3 the area of Iraq (56 million dunum). It lies between longitudes (40°28',12" - 41° 25',48") East and latitude (34° 24',54" - (34° 11', 6") from North (Mustafa et al., 2016).

Ramadi lies within the latitudes (33°48 - 33°07) to the north and longitudes (43°36 - 43°27) to the east.

Fallujah lies within latitudes (33°21 - 33°47) to the north and longitudes (43°49 - 43°44) to the east(Mustafa et al., 2016).

Euphrates extends 1178 and 604 km in Turkey and Syria, respectively(Saeed et al., 2021). Irrigated land represents less than 1% of the province's area, with groundwater available in large areas of the desert. Exploited lands will be in several types of them (suitable for cultivation, unfit, and semi-suitable)(Anbar & Agriculture Directorate, 2020). Irrigated land represents less than 1% of the province's area, with groundwater available in large areas of the desert. Exploited lands will be in several types of them (suitable for cultivation, unfit, and semi-suitable)

(Mohammad & Mustafa, 2020)

The first figure shows the areas targeted in the study.

2. The study aims to:

1- Calculate the water requirement and unmet demand for water for the agricultural sector in Anbar province.

2-Creating modern techniques in the field of water resource management and development, and reducing dependence on traditional sources, especially non-renewable groundwater. Among these techniques is the utilization of saline water for irrigation (drainage water).

THEORY AND METHODS

The different stages of surface water resource management in this study are: estimation of the amount of water received for each year in the Euphrates River, estimating the amount of water needed for the agricultural sector. The study will take the future water demand for Anbar Province for the agricultural sector into account using the WEAP model for the reference scenario and the scenario of using drainage water. The model is built for the purpose of planning and managing water resources in the region in accordance with the development plan (2040) which is prepared by the competent authorities.

1. Introduction to the WEAP model

This model was under development and use in the water-planning discipline for a long time (Raskina et al., 1992). The Aral Sea was the first region to be studied by the WEAP model. That first version of WEAP, however, was quite limited. Among the many shortcomings of the first version was the assumption of river independence in the allocation scheme, and prioritizing demand on upstream over downstream sites. The new WEAP21 circumvents those shortcomings in addition to introducing further major advances including a modern Graphic User Interface (GUI), a modern more robust and efficient solution algorithm for solving the water allocation problem, and the integration of hydrologic sub-modules that include a conceptual rainfall runoff, a sedimentary groundwater model, and a stream water quality model (Rosenzweig et al., 2004). The WEAP model which was initiated, developed, and maintained by the Stockholm Environment Institute (SEI), operates at a default time step of a month assuming the basic principles of water balance accounting. Different supply sources (e.g. rivers, groundwater, and reservoirs), withdrawals, water demands, and ecologies were taken into account (Raskin et al., 2001).

2. Selecting the Implemented Model

Choosing the Applicable Mode. There are many numerical models available for simulating surface water and groundwater management. These models have been reviewed, and the WEAP (Water Assessment and Planning) model has gained worldwide acceptance. It has been applied to numerous international problems and proven reliable. Accordingly, it was chosen to predict the annual water supply of the Euphrates River.

Historically, the WEAP model was developed in 1988. It is still under development by the Environment Institute of the Stockholm American Center at Tufts University in Somerville. WEAP is used in climate change studies and is applied by researchers and planners in many organizations worldwide. It is a modeling tool for water resource planning and can be used for policy analysis. WEAP simulates water demand, runoff, infiltration, and crop irrigation requirements. This is achieved through policy, climate, and technology changes(Rosenzweig et al., 2004).

2.1. Calibrating and Verifying Weap

WEAP was calibrated against an actual data set. It was then verified against a different actual data set. These data were obtained during the site visits from different governmental authorities and organizations.

2.2. The WEAP algorithm

The amount supplied to a demand site (DS) is the sum of

the inflows from its transmission links. (The inflow to the demand site from a supply source (Src) is defined as the outflow from the transmission link connecting them, i.e., net of any leakage along the transmission link)(Sieber et al., 2005).

$$DemandSiteInflow_{DS} = TransLinkOutflow_{Src,DS}, DS \tag{Eq.1}$$

The demand presented by some demand site (DS) is computed as the sum of the corresponding demands of all the bottom-level branches (Br) of that particular site(Sieber et al., 2005).

$$AnnualDemand_{DS} = \sum_{Br} (TotalActivityLevel_{Br} \times WaterUseRate_{Br}) \tag{Eq.2}$$

Unmet Demand

The amount of each demand site's requirement is not met, when some demand sites are not getting full coverage.

