

GREATER ZAB RIVER BASIN PLANNING (2050)A. J. Sharef¹R. N. Dara^{2,3}A. R. Ahmed¹

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ABSTRACT

This research was aimed to study the management of water resources within international basins, among which is the study of water authorities within the Greater Zab River Basin (GZRB) in the Kurdistan region - Iraq, where it is an international river shared by Iraq and Turkey, and aims to develop the river basin management and international cooperation between the authorities Shared water within the basin, as well as identifying factors that affect implementation, the principles, and joint projects. On the other hand, the interactions of water users competing for water inside the river basin were identified. For this reason, the Water Evaluation Analysis Planning (WEAP) model was applied to the basin to determine the optimal GZR planning system and plan optimum operating policy. The main issue with this planning is how the system meets future water needs. For this reason, optimal monthly water distribution policies have been simulated using the WEAP model using the past 33 years' debt, and the revaluated GZRB performance. An ideal simulation scheme has been developed and implemented for different scenarios such as domestic needs, irrigation water, and ecological water. This study compared to the official figures in the planning work that took place in the eighties. As a result of these comparisons, the average annual water supply was 368.1 million cubic meters in August 2032. Accordingly, it was proposed that the construction of the Bekhme Dam was completed because it understood that the water requirements could not be met in the current conditions.

Key words: river basin, water demand, water management, WEAP model

شريف وآخرون

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تخطيط حوض نهر الزاب الكبير (2050)

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الغرض من هذه الورقة هو دراسة إدارة الموارد المائية داخل الأحواض الدولية، ومن بينها دراسة السلطات المائية في حوض نهر الزاب الكبير (GZRB) في إقليم كردستان - العراق، حيث أنه نهر دولي يتقاسمه العراق. وتركيا، وتهدف إلى تطوير إدارة حوض النهر والتعاون الدولي بين السلطات المياه المشتركة داخل الحوض، وكذلك تحديد العوامل التي تؤثر على التنفيذ والمبادئ والمشاريع المشتركة. من ناحية أخرى، تم تحديد تفاعلات مستخدمي المياه المتنافسين على المياه داخل حوض النهر. لهذا السبب، تم تطبيق نموذج تخطيط تحليل تقييم المياه (WEAP) على الحوض لتحديد نظام تخطيط GZR الأمثل وتخطيط سياسة التشغيل المثالي. المشكلة الرئيسية في هذا التخطيط هي كيف يلبي النظام احتياجات المياه المستقبلية. لهذا السبب، تمت محاكاة سياسات توزيع المياه الشهرية المثلى باستخدام نموذج WEAP باستخدام معلومات 33 عامًا الماضية، وأداء GZRB المعاد تقييمه. تم تطوير وتنفيذ مخطط محاكاة مثالي لسيناريوهات مختلفة مثل الاحتياجات المنزلية ومياه الري والمياه البيئية. قورنت هذه الدراسة بالأرقام الرسمية في أعمال التخطيط التي تمت في الثمانينيات. ونتيجة لهذه المقارنات، بلغ متوسط إمدادات المياه السنوية 368.1 مليون متر مكعب في شهر اب 2032. وبناءً على ذلك، تم اقتراح الانتهاء من بناء سد بخمة لأنه متطلبات المياه لا يمكن تلبيتها في الظروف الحالية.

الكلمات المفتاحية: حوض النهر، الطلب على المياه، إدارة المياه؛ نموذج WEAP

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INTRODUCTION

The water scarcity is becoming a concern issue in our region because of the increasing water demand from all consuming sectors (9, 10, 17). Climate change, increased agricultural activities as well as water consumptions for industrial and household purposes are the prime aggravating factors of intensity of water shortage (15). Around 40 % of the world population are lives in the 263 trans-boundary watersheds, particularly as those that involve two or more countries. Half of the Earth's land surface covered by these trans-boundary basins and computed for an estimated 60% of global freshwater flow (12 and 20). The different countries' populations linked by trans-boundary river basins and for appropriate ecosystem units for international managing issues for thousands of millions of people, including the use of land, food provision, drought management, floods, and other based services for the watershed. Next, to one of the issues the only action by any country in an international basin is often ineffective (fish ladders only in an upstream country, for example), inefficient (hydropower development in a flat downstream country), or impossible (different development on boundary stretches). The managing of trans-boundary cooperation water resources is desirable but could be difficult, often due to unclear and contested property rights (3 and 8). With the increase of world's population, water demand increases and pressure on limited water resources intensifies. It is expected that, by the year 2050, the world population would reach to 9.9 billion (18). Due to the close tight population's growth to climate change, this could cause significant and high pressure on the availability of water resources. There is uncertainty on the exact number of people living on the earth in the coming decade, but the population will continue growing, this will influence water availability (18). According to the statistics references of the Ministry of Planning in the region of the three governorates of Iraq, Erbil Province, which is the capital of the area, shows a substantial increase in population. Based on the data, on yearly based, there will

be approximately an extra three million people in the next 33 years in Erbil province. This increase in population in Erbil-Iraq leads to an increase in water demand as well as food preparation. Based on the Erbil statistics, the water demand will be triple (1). Therefore, the new strategic plan for GZRB is essential. Taking this into account, this study will propose a substantial framework for developing Greater Zab River Basin (GZRB) for the next 33 years up to the year 2050.

However, Erbil's water resources have exposed to some risks and threats, in particular:

1. A fast-growing of population leads to the fast-growing demands.
2. Lack of regulation of groundwater uses.
3. Increasing water uses in the upstream of the river which is generated in Turkey, resulting in the declining inflow to the downstream of the Kurdistan Region.
4. The expected impacts of climate change to the river basin could have negative impact on the river.
5. Reach the food basket for self-sufficiency cause's growth water demand.

