EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology 2023, 24(9), 337–346
https://doi.org/10.12912/27197050/174224
ISSN 2719-7050, License CC-BY 4.0

Received: 2023.10.09
Accepted: 2023.10.23
Published: 2023.11.15

Investigation and Analysis the Activity of Al-Hindiya Barrage for the Water Demand Issue in Babylon Province, Iraq

Wisam S. Jaber[1], Zainab A. Omran[1*], Saif S. Alquzweeni[1]

[1] Department of Civil Engineering, College of Engineering, University of Babylon, Hilla, Iraq
* Corresponding author's e-mail: eng.zainab.ali@uobabylon.edu.iq

ABSTRACT

The Euphrates River faces seasonal changes in water flow in spring, the formations of snowmelt on mountains start to melt leading to increase water levels. In other hand, the water stream flow tends to shrinkage during the draught in the hot months. Climatic patterns, that contain the droughts and the raising of temperatures, influence the water levels. Al-Hindiya Barrage is the main regulation system that provides the water quantities toward Al-Hilla River stream. The fluctuation in water sharing can negatively impact the required productivity of water. The study aimed to build management system for water sharing in Babylon Province that can be used for improve the plan to conserve water demand in domestic and agriculture requirements. The study processed the analysis and modeling by starting of collecting initial data of the average flow rates in Euphrates River toward the Al-Hindiya Barrage for the past ten years. The data also included the annual production of the main crops according to the areas bounded Al-Hilla River. The population growth was calculated for the years up to 2048 then the daily water demand and the water demand for agriculture were determined for the future years and curve fittings were applied to get the correlation equations. The investigation of the water requirements for the main crops (wheat, barely, and corn) was satisfied. The study used the equations of correlation for daily water demand and for crops production to derive Water Demand Index WDI for summer and winter to enhance the water sharing management in the water distribution system. The water demand for agriculture were estimated for the regions in Babylon province: (Hilla City, Abi Gharaq, Al-Hindiya Barrage, Al Midhatiya, Al Hashimiyah, and Al-Qasim). The study achieved in the explanation of WDI two goals: first was managing of water sharing for better conserving, and second was the availability of extra water quantities to be stored for future using.

Keywords: Al-Hindiya Barrage, water demand index, population growth, crop production, Al-Hilla River, water share.

INTRODUCTION

Water sharing managing systems show an essential role in satisfying regions demand of water including equiTable supply and responsible use of water resources. Outstanding an equilibrium between agricultural irrigation, environmental preservation, and urban consumption. Positive water sharing management makes plans against climate challenges and reduces conflicts, safeguarding the water resource for future generations (Qureshi, 2018). The fast growing population, rising of irrigation regions, and increasing Industrialization and urban lands are putting extra stresses on the matter of water resources. The main problem of water lack in some cases been particular as the lower managing consideration on the irrigation demand (Hussain & Khoso, 2014). The managing of water sharing for the purpose of domestic and for irrigation purposes is an effective strategy to ensure the reaching for sustainable water usage. Efficient strategy involves the division of water resources for households and agricultural requirements, studying the demands of both urban and rural lands (Sirimewan et al., 2021). The domestic and agricultural water consumption must be analyzed to build the better plans for conserving water using. Balancing the requirements of households and farms lead to enhance water security and also supporting both agricultural productivity and daily living (Masseroni et al., 2020). Al-Hindiya barrage was built in the early 1950s and has played an important role in the development of Iraq's water and agriculture management systems (Abdullah & Al-Ansari, 2020). Its primary function is to control the velocity of the Euphrates River, ensuring a steady supply of water for irrigation in the surrounding areas. Al-Hindiya Barrage is an important infrastructure project in Iraq, helping as a water resource management structure, flood control measure, and regional source of hydroelectric power (Saleh et al., 2021) (Al-Saati et al., 2021) . The situation of the climate of Iraq is dry and hot in summer and cold in winter so that Iraq is approximately higher than 48 degrees C in August and near to freezing in January (Abd El Mooty et al., 2016). By efficiently assigning and conserving water resources, address the challenges of population growth and weather state can be important scope to improve the water management system. The matter of agricultural practices and the urban planning can show effective water demand management (Talpur et al., 2023). The active work in this branch can include safeguarding this valuable resource for generations, encouraging the sounds for environmental health, and developing a balanced and strong global water system (Yang et al., 2020).

The study built analysis and modeling processes for the quantities of water that arrived from Al-Hindiya barrage toward Al-Hilla River by identifying the fluctuant of water share demand for daily uses and for agriculture in Babylon province. The population growth was considered and determined up to the year 2048 then indices were derived to improve the water management system for the hot and cold seasons.