3. Description and input data

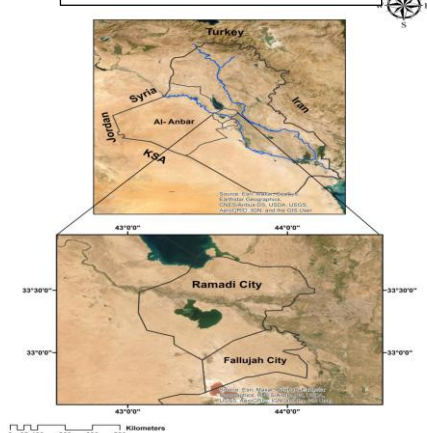
The agricultural demand for water in Iraq acquires the greatest portion, taking into account the horizontal and vertical expansion in the agricultural areas, mean cultivating new lands and increasing the average productivity per unit alone, the agricultural area to meet the growing demand for agricultural production and achieving self-sufficiency that requires identifying irrigated crops with the average productivity per of crops and the amount of agricultural production required to be achieved for all of these crops(The Unified Arab Economic Report, 2003). Our study will be only for arable lands that depend on the Euphrates in irrigation.

What is sown in the province during the summer and winter seasons is estimated at (500) thousand dunums or (125) thousand hectares. Including the following crops (wheat, barley, Clover, winter vegetables, yellow corn, white corn, jet, summer vegetables, sesame, palm, and fruits)(Anbar & Agriculture Directorate, 2020). Agricultural drainage water is the quantities of water that comes out from the area of the roots of crops and originally resulting from washing the soil after irrigation operations. Its quantities are estimated at 15% of the amount of irrigation water provided to the plants. To reach groundwater reservoirs, many countries have begun to reuse this water for irrigation in some regions of the world due to the scarcity of fresh water.

A WEAP model was implemented, the spatial scope, which includes the cities of Ramadi and Fallujah, was represented by one node and one administrative region on the map within the WEAP model, and an annual time step was used as shown in Figure (2). and data on the annual flows of the Euphrates River and the water allocation for the study area were entered. In addition, data on agricultural areas, water requirements, consumption, and losses for each crop grown in the study area were entered, as shown in the figure (3,4).

Agriculture in Anbar province depends on Surface irrigation and pumping or on wells, Springs, and rain in limited quantities (Planning et al., 2013).To calculate the annual agricultural demand for water, you must know the annual total need for each crop, where data were obtained for the total water requirement of the crop that includes (water consumption, field losses, transport losses, field capacity) in table (1) as showing the total water requirement for each crop. The (2) table shows the average annual net irrigation rates (mm). The (3) table shows the average agricultural pattern in Anbar Governorate (%) (Requirements, 2014).

Figure 1. Study area



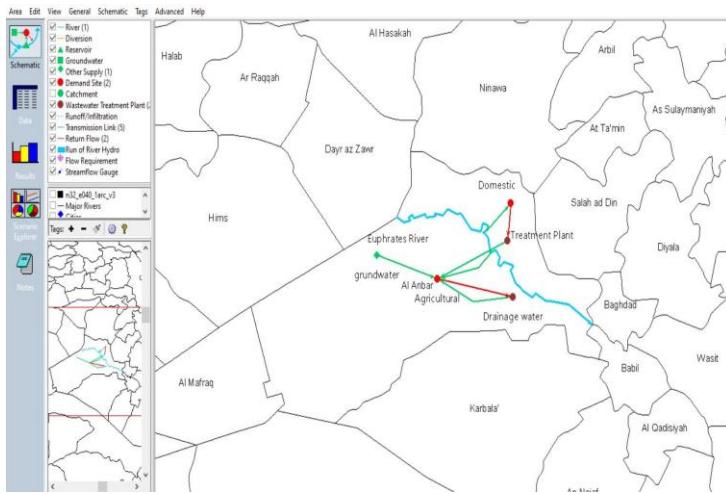


Figure 2. The figure shows applying the WEAP model and supplying the market to supply and demand scenarios in the study area.