The annual flow of GZR is about 13.3 billion cubic meters (13300 Mm³). However, due to the lack of strategic projects within the river basin, the government did not obtain significant benefits from the flow of water from this river. The rate of river flow in winter can be more than 2500 m³/sec. because it is the rainy season, and this may cause floods in the area. While in the summer, the discharge may reach 50 m³/sec. This rate may adversely affect the environment, such as the deterioration of water quality due to the lack of waste water treatment projects in cities located within this basin (13).

MATERIALS AND METHODS

Study area

Greater Zab River is one of the major Tigris river tributaries. It flows 390km downstream of its original source from Turkey (1 and 2). The hydrographic pattern of Northern Iraq dominated by four major rivers with a general flow direction from the northeast to the southwest (Fig. 1).

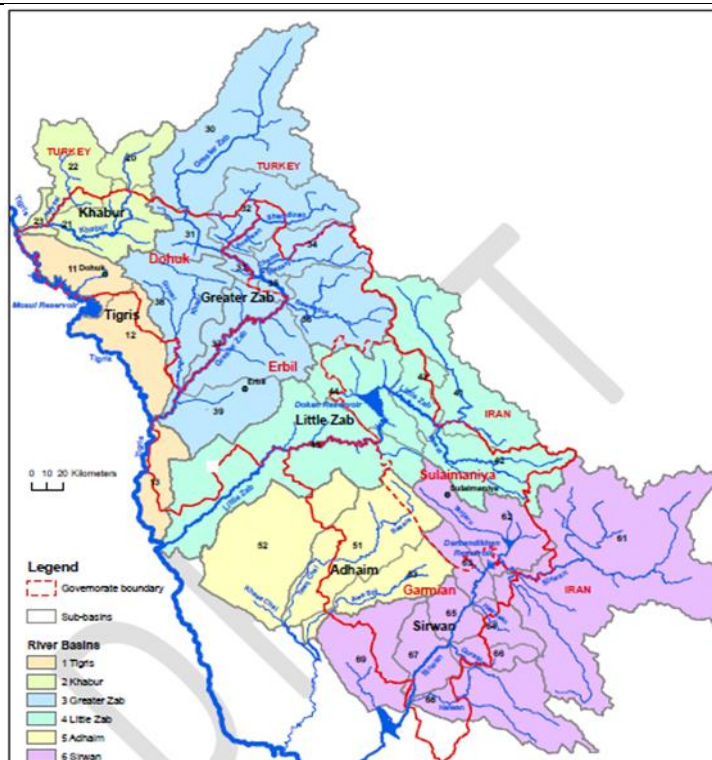


Fig. 1. Tigris Tributary River map within Iraq (5)

Four rivers from north to south such as Khabur, Greater Zab, Little Zab and Sirwan are joining to the Tigr, outside the border of Iraq. Those four main rivers and some of their major tributaries originate in Turkey (Khabur and Greater Zab) or Iran (Little Zab and Sirwan). A fifth, smaller river basin, the Adhaim basin, is entirely within Iraq. A third large storage dam, Bekhme, planned on the

GZR uncompleted; in fact, this dam had been under construction during the 1984s. (13) The whole river basin has an area of 26306 km²; it is the most important river basin in Erbil province as it covers 1/3 of the whole north of Iraq provinces area including the city of Erbil (1).Table 1 shows the area size and proportions of the basin within regional and national level.

Table 1 River basin tributaries (1)

River basin	Tigris direct	Khabur	Greater Zab	Lesser Zab	Adhaim	Sirwan	
Origin	Turkey	Turkey	Turkey	Iran	Iraq	Iran	
Catchment	Upstream/ Iraq	40,600	1,303	9,414	4,883	-	17,423
Area	North Iraq	2,770	2,627	16,696	12,229	5,774	9,266
Km ²	Total at mouth	n/a	6,027	26,331	19,593	n/a	n/a
Existing Large Dam	Mosul	-	Un completed dam	Dokan	-	Darbandikhan	
Province	Dohuk		Erbil		Sulaimanya		

Table 2. GZR tributaries and its catchment area with average annual flow feed GZR

Sub River	Catchment Area km ²	Annual Precipitation mm	Average Annual Flow m ³ /sec	Annual Flow BCM
Zab River Turkey	9422	1200	168.08	5.3
Sheen River	3341	1200	67.38	2.1
Chama River.	1844	1100	34.1	1.07
Rwandwz River	2956	900	44.7	1.41
Khazer River	3303	600	31.4	0.99

In general, the GZR is fed by the four above mainlined branches and a large proportion of the total flows comes from the above four tributaries, the annual flow for the GZR more

than 13.3 billion cubic meters.(4) Each river basin, therefore, includes three major hydrological zones:

1- A high mountain zone (equivalent to the geological “thrust zone”) with limited groundwater storage but high precipitation and significant snow storage. The area is sparsely inhabitant (even partly uninhabited due to security issues) and characterized by steep slopes and narrow valleys.

2- A more or less certified zone that drains the major karstic-fissured aquifers of the region. The relief is dominated by elongated mountain ridges that are often crossed by the rivers through narrow gaps which offer suitable sites for dam construction. From a hydrological point of view, the area is very heterogeneous, with phenomena such as canyons, dry valleys on the other hand, large springs (yielding several m³/s throughout the year) which are fed by large subterranean karst systems.

3- Finally, the lowland plains, with a typical elevation between 300 m a.s.l and 600 m a.s.l. The area is partly agricultural land, partly eroded ‘badland’ and includes both densely populated (around the KR capital Erbil) and sparsely inhabited areas. Significant parts of the plains are made up of the highly productive Bakhtiari aquifer, which is partly covered by fluvial deposits and terraces or less permeable layers. Groundwater resources, which are mostly of good quality but limited due to low precipitation (300 to 500 mm/y), are being used intensively by several thousands of deep wells. Most of the lowland tributaries are seasonal valleys, without permanent base flow during the dry seasons (6), as shown in Fig. 2 and the monthly discharge for five sub-basins illustrate in table 3.