METHODOLOGY

Collection of data

The sharing of water that can be produced by Al-Hindiya barrage is important for feeding A-Hilla River that passes throw the main fields in Al-Hilla City. The study took into account the contribution of the water sharing for two main lines of consumption. The two lines were the daily water demand based on the population of Al-Hila city and the water requirement for the agriculture of the main plants in the city which are (wheat, barley, and corn). Accroding to Iraqi Ministry of Water Resources, The average water demand was classified into summer and winter magnitudes, the values of these demands are 380 and 220 l/c/day respectively. These main crops that Babylon province is known for agriculture and production of these types of crops (Dhahir, 2019; Ewaid et al., 2020; Ahmed et al., 2020). The plan view in Figure 1 was made by using the Google Earth pro program for the zone of Al-Hindiya Barrage. The Figure explained clearly the stream of the barrage toward Al-Hilla River. The formation of the upstream area before the barrage was showed in Figure 2. The Figure was built by using the elevation database of the barrage region based on Earth Google Pro and processed these data by using ArcGIS pro

Fig. 1. The plan view of Al-Hindiya barrage Zone

Fig. 2. The formation of the upstream area for Al-Hindiya barrage Zone

program. The Figure illustrated the division of the water body in the barrage barrier toward al-Hilla River and the continuity of Euphrates River. The average data of inflow rates for the past ten years were showed in Table 1, the data were obtained by the help of the Iraqi Ministry of Water Resources. The average inflow rates in Table 1 were used in the study as the source of water to Babylon Province so that the water demand must be less than these data for non-critical cases The places and quantities of the main crops production in Babylon province were obtained from the Iraqi Ministry of Agriculture, the places in the province were explained in Figure 3 by using Google Earth pro, the data of production and the total production for the crops of (wheat, barley, and corn) were listed in Table 2. The data in Table 2 were so important to examine the available water shares and how these shares can lead to the required crop production.

Table 1. The average inflow rates of Al-Hindiya barrage

Month	Q m^3/s
October	248
November	181
December	150
January	148
February	135
March	162
April	171
May	212
June	380
July	372
August	318
September	295

Determination of Population Growth

The population of Babylon Province according to the Iraqi Ministry of Planning is 2190351 capita in 2022. The rate of population is 3% so that for number of years coming, the population can be calculated according to the exponential growth rate as following (Hathout, 2013) (Al-Eideh & Al-Omar, 2019):

$$n_t = n_0 \, e^{r\,t} \tag{1}$$

where: n_t – the population at time t in years; n_0 – the population at current years; r – the rate of population growth; t – the time in years.

According to Eq. 1, The population growth for the years up to 2048 in Babylon province was explained in the following Figure:

Deriving of indices

For analyzing the requirement of water demand according to the inflow rates quantities based on the winter and summer demand, the study supposed the term WDI which mean Water Demand Index to investigate and compare how the available water production can match the actual demand.

$$WDI = \frac{total\ demand}{total\ production\ of\ water} * 100\% \tag{2}$$

$$WD_{winter} = (21.354x - 42748) * 10^3 + (0.0443x - 88.711) * 353 * 10^3 \tag{3}$$

The value of WDI can be used to Figure out how the water share lead to exhaust the water body from Al-Hilla River. The value of WDI