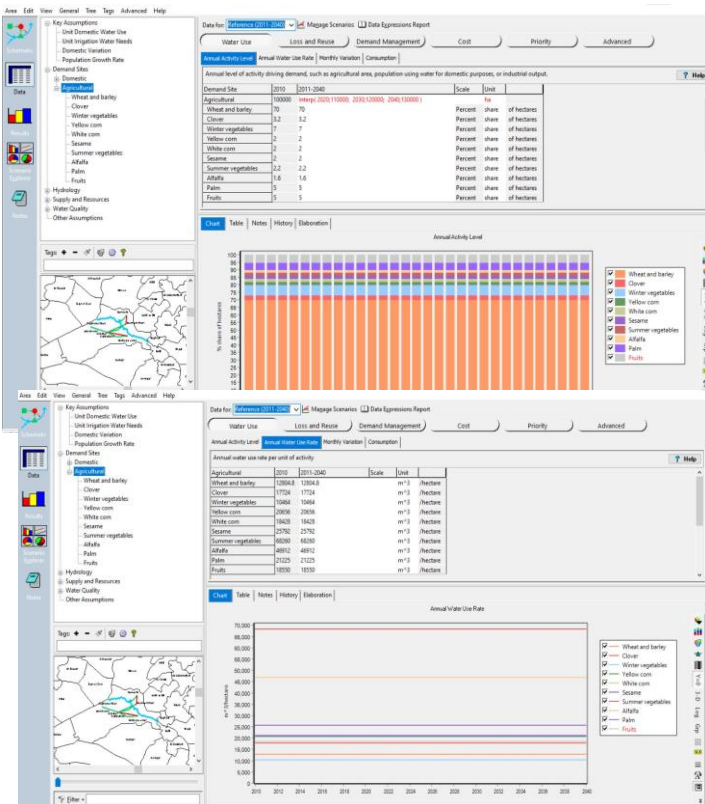


Figure 3. The figure shows the agricultural areas for each crop in the study region.

Table 1. Shows the agricultural areas used in the agricultural sector.

Crop type	Water requirements (m ³ / dunum)	Water requirements (m ³ / hectare)
1-Wheat	3201.2	12804.8
2-Barley	3201.2	12804.8
3-Clover	4431	17724
4-Winter vegetables	2616	10464
5-Yellow corn	5239	20956
6-White corn	4607	18428
7-Sesame	6448	25792
8-Summervetables	17065	68260
9- alfalfa	11728	46912
10-Palm	5306	21225
11-Fruits	4637	18550

Table 2: Average annual net irrigation rates (mm)

Winter crops		Summer crops			Perennial Crops		
Wheat	386	Cotton	1177	Potatoes (Spring)	616	Vineyards	1325
Barley	339	Sesame	954	Fodder (Maize/Sorghum)	1298	Orchards	1569
Berseem	518	Safflower	409	Tobacco	1259	Alfalfa	1840
Linseed	429	Maize for grain	757	Sunflower	748	Date Palms	1827
Beans (grain)	365	Sorghum (grain)	1015	Sugar beet	1300		
Sugar beet	738	Green gram	1012	Tomatoes	1221		
Vegetables	372	Rice (Anbar)	1420/2628	Eggplants	1251		
Potatoes (Autumn)	399	Watermelon	964	Okra	1322		

Table 1.3: Average cropping pattern for Anbar province (%)

Winter crops (69.3)		Summer crops(27.5)		Perennial crops (14.9)	
Wheat	36.3	Cotton	9.6	Perennial plants	8.3
Barley	13.9	Sesame, sunflower	1.8	Perennial grass	6.6
Grain, legumes	4.5	Millet, sorghum, maize	2.7		
Green fodder mixtures	2.4	Grain, legumes	2.1		
Linseed	1.4	Potato	1.0		
Vegetables	2.5	Vegetables	5.8		
Potato	1.2	Cucurbits	3.7		
Berseem	7.1	Other crops	0.8		