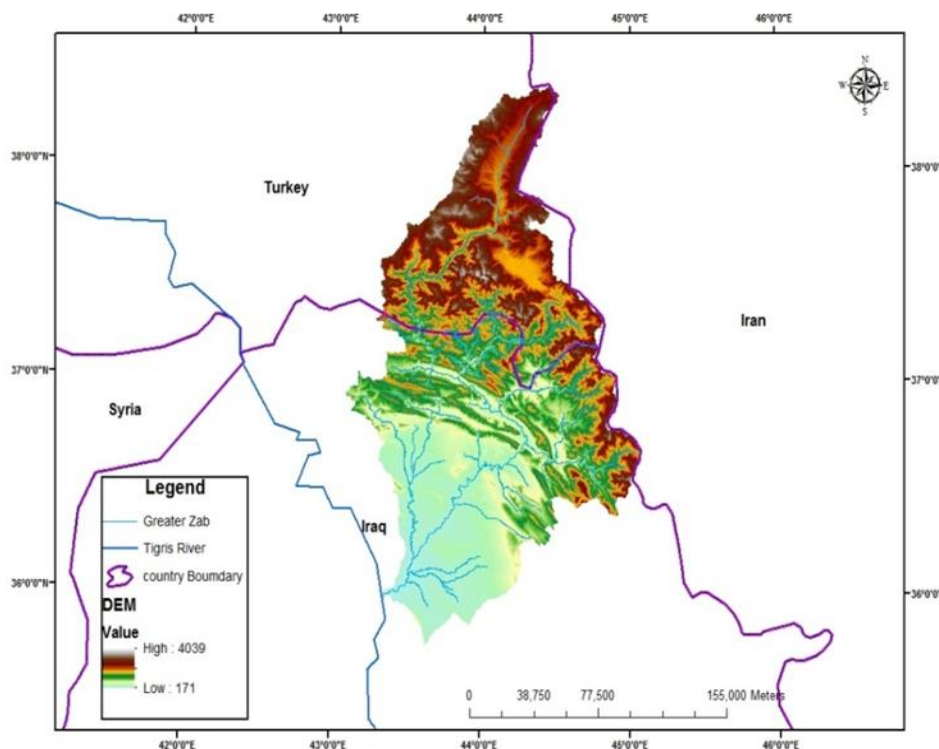


Fig. 2. Elevation map for GZRB study area

Table 3. Annual and monthly river flow for GZRB

		Mean annual flow rate (Mm ³)	Ecological limit (Mm ³ / month)	Lowest monthly flow rate (Mm ³)	Months
SB1	Mean Year	2700	23	80	September
	Dry Year	1900	23	20	June – Aug.
SB2	Mean Year	8700	73	220	September
	Dry Year	5700	73	150	September
SB3	Mean Year	9000	75	230	September
	Dry Year	5900	75	150	August
SB4	Mean Year	8900	75	220	September
	Dry Year	5900	75	150	August
SB5	Mean Year	9300	80	230	September
	Dry Year	6200	80	160	August

The basin has been divided into two main areas, the plain area including Erbil plain and the mountain area in the Northern part of the basin. Plains and foothills, these areas is characterized by flatter soils permitting easier cultivation than the mountain zones. Precipitations usually arw exceed to 700 mm / year and are even less than 350 mm for the driest part close to Erbil city. Therefore, possibilities of growing wheat without supplementary irrigation are limited. Farmers are often plant barley to limit the loss of yields in cases of restricted rains. According to different factors including proximity to the river, to main urban centers the amount of rain, we have differentiated three sub-zones. Mountain area: the mountain areas see a succession of forests, rangelands, arable lands and irrigated valleys. The tree cover of the region's mountain slopes reaches elevations of 600 m to 2000 m and dominantly makeup of Oak woodlands and some Oak forests, holding

medium-sized trees, often with a widespread crown. They are a major source of income and essential to the livelihood of the mountain population (small farmers). The breeders of the region follow transhumance, moving their group of sheep and goats to higher mountain pastures in summer and down to the plains in winter. The amount of rain (over 900 mm/year) permits rained cultivation of wheat (and barley), while irrigation of vegetables and orchards is concentrated in small areas in the valleys to permanent springs and rivers. Fig. 3 shows the boundaries of climatic agricultural areas and sub-regions in the Great Zab River Basin, and is divided into three main regions, which are the mountainous region from which most of the water is constructed, and it is considered a rainy area, and the hillside region that is located most of the lands produced for agriculture and lands with plains that are the lower part of the river basin, which is one of the seed production areas (wheat and barley)

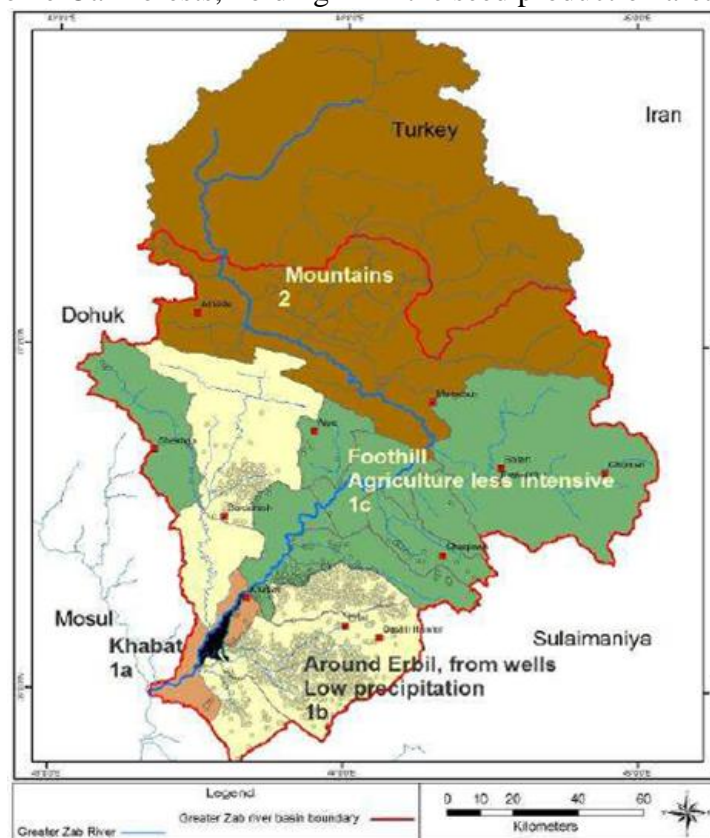


Fig. 3. Map of agro-climatic zones (5)