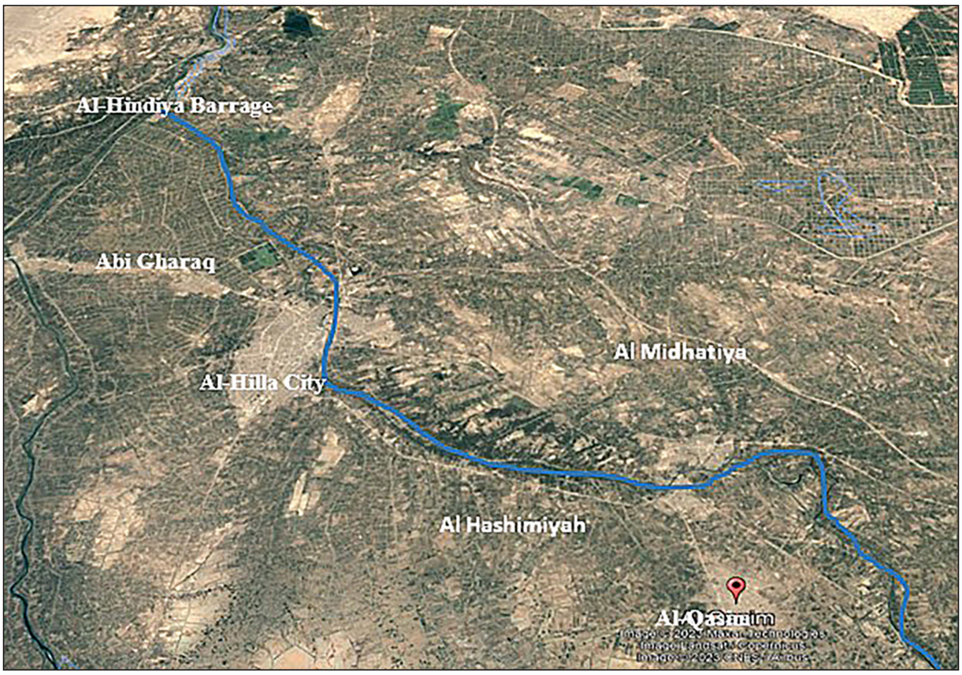

Fig. 3. The agriculture areas of main crops in Babylon Province

Table 2. The production of wheat, barely, and corn crops in the areas near Al-Hilla River

Place	Wheat (ton/year)	Barely (ton/year)	Corn (ton/year)
Hilla City	19960	2956	1861
Abi Gharaq	3942	1971	2585
Al-Hindiya Barrage	3853	1478	3619
Al Midhatiya	44767	2956	13441
Al Hashimiyah	6898	1478	2585
Al-Qasim	8869	1971	3619
Total	88288	12810	27709

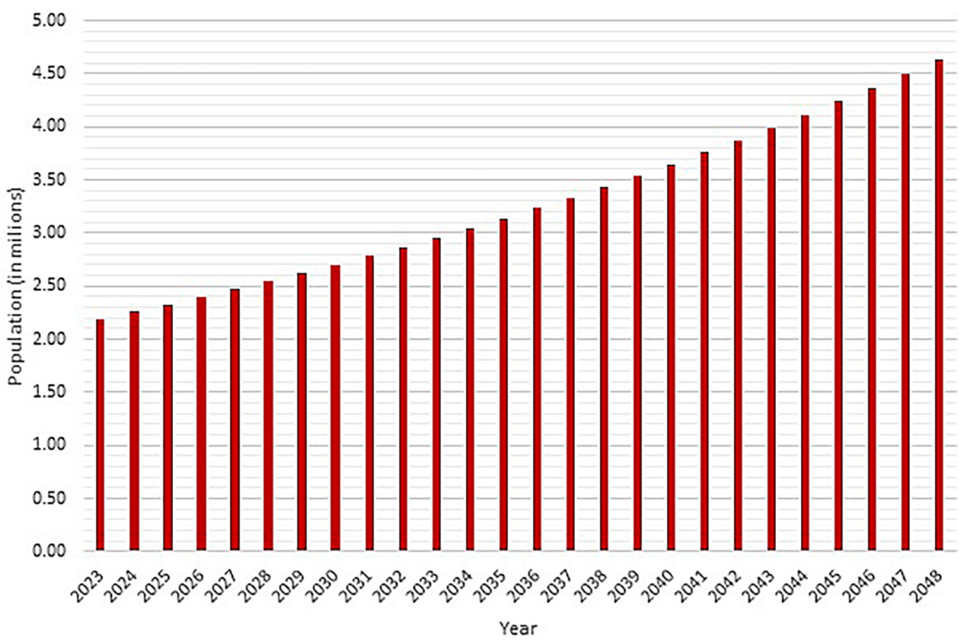

Fig. 4. The prediction of population growth in Babylon Province

must be as less as possible so the water source productivity can cover the required demand of water. The WDI can manage the availability of water storage plan to avoid drought cases.

RESULTS AND DISCUSSION

By using the population growth in Figure 1, The winter and summer water demand in (m^3/day) were calculated by multiplying the daily water demand per capita with the poplation value. The results for winter and summer including the correlation equations were showed in Figures 5 and 6 respectively. For deriving the water demnad indices, curve fitting analysis were made for the population growth data to get the corrleated equation. The results were explained in Figure 7. The water share percent for each place based on the data in Table 2 were converted to the percent of water share by dividing the share of each place by the total sharing. These process can give more figurative view about the productivity of places in Babylon Province for water management system. The results of water sharing percents were illustratred in Table 3. From Table 2 based on the data from the Iraqi Ministry of Agriculture, the crop production for the main crops in Babylon Province were (88288 ton/ year for wheat, 12810 ton/ year for barley, and 27709 ton/ year for corn. The average quantity of water needed for production one ton of crop is 1000 m^3. The water quantity needed per day for the crops production was calculated as: (88288 + 12810 + 27709)*1000/(365) = 353 *10^3 m^3/day. For satisfying the better water managent system with fair share of water, the following equations were derived for water demand (WD) related to the anasyslis processes and the correlation equations:

$$WD_{winter} = (21.354x - 42748) * 10^3 + (0.0443x - 88.711) * 353 * 10^3 \quad (3)$$

$$WD_{summer} = (36.885x - 73837) * 10^3 + (0.0443x - 88.711) * 353 * 10^3 \quad (4)$$

The WDI then can be calculated from the following formula:

$$WDI = \frac{WD}{Q_{av}} * 100\% \quad (5)$$

where: WD – the water demand for specific seacon, Q_{av} – the average inflow rate.