RESULTS ANALYSIS AND DISCUSSION

The results were obtained, analyzed, and graphically represented in Figures 5 through 9, as follows:

Figure 5 illustrates the flow of the Euphrates River from 2008 to 2040. The results indicate a continued decline in the river's future discharge due to climate change, drought, and unsound water policies among countries. Figure 6 presents the projected future water demand for the first reference scenario in Anbar within the agricultural sector for the year 2008. The figure also indicates the water requirement for each crop, which reached 1,975.2 million cubic meters. Figure 7 presents the projected future water demand from 2008 to 2040 within the agricultural sector. The projected water demand exceeds 2,500 million cubic meters, prompting us to consider solutions and alternatives to meet future demand while continuing to expand agricultural land. This highlights the significant difference in water demand between the past and future. Figure 8 emphasizes the unmet future demand for the reference scenario within the agricultural sector. The WEAP model provides future projections of unmet water demand, with the amount of unmet water reaching 153.19 million cubic meters in 2040. This gives us predictive figures and quantities for future water needs, indicating a significant risk of water scarcity. The agricultural sector consumes the largest amount of water due to the expansion of agricultural land, the high consumption of crops, and the reliance on surface water alone in this region. Figure 9 illustrates the second scenario: reusing agricultural drainage water to irrigate certain crops to alleviate the unmet water demand. The amount of treated water under this scenario in 2040 is estimated at 273.3 million cubic meters.

- Agricultural drainage water can be used for re-irrigating some crops, but this depends on the crop type, its salt tolerance, and the irrigation method. It can be used for barley, cotton, and alfalfa, where the estimated 273.3 million cubic meters of treated water can irrigate 60,733 hectares. This method can also be used for less sensitive trees, such as olives and pomegranates, to irrigate 45,550 hectares.
- The projected decline in water availability from 2008 to 2040 depends on climatic conditions, water scarcity, the sharp decline in surface water levels (Euphrates River), and the central government's agricultural investment plan to expand cultivated areas.
- Using agricultural drainage water offers several benefits, including reducing pressure on freshwater resources and lowering the cost of fertilizers containing essential nutrients like nitrogen and phosphorus.
- Wastewater can be treated using several low-cost methods, including natural wetland treatment, sedimentation and evaporation ponds, physical treatment such as filtration, and chemical treatment such as condensation and flocculation. For the study area in Anbar Governorate, a sustainable and low-cost treatment method is suitable, along with an appropriate irrigation system such as mixing, drip, wetland, and filtration.
- It is expected that using this scenario will provide 20% of the treated supplemental water needed for irrigating the required agricultural areas.

This study was conducted in a WEAP model from the year 2008 to the year 2040. Data on the annual inflow of the Euphrates River water entering Anbar Province were obtained at Al-Qaim city Station for several years as shown in Figure 5.

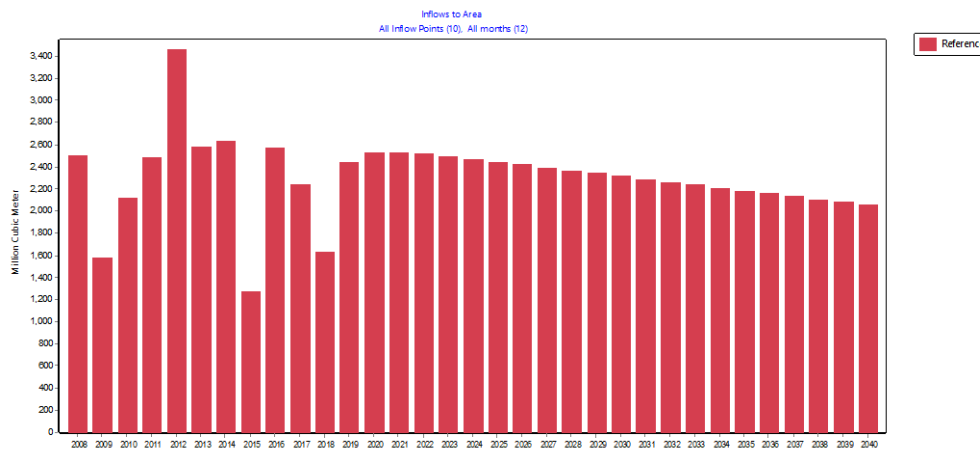


Figure 5. The annual water inflow of the Euphrates River in Anbar province.