regarding to domestic water demand, according to data collection the most of the households (77%) obtain their drinking water through pipes. The other main source of drinking water is through tanker-trucks. Drinking water is supplied by a mix of surface

and groundwater: for instance, 5000 wells are used for drinking purposes in Erbil Erbil city gets 40 % of its irrigating water from wells, while in the mountain area, main intakes for drinking purposes come above all from the surface and springs resources. Water

production and distribution are mainly financed by the government. Water is almost not paid by the population: (10000 ID) per month and per connection house (200 m²) (around 8 \$). Municipal buildings, as hospitals, schools, don't pay water as well. Environmental problems have been marked largely by scientific warnings, public interest, political agendas, and media attention. Policy issues remain a problem when it comes to water. Most of the available water supplies in the region, which exceeded 80 percent, were used for irrigation purposes. (6), In addition, water efficiency levels are relatively low in the region, usually between 37% and 53%. As this study suggests, water policies in Erbil province will need to improve supply and demand management as well as allocate more resources for the development of local desalination technologies. (5) The minimum discharge for GZR during dry year August 2001 was 51 m³/sec in Kalak water flow measurement station, therefore the study assumed minimum inflow as an environmental flow requirement up to the year start construction Bekhme reservoir on GZR and it is estimated to be 90 m³/sec in the year 2035

due to the water unmet water requirements. In addition, water use in Erbil governorate industry generally from groundwater and is high due to a combination of factors including obsolete process technology, poor recycling and reuse practices and poor wastewater treatment. There is a very low level of awareness about the problem and needs for wastewater treatment by industry. The efficiency of utilization in all the industrial uses of water should optimize and an awareness of water as a scarce resource should be fostered. The water resources should be kept from change and should be able to be used by making greatest degree retention, taking away pollution and unimportant loss.

Methodology

the WEAP model used by this study for plan and manage the water resources, the software package installed and it used as a working methodology (20). In this study we used WEAP to represent inflows, demand sites, reservoirs, transmission links (diversions), return flows, reach gains and losses, and to simulate the effects of these system components on deliveries to demand sites Fig. 4. (19 and 21)

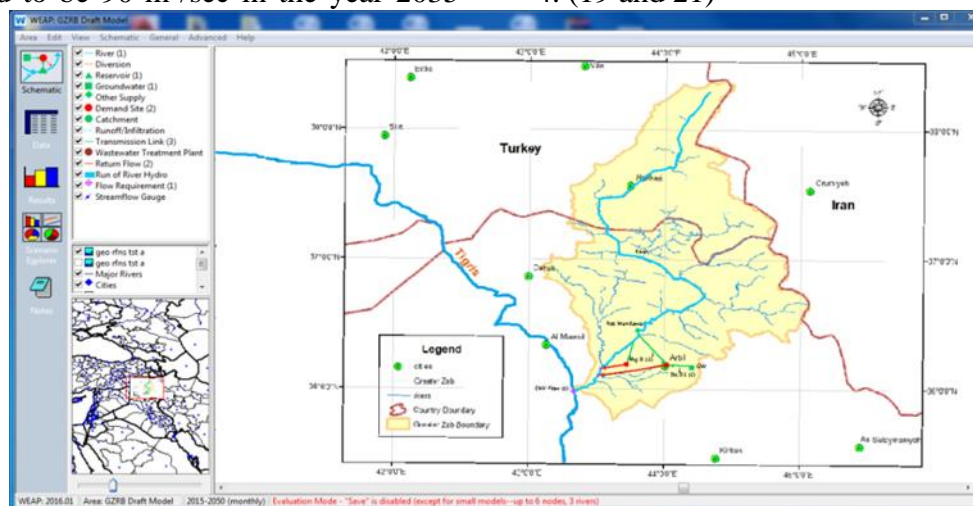


Fig. 4. Schematic for the GZR WEAP Model

Finally, simulate each scenario to determine the effects on deliveries and unmet demand to the GZR and new urban users in Erbil Governorate. The development of a valid and credible water and agriculture systems model for the GZR is the final component of the analytical approach. A model development period using historic data from 2000 – 2016 was used for model setup and configuration. Once the GZR WEAP model calibrated and validated against the historical period, it was

used to project forward under different assumptions of resource use and climate. A future planning period of 2016 through 2050 was considered in the analysis. The annual agriculture water required used by model is (3500 m³/ha) and the irrigation land in Erbil Governorate for the year 2015 calculated is (117110 ha). The GZR includes the demand centers of the city of Erbil and surrounding districts and sub-districts. Demands include indoor, outdoor and amenity uses. The model

uses a single demand object to represent the forestry uses and assumes average water requirement about, (3500 m³/hectare per year). A single demand object also used to represent amenity water use, where we assume that (99745 ha.) are under active irrigation, using (506 MCM) per year. According to the survey

and data collection of this study found the key assumptions, both units of domestic water needs and irrigation water requirements, annual unit domestic water use per capita (179 m³) and the annual unit irrigation water needs 3500 m³ used by WEAP.