The impact of the average inflow rates on the derived WDI were drawn in Figures 8 and 9 for winter and summer seasons.

As showed in Fig. 8 and 9, The WDI values were raised noticeably along the coming years, these values showed an index for the demand

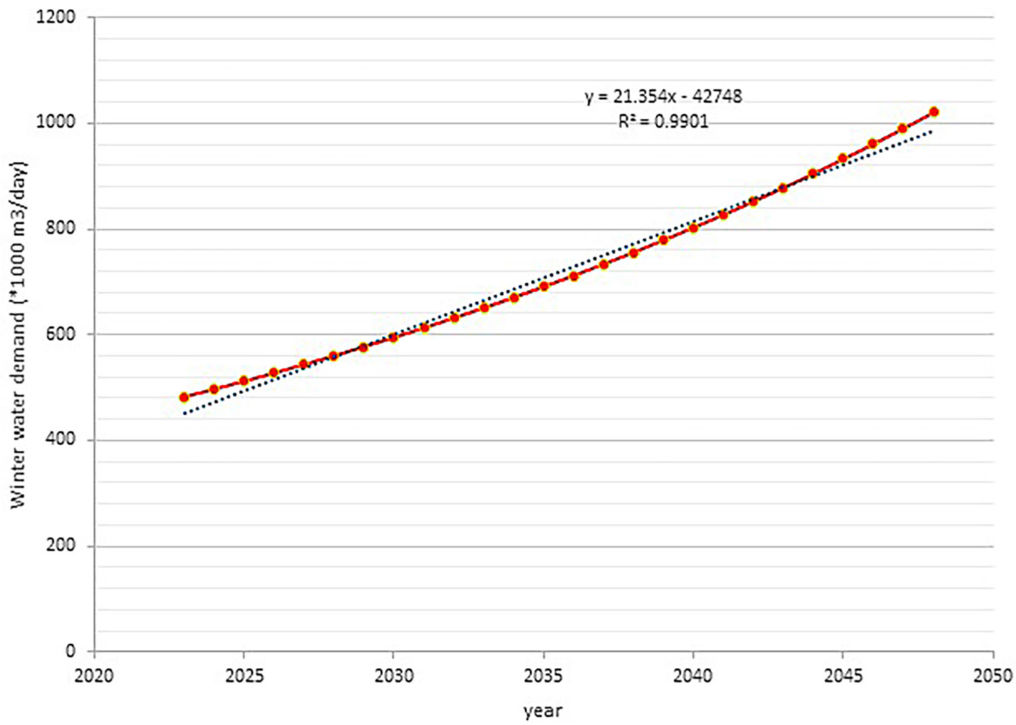

Fig. 5. The winter water demand increment in Babylon Province

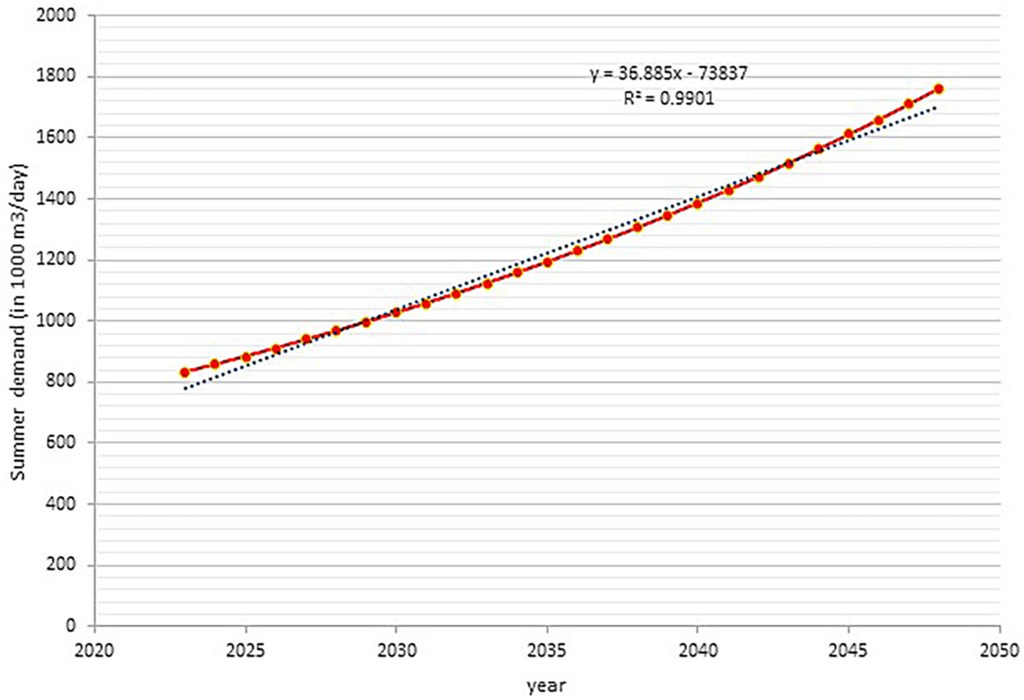

Fig. 6. The summer water demand increment in Babylon Province

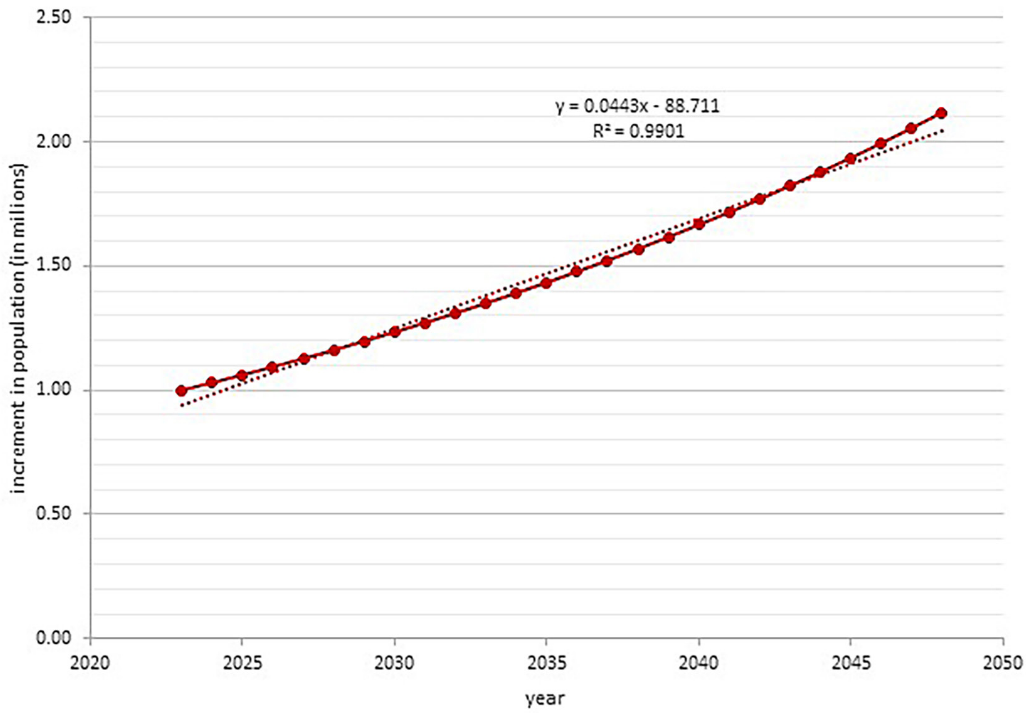

Fig. 7. Fitting the increment in population in Babylon Province

loading on the water share for production the main crops in the province. The magnitudes of water demand for agriculture purpose in the case study areas were determined based on the percent of water share, the quantity of water for crop production, and the population increment. The results were illustrated in Table 4 and Figure 10. The region of Al Midhatiya has the high water share quantity for agriculture system as these land located in the east of Al-Hilla River with large area relatively and also it include the heighest production of the main crops in Province. The

Table 3. The water share percents for wheat, barely, and corn crops in the areas near Al-Hilla River

Place	Water share for wheat (%)	Water share for barely (%)	Water share for corn (%)	Total share (%)
Hilla City	23	23	7	17
Abi Gharaq	4	15	9	10
Al-Hindiya Barrage	4	12	13	10
Al Midhatiya	51	23	49	41
Al Hashimiyah	8	12	9	10
Al-Qasim	10	15	13	13