After entering the agricultural areas and the water requirement for each crop, we will calculate the total water demand for the agricultural sector in the year 2008, as shown in the figure (6).

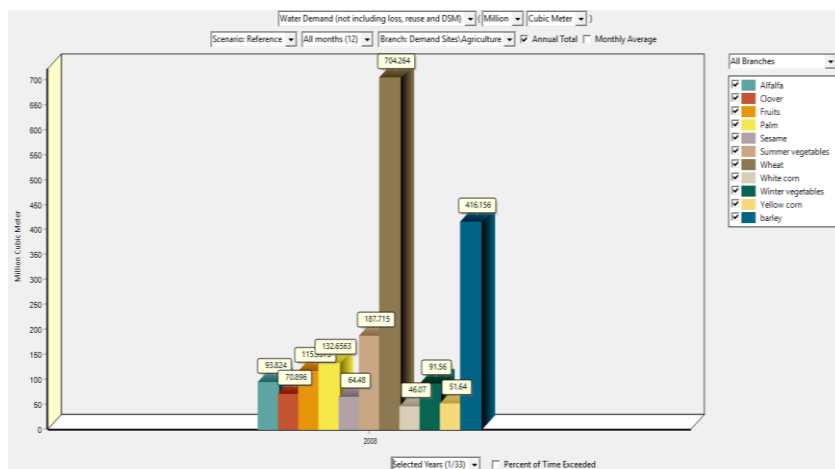


Figure 6. Water demand for agricultural crops in Anbar province for the base year 2008.

In the reference scenario, the results indicate that the demand for water for the agricultural sector in the future was 1975.2 million cubic meters, which is the same amount of demand in the base year, since the cultivated areas and crops have not changed. Figure (7) shows the results of water demand for the agricultural sector in Anbar province.

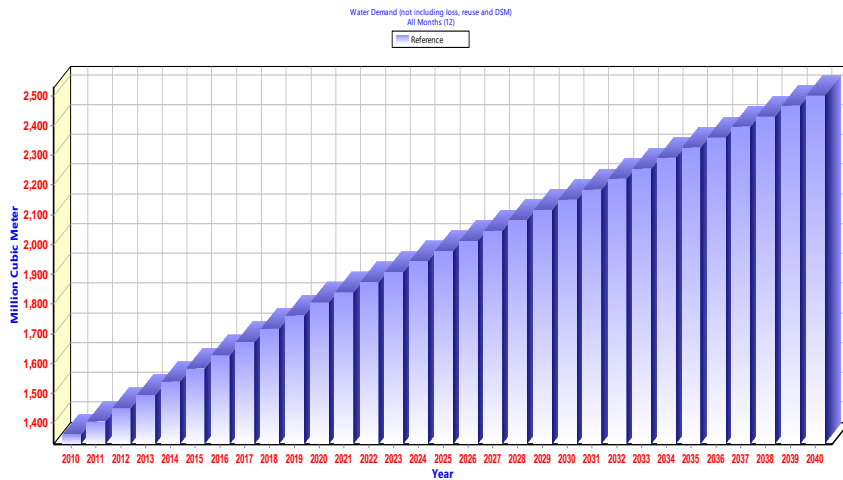


Figure 7. Results of future water demand for the agricultural sector for the reference scenario in Anbar province.

In figure (8) shows the results of the unmet demand for the agricultural sector in Anbar province. Where the variation appears in the amount of unmet demand for water due to the differences and change in the annual inflow of the Euphrates river.