Table 4. Illustrates unit water needs for irrigation

Year	Annual unit irrigation water needs (m ³)
2015	3500
2020	3400
2025	3300
2030	4300

Year	Annual unit irrigation water needs (m ³)
2035	3200
2040	3150
2045	3100
205	3050

The last date of Census is 2015, the population at 2015 was (1981013) people and the proposed (Normal) growth rate (3.4%) by the time unit of irrigation water needs will decrease due to decreasing losses in the system by using new technology and new irrigation systems, the data of irrigation water needs used in model. This data used in the proposed scenario where the population growth normal and it is 3.4 % as a reference scenario, then the model creating running scenarios. The second scenario to model account high population

growth, this scenario looks impact of increasing population growth from the value of 3.4 % to 5%. Whether precipitation is generally decreasing in GZRB has been widely discussed, in particular after the exceptional drought period from 1989 and 1999 to 2001 which caused a significant depletion of water resources. However, clusters of dry years are a normal statistical phenomenon in regions with high climatic variability and are not necessarily an indication of climate change as shown in the table 5 and Fig. 5.



Fig. 5 . Monthly water flow (m3/sec) at Kalak station (flood and drought)

Table 5. Average monthly discharge at Kalak (m3/s) for (dry, wet) year 2014 (5)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dry year 1989	67.2	83.4	102.6	82.2	60.9	242.1	312.9	246.5	96.1	38.1	33.8	35.1
Wet Year 1969	168.7	308.3	836.5	603.6	554.2	1,646	1,781	1,632	698	351.5	227	180.4
Year 2015	202	233	265	242	250	412	393	338	239	182	154	138

RESULTS AND DISCUSSION

Create scenarios

The data arrangement required by software after the difficulty of data collection from several directorates, then installed GIS raster map for GZRB, inserted to the WEAP system program and created two big demands the agriculture and domestic water use as well as linked to the river system.

Scenario reference

Consider 3.4% as a normal case of the annual population growth ratio. First, the model was run as a current situation which called scenario reference. The output result is the water supply which cannot cover the demand during the year 2046 to 2050 for august and September. This indicated that the basin is facing problems regarding to water resource

availability. Thus, the government has to think and establish strategy plan carefully for future generation. The unmet water demand, water

supply delivered and total water requirement for agriculture and domestic purposes in august and September is shown in Table 6

Table 6. Illustrates water supply required, demanded and sufficient water

1- Supply water requirement in August and September from 2046 -2050

Water Use	Supply water requirement in August and September from 2046 -2050 (MCM) Million m ³									
	2046		2047		2048		2049		2050	
	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept
Agriculture	280.3	233.6	288.1	240.1	295.8	246.5	303.5	252.9	311.1	259.3
Domestic	57.7	50.2	58.4	50.8	59.2	51.5	59.9	52.1	60.6	52.7
Total	338	283.8	346.5	290.9	355	298	363.4	305	371.7	312

1- Unmet Water Demand in August and September from 2046 -2050

Water Use	Unmet Water Demand in August and September from 2046 -2050 (MCM) Million m ³									
	2046		2047		2048		2049		2050	
	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept
Agriculture	2.7	3.1	9.8	9.1	16.9	15	23.9	20.8	30.9	26.6
Domestic	0.5	0.6	1.9	1.9	3.3	3.1	4.7	4.2	6	5.4
Total	3.2	3.7	11.7	11	20.2	18.1	28.6	25	36.9	32

2- Total Water Supply Delivered in August and September from 2046 -2050

Water Use	Total Water Supply Delivered in August and September from 2046 -2050 (MCM) Million m ³									
	2046		2047		2048		2049		2050	
	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept
Agriculture	277.6	230.4	278.3	231	279	231.6	279.6	232.1	280.2	232.6
Domestic	57.2	49.5	56.5	48.9	55.8	48.4	55.2	47.8	54.6	47.3
Total	334.8	279.9	334.8	279.9	334.8	280	334.8	279.9	334.8	279.9

The water supply deficient to cover and met demand in dry months (August and September) which the water demand very big and the maximum around 37 MCM in the year 2050, Fig. 6 shows the output and result from run scenario reference, included the water

demand and water supply in two months during the unmet years according to the model run, therefore the government has to give priority and plan for completing Bekhme dam and its very important for water resources management in GZRB.

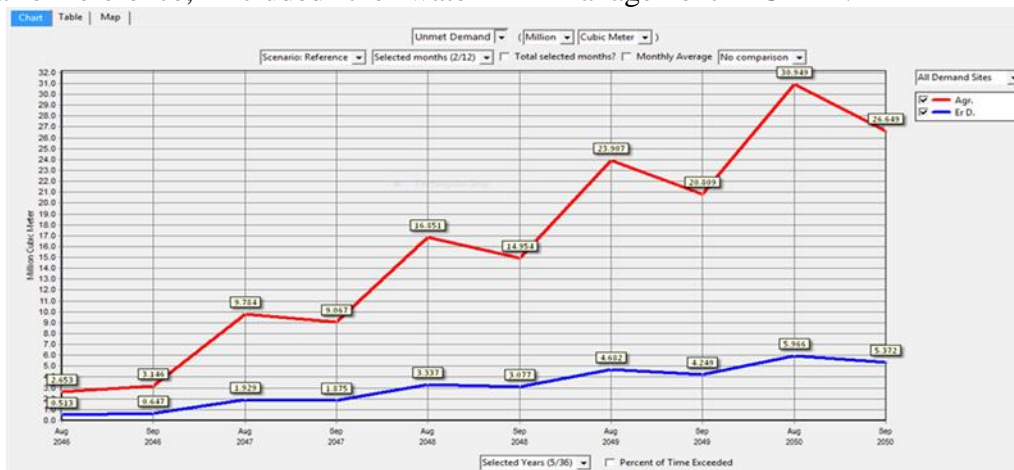


Fig. 6. Aug. and Sep. 2046-2050 unmet Dem. for Agri. and Dom. water uses

Scenario high population growth

The scenario of high growth population is one of the opportunities to happen in future. For this scenario, the annual growth ratio calculated as a high ratio 5%. In this case the population in 2050 closed to 10 million people, after insert all data required by

software, run model takes account future growth population called scenario high population growth. The output result is the water supply can't cover the demand during the year 2032 to 2050 in both months august and September.