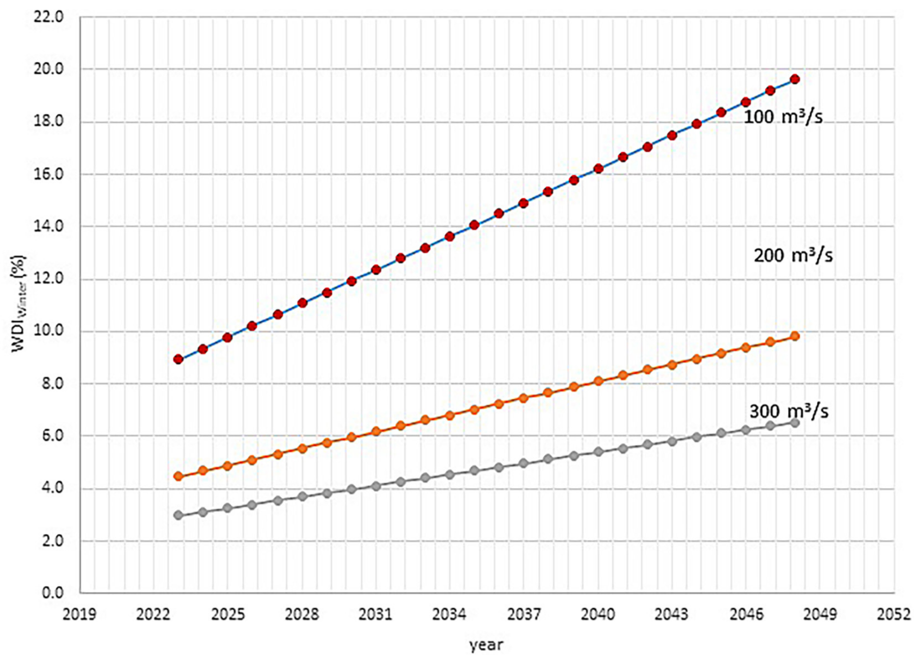

Fig. 8. The WDI_{Winter} values according to the inflow rates

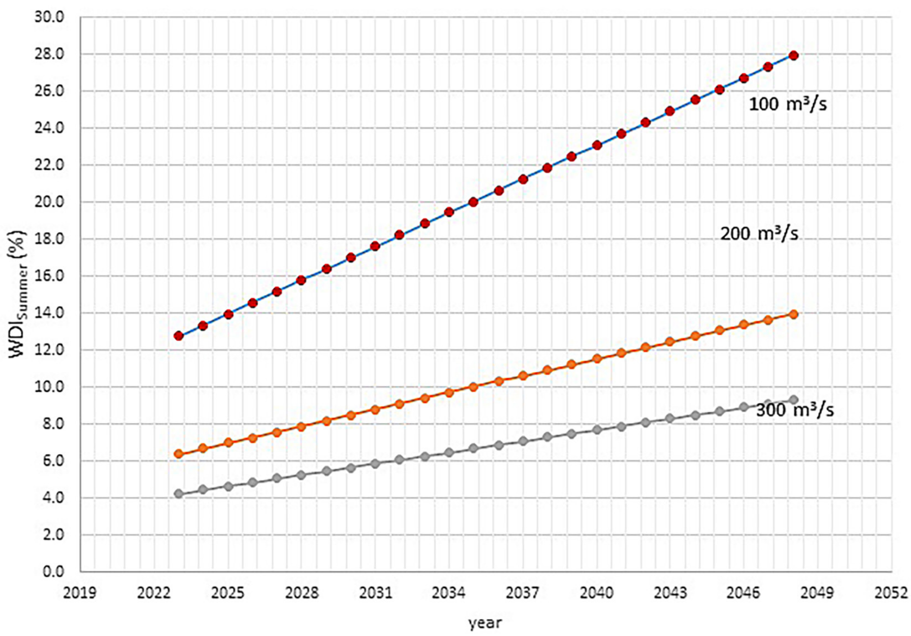

Fig. 9. The WDI_{Summer} values according to the inflow rates

Table 4. The magnitude of water demand (*1000 m3/day) for agriculture purpose in the case study areas