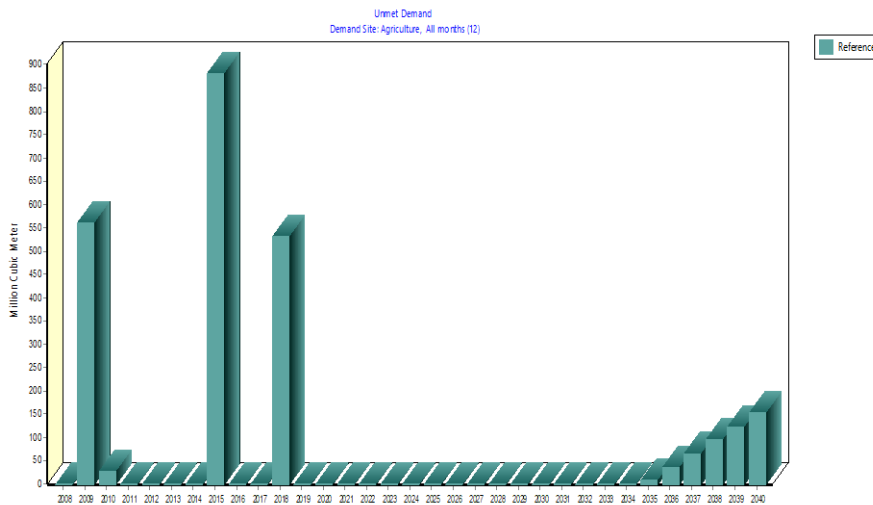


Figure 8. Results of unmet demand for water for the agricultural sector in the future for the reference scenario in Anbar province.

In the scenario of using agricultural drainage water, the results in Figure (9) indicate the possibility of making use of the water that is surplus to the plant's need and leaking into the drainage for reuse in the agricultural sector after carrying out the necessary treatment for that water.

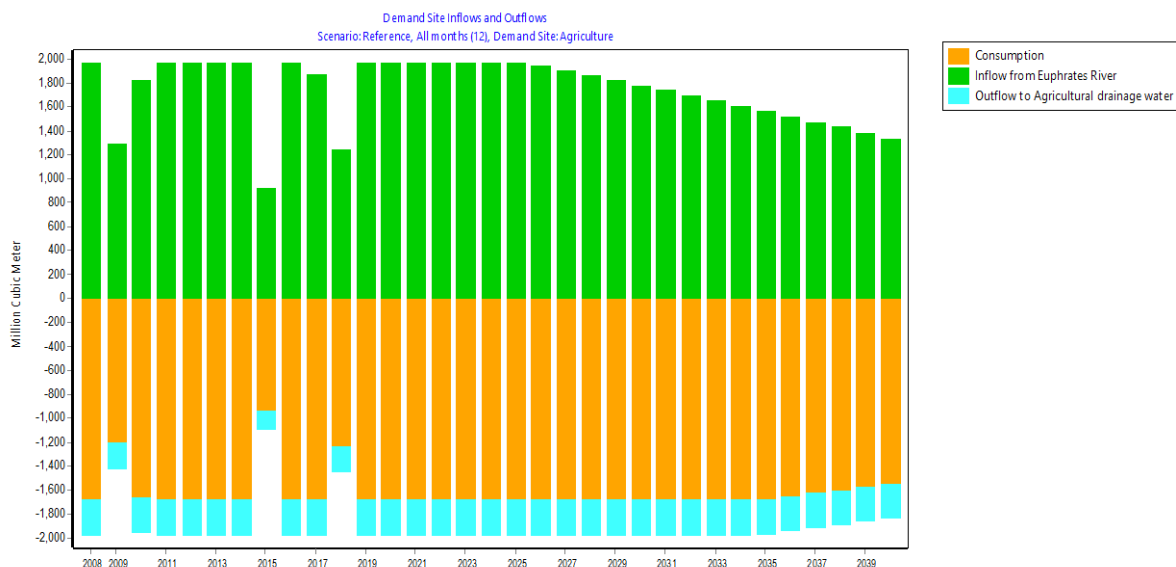


Figure 9. Results of agricultural drainage water and actual consumed water in the future for the agricultural sector in Anbar province.

Conclusions

The Water Assessment Model (WEAP) was used to estimate the amount of water demand for the agricultural sector and the amount of future agricultural drainage water for the cities of Anbar province in Iraq. Based on the results obtained from this study, the following can be concluded:

- In the reference scenario, the demand for water for the agricultural sector in the year 2040 was 1975.2 million cubic meters.
- In the reference scenario, the unmet demand for water from the agricultural sector in 2040 was 153.19 million cubic meters.
- In the agricultural drainage water scenario, the amount of agricultural drainage water that could be used to irrigate agricultural areas in the year 2040 was 273.3 million cubic meters.