Table 7. Illustrates the unmet water demand started from 2032 -2050

Total Unmet Water Demanded in August and September from 2032 -2050 (MCM) Million m ³										
Water Use	2032		2033		2034		2035		2036	
	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept
Agriculture	28.6	24.5	56	47.3	83.7	70.3	111.4	93.4	131	109.7
Domestic	4.7	4.2	8.8	7.8	12.7	11.1	16.2	14.2	18.8	16.5
Total	33.3	28.7	64.8	55.1	96.4	81.4	127.6	107.6	149.8	126.2
	2037		2038		2039		2040		2041	
Water Use	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept
Agriculture	150.6	126	170.1	142.2	189.6	158.4	208.9	174.6	237.7	198.6
Domestic	21.5	18.7	24.1	21	26.7	23.3	29.4	25.6	33.2	28.9
Total	172.1	144.7	194.2	163.2	216.3	181.7	238.3	200.2	270.9	227.5
	2042		2043		2044		2045		2046	
Water Use	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept
Agriculture	266.4	222.5	295	246	323.6	270.1	352	293.8	378.1	315.5
Domestic	37	32.2	40.9	35.7	45	39.2	49.1	42.8	52.1	45.4
Total	303.4	254.7	335.9	281.7	368.6	309.3	401.1	336.6	430.2	360.9
	2047		2048		2049		2050		2051	
Water Use	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept
Agriculture	404	337.1	429.8	358.6	455.5	380	481	401.2		
Domestic	55.2	48.1	58.2	50.7	61.2	53.2	64.2	55.8		
Total	459.2	385.2	488	409.3	516.7	433.2	545.2	457		

Table 8. Total water supply in August and September from 2032-2050

Water Supply Requirement in August and September from 2032 -2050 (MCM) Million m ³										
Water Use	2032		2033		2034		2035		2036	
	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept
Agriculture	315.4	262.8	344.9	287.4	374.4	311.9	403.5	336.3	423.5	353
Domestic	52.7	45.8	54.7	47.6	56.8	49.4	58.9	51.2	61.1	53.2
Total	368.1	308.6	399.6	335	431.2	361.3	462.4	387.5	484.6	406.2
	2037		2038		2039		2040		2041	
Water Use	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept
Agriculture	443.5	369.5	463.2	386	482.9	402.3	502.3	418.6	531.4	442.9
Domestic	63.4	55.1	65.8	57.2	68.2	59.3	70.8	61.5	74.3	64.6
Total	506.9	424.6	529	443.2	551.1	461.6	573.1	480.1	605.7	507.5
	2042		2043		2044		2045		2046	
Water Use	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept
Agriculture	560.3	466.9	588.9	490.4	617.4	514.5	645.7	538	672.2	560.1
Domestic	77.9	67.8	81.8	71.2	86	74.7	90.2	78.5	92.8	80.7
Total	638.2	534.7	670.7	561.6	703.4	589.2	735.9	616.5	765	640.8
	2047		2048		2049		2050		2051	
Water Use	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept	Aug	Sept
Agriculture	698.5	582	724.6	603.8	750.5	634.4	776.3	646.8		
Domestic	95.5	83.1	98.2	85.4	101	87.7	103.7	90.1		
Total	794	665.1	822.8	689.2	851.5	722.1	880	736.9		

Scenario environment flow (SEF)

In this scenario, the environment flows calculated into account monthly river flow 50 m³/sec. flow release to downstream Tigris River. This scenario the monthly water flow mandatory release to downstream by the Iraqi government. That proposed as a minimum river flow during the dry season. The scenario SEF is one of the opportunity to happen in future, for this scenario the annual growth ratio calculated as a proposed 3.4% and high ratio 5%. After inserting all data required by software, model run take account future growth population for both scenarios SR and

SHP, on the other hand, the river flow mandatory release environment, then the output result is the water supply cannot cover the demand during the year 2030 to 2050 in both months August and September it means the 16 years before the scenario reference when the environment flow required and in SR. But in this case and when the calculation is done for SHP the water unmet will happen start from 2021 and the river facing problems regarding water resource availability and the government has to think about this challenges will happen in case the number of population reach 10 million, therefore, province should

take account this probability and establish strategy plan starting from 2021 carefully for future generation, the unmet water demand, water supply delivered and total water

requirement for both users agriculture and domestic in August and September as shown in Fig. 7 to 8.