Year	Hilla City	Abi Gharaq	Al Hindiya Barrage	Al Midhatiya	Al Hashimiyah	Al-Qasim
2023	56.0	31.2	30.9	130.6	30.6	41.1
2024	58.7	32.7	32.4	137.0	32.1	43.1
2025	61.4	34.2	34.0	143.4	33.6	45.1
2026	64.2	35.7	35.5	149.8	35.1	47.1
2027	66.9	37.3	37.0	156.1	36.6	49.1
2028	69.6	38.8	38.5	162.5	38.1	51.1
2029	72.4	40.3	40.0	168.9	39.6	53.2
2030	75.1	41.8	41.5	175.3	41.1	55.2
2031	77.8	43.3	43.0	181.6	42.6	57.2
2032	80.6	44.9	44.5	188.0	44.1	59.2
2033	83.3	46.4	46.0	194.4	45.6	61.2
2034	86.0	47.9	47.5	200.8	47.1	63.2
2035	88.8	49.4	49.1	207.1	48.6	65.2
2036	91.5	50.9	50.6	213.5	50.1	67.2
2037	94.2	52.5	52.1	219.9	51.6	69.2
2038	97.0	54.0	53.6	226.3	53.1	71.2
2039	99.7	55.5	55.1	232.6	54.6	73.2
2040	102.4	57.0	56.6	239.0	56.1	75.2
2041	105.1	58.5	58.1	245.4	57.5	77.2
2042	107.9	60.1	59.6	251.8	59.0	79.2
2043	110.6	61.6	61.1	258.1	60.5	81.2
2044	113.3	63.1	62.6	264.5	62.0	83.3
2045	116.1	64.6	64.2	270.9	63.5	85.3
2046	118.8	66.2	65.7	277.3	65.0	87.3
2047	121.5	67.7	67.2	283.6	66.5	89.3
2048	124.3	69.2	68.7	290.0	68.0	91.3

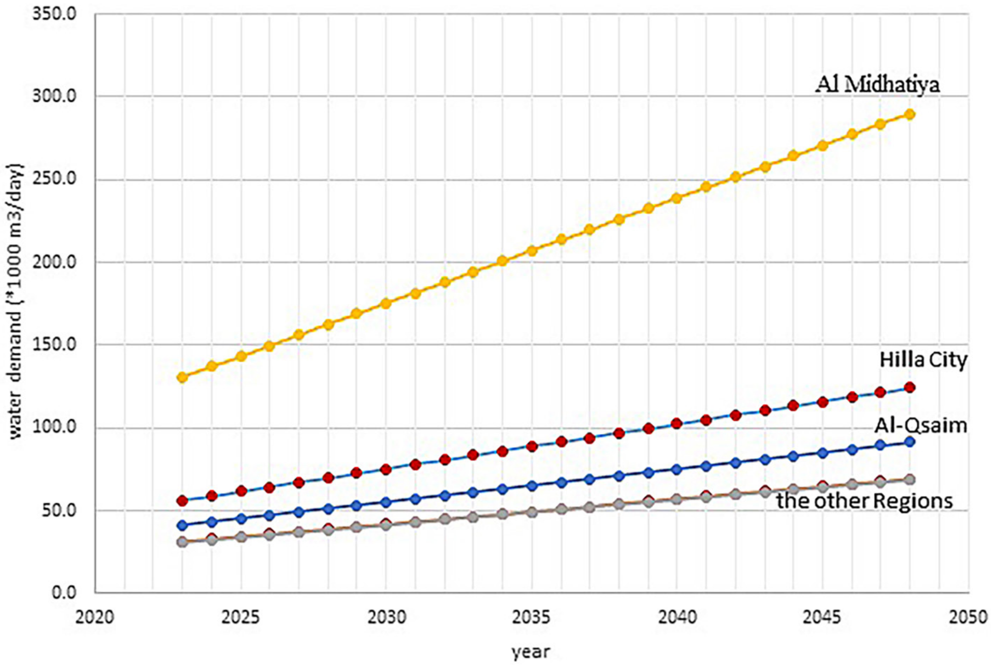

Fig. 10. The water share demand (m3/day) in the case study areas

magnitude of water demand for agriculture was calculated by the following:

$$\textit{Water demand for agriculture} = (0.0443x - 88.711) \cdot 353 \cdot \textit{the percent of water share} \quad (6)$$

where: x – the year of calculation, and the percent of water share can be get from Table 3.

CONCLUSIONS

The analysis and modeling of the water sharing were made from Al-Hindiya Barrage toward al-Hilla River for feeding the water requirement of domestic water demand and the main crops growth purpose. The study found that the water share can be assumed in three important classes relating to the inflow rates and the barrage capacity. The classes were 100, 200, and 300 cubic meter per second. The demand loading was calculated for the main domestic consumption and the agriculture for the main crops. The study classified the productivity source of the main crops (wheat, barely, and corn) according to the region of agriculture in Babylon Province. The study found that the magnitudes of water demand index for summer (WDI_{Summer}) as the inflow rate is 100 m3/s can reach to high values (about 30% of the Hilla River water share). These values can exhaust more water body from the river and lead to great decrease in the water depth which can reflect negatively the water treatment units and impact the other water uses. The study built number of charts to improve the water sharing controlling for the related areas in current and future. The water sharing conserving can be achieved by reducing the extra demand by public awareness system and by using advance watering system in the field based on the plant water fingerprint. The development of better storage system in the farmers and in the municipal area can assist the controlling of the demand issue by using the data of WDI in winter and get the benefit in the storage portion of the extra water quantities to be used in draught time. The study drive equation for WDI in winter and summer and also for the daily water demand to ease the managing the water distribution system.