This study demonstrates that agricultural drainage water reuse is a viable option for mitigating water scarcity and enhancing water sustainability, provided that appropriate treatment levels are applied according to the intended agricultural use. The results indicate that at least secondary treatment, in addition to targeted remediation where necessary, is essential to ensure compliance with irrigation water quality standards.

Successful implementation also depends on the availability of adequate infrastructure, including treatment facilities, transport and distribution networks, and effective operation and monitoring frameworks.

This study is subject to several assumptions and limitations, including the assumption of constant irrigation efficiency, simplified drainage flow estimation, exclusion of dynamic water quality variations, data uncertainties, and the implications of model simplification. Therefore, the results should be interpreted as indicators, not predictions. Future research should focus on integrating dynamic water quality modeling, uncertainty analysis, and improved representation of irrigation and drainage processes to support more informed decisions.

Recommendations

Based on the findings, the following recommendations were proposed:

- Implementing an agricultural drainage water system to reduce water scarcity and achieve promising integrated management in the agricultural sector, making it a supporter of surface water and a successful alternative in water resource management.
- Economic and environmental feasibility assessment of reuse.
- Implementing new solutions to enhance the utilization of surface water (such as reusing treated water and utilizing groundwater to achieve integrated management of all available water resources).
- Using modern irrigation methods to achieve sustainability in the agricultural sector, such as drip and sprinkler irrigation, as these are among the most modern methods for rationalizing water consumption, especially in terms of plant water requirements, and avoiding wasteful irrigation methods.
- Reusing agricultural drainage water, as large quantities of water are available that can be reused and reused for agricultural irrigation to achieve sustainable water management.
- Study of the impact of reuse on soil and crops.
- Using saline well water and mixing it with fresh water.