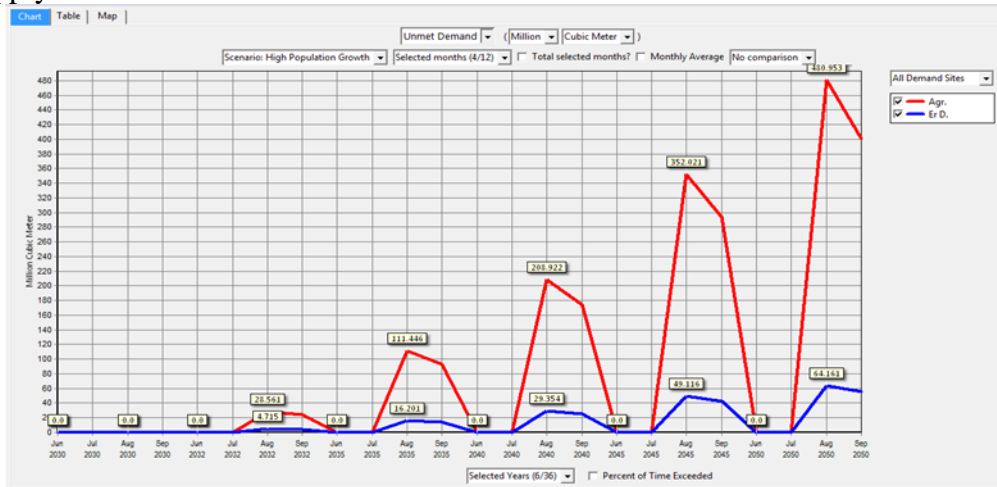


Fig. 7. Illustrates the unmet quantity of water during 2032 to 2050

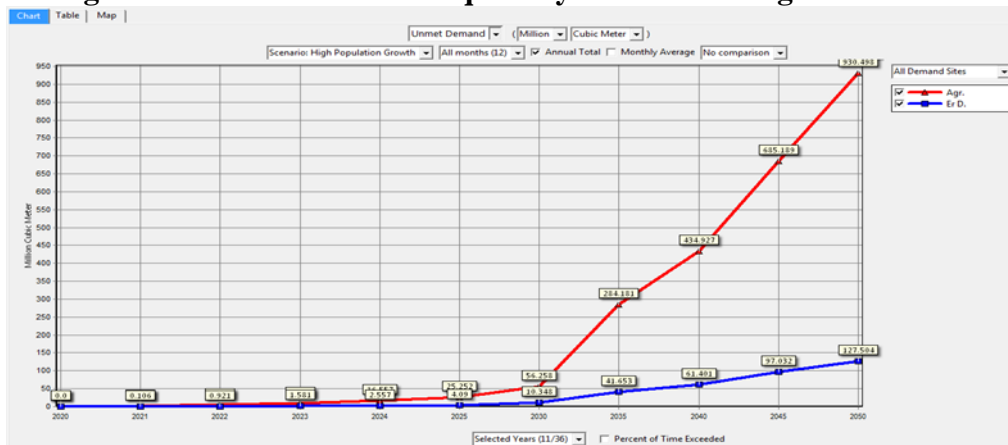


Fig.8. Unmet Demand chart for SHPG, environment flow mandatory

The result for three scenarios (SR, SHPG, and SEF) demonstrated us below Fig.9 to 11 in

addition to the comparison of the above three scenario.

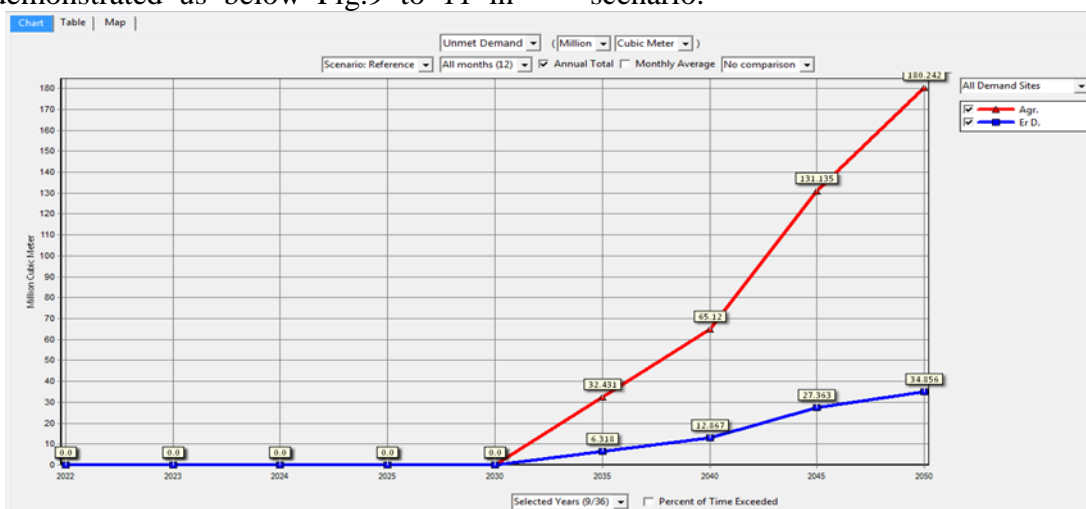


Fig. 9. Unmet Demand chart for SR, environment flow mandatory

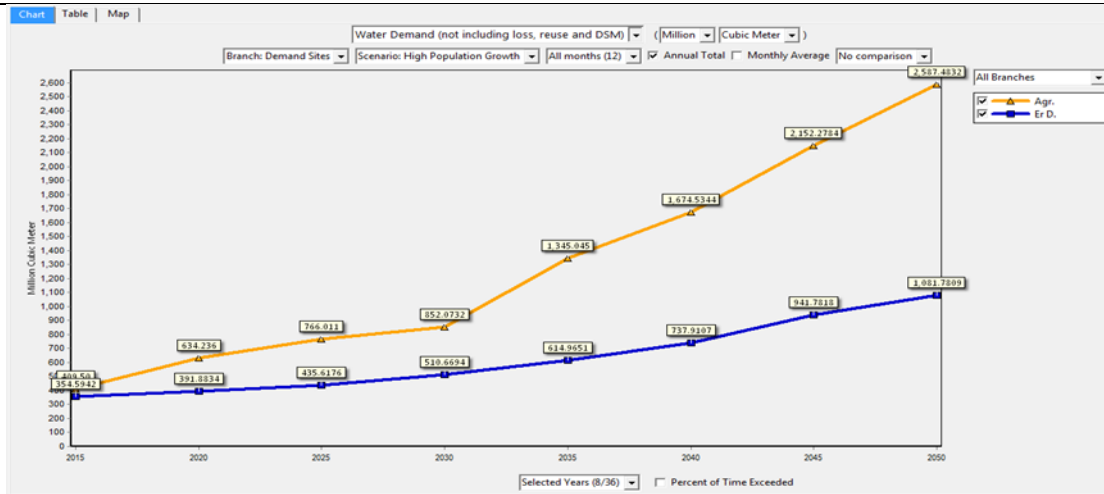


Fig. 10. Water Demand chart per demand sector (Agr. and dom.) for SHPG, and environment flow mandatory