Acknowledgements

Analysis and modeling the water management system in Iraq can be handled in future studied in the way of designing water storage system in number of suiTable places in the middle and south of Iraq, these types of studies lead to important benefits as the water sharing can head severe deficit based on the lack of water resources production quantities. The developing of advanced irrigation systems and the sustainable using of the water sharing can be adopted in studies to improve the goals of water conserving.

REFERENCES

1. Abd El Mooty, M., Kansoh, R., Abdulhadi, A. 2016. Challenges of Water Resources in Iraq. Journal of Waste Water Treatment & Analysis, 07(04). https://doi.org/10.4172/2157-7587.1000260
2. Abdullah, M., Al-Ansari, N. (2020). Irrigation projects in Iraq. Journal of Earth Sciences and Geotechnical Engineering, 11(2), 35–160. https://doi.org/10.47260/jesge/1123
3. Ahmed, A., Al, H., Hassoon, A.S., Adnan, A., Alaameri, K. 2020. Effect Of Variety And Planting Date On Growth And Yield Of Barley. April, 4–8. https://doi.org/10.13140/RG.2.2.28756.42886
4. Al-Eideh, B.M., Al-Omar, H.O. 2019. Population Projection Model using Exponential Growth Function with a Birth and Death Diffusion Growth Rate Processes. European Journal of Scientific Research, 151(3), 271–276. http://www.europeanjournalofscientificresearch.com
5. Al-Saati, N.H., Omran, I.I., Salman, A.A., Al-Saati, Z., Hashim, K.S. 2021. Statistical modeling of monthly streamflow using time series and artificial neural network models: Hindiya barrage as a case study. Water Practice and Technology, 16(2), 681–691. https://doi.org/10.2166/wpt.2021.012
6. Dhahir, A. 2019. the Reality of Agricultural Techniques Used By Farmers to Reduce Losses in Wheat and Barley Crops in The Governorates of the Central Region of Iraq. July.
7. Ewaid, S.H., Abed, S.A., Al-ansari, N. 2020. Assessment of Main Cereal Crop Trade Impacts on Water and Land Security in Iraq. January. https://doi.org/10.3390/agronomy10010098
8. Hathout, D. 2013. Modeling Population Growth: Exponential and Hyperbolic Modeling. Applied Mathematics, 04(02), 299–304. https://doi.org/10.4236/am.2013.42045
9. Hussain, F., Khoso, S. 2014. Water Shortage; Its Causes , Impacts and Remedial Measures. 6th International Civil Engineering Congress, January, 1–6.
10. Masseroni, D., Arbat, G., de Lima, I.P. 2020. Editorial-managing and planning water resources for irrigation: Smart-irrigation systems for providing

sustainable agriculture and maintaining ecosystem services. Water (Switzerland), 12(1). https://doi.org/10.3390/w12010263

11. Qureshi, A. 2018. Managing surface water for irrigation. December, 141–160. https://doi.org/10.19103/as.2017.0037.06
12. Saleh, L.A.M., Majeed, S.A.A.-D., Algretawee, H.H. 2021. Analysis of the Euphrates River's movement within Al-Hindiya, Karbala, relative to steady flow conditions using the HEC-RAS model. IOP Conference Series: Materials Science and Engineering, 1067(1), 012081. https://doi.org/10.1088/1757-899x/1067/1/012081
13. Sirimewan, D.C., Mendis, A.P.K.D., Rajini, D., Samaraweera, A., Manjula, N.H.C. 2021. Analysis of issues in sustainable water management of irrigation systems: case of a developing country. Built Environment Project and Asset Management, 11(4), 529–543. https://doi.org/10.1108/BEPAM-02-2020-0038
14. Talpur, Z., Zaidi, A.Z., Ahmed, S., Mengistu, T.D., Choi, S.J., Chung, I.M. 2023. Estimation of Crop Water Productivity Using GIS and Remote Sensing Techniques. Sustainability (Switzerland), 15(14). https://doi.org/10.3390/su151411154
15. Yang, L., Hao, M., Cao, Q., Liu, K., Xiao, L., Pei, L., Wu, X. 2020. Quantitative Impact and Research on Water Supply Management and Demand in Beijing under the WEAP Model. IOP Conference Series: Earth and Environmental Science, 514(2). https://doi.org/10.1088/1755-1315/514/2/022055