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- [1] Abbood, R. T., Mustafa, A. S., & Al-Somaydai, J. A. (2023). Investigations of Groundwater and Soil Specification at AL-Warrar Canal Reach, Ramadi City-Iraq. *IOP Conference Series: Earth and Environmental Science*, 1222(1). <https://doi.org/10.1088/1755-1315/1222/1/012013>
- [2] Anbar, G., & Agriculture Directorate, P. and F. S. (2020). *Unpublished data*.
- [3] Ayed, B., Khlif, N., Jmal, I., & Bouri, S. (2022). Integration of GIS and WEAP models for groundwater resource management in arid regions: case of the Djeffara-Medenine shallow aquifer (Southeastern Tunisia). *Arabian Journal of Geosciences*, 15(10), 994. <https://doi.org/10.1007/s12517-022-10277-1>
- [4] Badri, B. H. A., & Muhammad, A. A. (2007). *Water Crisis and its Influence on Agricultural Sector in Iraq for the period (1990-2007)*.
- [5] Falah, J. A. (2011). *USING THE DRAINAGE WATER FOR IRRIGATION OF COTTON GROWTH*.
- [6] Fleifle, A. E., Saavedra Valeriano, O. C., Nagy, H. M., Elfetiany, F. A., Tawfik, A., & Elzeir, M. (2013). 6Simulation-Optimization Model for Intermediate Reuse of Agriculture Drainage Water in Egypt. *Journal of Environmental Engineering*, 139(3), 391–401. [https://doi.org/10.1061/\(asce\)ee.1943-7870.0000605](https://doi.org/10.1061/(asce)ee.1943-7870.0000605)
- [7] Hammadi Al- Shaabani, M. M., & Nashed, R. S. A. (2025). Effects of Climate Change on Drainage and Water Security of the Euphrates River in Iraq: Challenges and Prospects for the Future. *Journal of Tikrit University for Humanities*, 32(3.6), 112–134. <https://doi.org/https://doi.org/10.25130/jtuh.32.3.6.2025.6>
- [8] Husainiya, A.-. (2011). *EVALUATION OF THE DRAINAGE WATER QUALITY AT THE NORTH PART OF BAGHDAD CITY AND SUITABILITY FOR*.
- [9] Iraq Country Water Resource Assistance Strategy : Addressing Major Threats to People's Livelihoods. (2006). *Iraq Country Water Resource Assistance Strategy : Addressing Major Threats to People's Livelihoods*, 36297. <https://doi.org/10.1596/19449>
- [10] Jaber, S. I. K. and A. A. W. (2015). Evaluate the viability of the western Levantine drainage water for irrigation purposes. *University of Babylon / Engineering Sciences*, 23(1).
- [11] Mohammad, S., & Mustafa, A. (2020). *Sustainable Management of Water Resources in The Upper Euphrates Basin-Iraq*. 4, 308–317.
- [12] Mustafa, A. S., Sulaiman, S. O., & Hussein, O. M. (2016). Application of swat model for sediment loads from valleys transmitted to Haditha reservoir. *Journal of Engineering*, 22(1), 184–197.
- [13] Noon, A. M., Elmolla, A. M., Mohamed, M. I., & Mustafa, A. S. (2022). Investigating Water Demand under Different Irrigation Techniques Numerically in Al-Anbar Province-Iraq: A Case Study. *Environment and Ecology Research*, 10(5), 592–606. <https://doi.org/10.13189/eer.2022.100507>
- [14] Noon, A. M., Elmolla, A. M., Mohamed, M. I., & Mustafa, A. S. (2024). Integrated Approaches to Water Resource Management in Anbar Province, Iraq: Strategies for Addressing Scarcity and Enhancing Agricultural Sustainability. *International Journal of Design and Nature and Ecodynamics*, 19(6), 2161–2170. <https://doi.org/10.18280/ij dne.190632>
- [15] Planning, M. of A., Statistical, "Agricultural, Organization, Statistical, C., & Baghdad. (2013). *Unpublished data*.
- [16] Raskin, P., Sieber, J., & Huber-Lee, A. (2001). *Water Evaluation and Planning System: User guide for WEAP 21*. Tellus Institute, Boston, MA, 15.
- [17] Raskina, P., Hansen, E., Zhu, Z., & Stavisky, D. (1992). Simulation of water supply and demand in the aral sea region. *Water International*, 17(2), 55–67. <https://doi.org/10.1080/02508069208686127>
- [18] Requirements, C. W. (2014). *Strategy for Water and Land Resources in Iraq CONFIDENTIAL APPENDIX F – WATER DEMAND REPORT F . 3 - AGRICULTURAL WATER DEMAND* -. 6.
- [19] Resources, M. of W. (1996). *Water balance of natural resources*. 211.
- [20] Rosenzweig, C., Strzepek, K. M., Major, D. C., Iglesias, A., Yates, D. N., McCluskey, A., & Hillel, D. (2004). Water resources for agriculture in a changing climate: International case studies. *Global Environmental Change*, 14(4), 345–360. <https://doi.org/10.1016/j.gloenvcha.2004.09.003>
- [21] Mustafa, S. A. (2009). Evaluation of Water Quality Parameters in the Euphrates River within Ramadi City and Al-Dhiban Canal. *Journal of University of Anbar for Pure Science*, 3(2), 100–109. <https://doi.org/10.37652/juaps.2009.15285>
- [22] Saeed, S. F., Mustafa, A. S., & Aukidy, M. Al. (2021). Assessment of Flood Frequency Using Maximum Flow Records for the Euphrates River, Iraq. *IOP Conference Series: Materials Science and Engineering*, 1076(1), 012111. <https://doi.org/10.1088/1757-899x/1076/1/012111>
- [23] Sieber, J., Swartz, C., & Huber Lee, A. (2005). *WEAP (Water Evaluation and Planning System), User guide for WEAP21*. Stockholm Environment Institute, U.S. Center, USA.
- [24] Sulaiman, S.O., Najm, A.B.A., Kamel, A.H., Al-Ansari, N. (2021). Evaluate the optimal future demand of water consumption in Al-Anbar province in the west of Iraq. *International Journal of Sustainable Development and Planning*. *International Information and Engineering Technology Association*, 16(3), 457–462. <https://doi.org/https://doi.org/10.18280/ij sdp.160306>
- [25] *The unified Arab economic report*. (2003). 33.