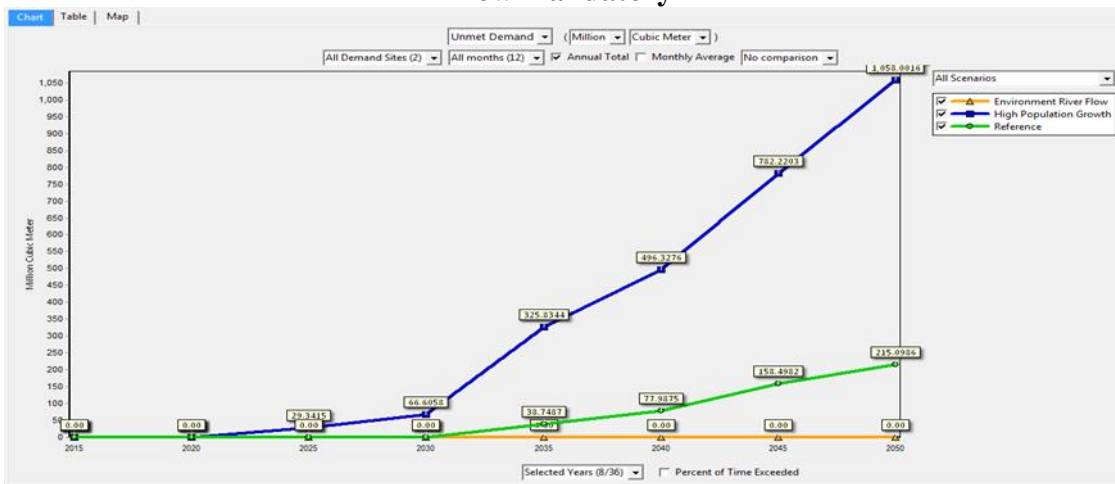


Fig. 11. Unmet Demand table the three scenarios (SR, SHPG, and SEF), environment flow mandatory

Table 9. Scenario SR illustrates (Arg. and Dom.) Sectors in case Monthly Ave. Env. Flow 50 MCM

Scenario SR Sector of Domestic (Monthly Ave. Environment Flow 50 m ³ /sec.)							
Year / Annual Water Volume MCM							
	2021	2025	2030	2035	2040	2045	2050
Water Requirement	364	373.6	405.6	458.62	514.1	621.6	666.9
Water Supply	364	373.6	405.6	452.3	502.7	594	632
Water Unmet	0	0	0	6.32	11.4	27.6	34.9
Scenario SHPG Sector of Domestic (Monthly Ave. Environment Flow 50 CM)							
Year / Annual Water Volume MCM							
	2021	2025	2030	2035	2040	2045	2050
Water Requirement	396	435.6	510.7	615	738	942	1082
Water Supply	395.9	431.5	500.4	573.3	676.6	845	954.5
Water Unmet	0.1	4.1	10.3	41.7	61.4	97	127.5

Table 10. Scenario SHPG (Arg. and Dom.) sectors in case monthly average environment flow 50 MCM

Scenario SR Sector of Agriculture (Monthly Ave. Environment Flow 50 m ³ /sec.)							
Year / Annual Water Volume MCM							
	2021	2025	2030	2035	2040	2045	2050
Water Requirement	400	531.5	607	727.4	859.6	1039.1	1217.2
Water Supply	400	531.5	607	695	794.5	908	1037
Water Unmet	0	0	0	32.4	65.1	131.1	180.2
Scenario SHPG Sector of Agriculture (Monthly Ave. Environment Flow 50 m ³ /sec.)							
Year / Annual Water Volume MCM							
	2021	2025	2030	2035	2040	2045	2050
Water Requirement	652	791.7	908.4	1629.3	2105.4	2837.5	3518
Water Supply	650	766.4	852.1	1345.1	1670.5	2152.3	2587.5
Water Unmet	2	25.3	56.3	284.2	434.9	685.2	930.5

CONCLUSION

As a result, most of Iraq now has limited access to clean water supplies or sanitation and garbage collection, in the three KRG provinces, where it has developed in recent years but also under an acceptable proportion of sewage, garbage collection and recycling. Serious environmental and health risks associated with contaminated water supplies, improper handling of solid waste and sewage disposal threaten to add to the burden of the already overloaded health system. In addition, the concentration of economic and social activities in Iraq's major urban centers has also led to the prevalence of underserved neighborhoods in major Iraqi cities. The loss of water within the water supply systems and the technologies used are inefficient and not qualify. Recalculations of water per capita are reviewed. For per capita water supply becomes more stringent. Governments need to implement strategic planning that can increase water use efficiency and improve the allocation of scarce resources between agricultural, industrial and local areas. Thus, there will be provision for future water use. The management and establish a long-term strategic plan for GZRB is very important for Iraq and Erbil governorate, due to the growth of abnormal population, in this case, the population increase causes to prepare water and foods. According to the MOP data, the population at 2050 will meet 6 million people as proposed mean three-time increasing (normal growing), on the other hand the climate change to the worst(drier) causes to decreasing the water resources, therefore this

research is highly important to find operation system for the next 33 years for GZRB.

Three scenarios taking in to account:-

The first, reference scenario, the ratio of population growth 3.4% as a normal case were proposed by MOP taking into account, and the result shows that water supply can't cover the water requirement in Aug. & Sep. at the year 2046. The second scenario, high population growth, also the ratio 5 % identified by the MOP and model run done, the result shows the water supply can't cover the water requirement and deficit in Aug. & Sep. at the year 2032. The third is environment scenario, in this case, the monthly environment river flow requirement 50 m³/sec. required by Tigris River and the result shows that unmet demand in Aug. and Sep. at the year 2021.

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