Evaluation of some irrigation projects in Dukan watershed as controlling and conservation of water resources

Ministry of water resources
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Summary

The area of study is located between series of mountainous nearly parallel ranges varying in height from 2000 to3000m folded zone which is near Sulaymaniyah city and between 3000-3500 m near the Iraqi – Iranian borders with very heavy slope decreasing from east to west.

The annual averages discharge of the little Zab to Dukan reservoir about (7) billion m3. Because of the nature of the area as shown with vary strong slope and very raped flowing of surface water in the river that effect very active soil erosion .

The objective of the study is an assessment of the projects irrigation implemented in the region tributaries, and to providing the necessary water as well as get benefits from water resource that exist in the study area within the province of moist , with conserving and store the remaining in the basin of Dukan in order to release when needed in downtown areas and southern of Iraq which suffering from water scarcity, especially in summer days , periods of drought whenever lack of rainfall. A region characterized by severely sloped with high speed of flow in Little Zab river, making the way to controlling the water very difficult.

While collecting information about the implemented irrigation projects compared with the study area found its small and there is plenty of winter agriculture, which depends on the rains due to frequent rain in the study area. It requires to calculate discharge of water provided to the Little Zab River and discharge of these areas which received for irrigation and the discharge of water provided to the Dukan reservoir and quantity of water release from when needed to the downtown areas and southern of Iraq (outside of the study area) which suffer from water scarcity with finding ways to balance water needs and the available water resources in the region.

Introduction

The study area in Kurdistan, northeastern of Iraq, Sulaymaniyah. Include the upper part of little zab river basin and tributaries which flows into the artificial Dukan lake after the implementation of Dukan dam at (1958) with five districts, namely, (Rania, Bashdr, Sharbajyer, Banjwen and Dukan) watershed located between latitude 35 20" -36 30" north and longitudinal 44 30" -46 20" east.

Little Zab River one of the important tributaries which feed the Tigris River.

The total length of the river (400) km and with great slope in Iranian territories between the upstream and the beginning of the common border with Iraq (1-150 m). Increasingly, the slump is the common border up to (1-70 m).

The total area of the basin (22 250 km 2), which is located (5000) km 2 in the Iranian territories, and the remaining portion of area (17 250) km 2 in Iraqi territories, the area of the basin in the study area (7413) km 2. Dukan watershed occupying about (43%) of Little Zab river basin fig (1and 2).

The annual rate of water contained in the Little Zab River beyond (7) billion cubic meter, in addition to the waters of the Little Zab frequent rain and ground water means that there is an abundance of water in this area. Due to the presence of such large amounts of water in the study area and because of Iraq suffers a lack of water income in Tigris river with the low amounts of rain falling in addition to semi-desert climate, so have to take benefit of this water especially the downtown areas and southern Iraq and it shows the need to establish irrigation projects and take advantage of the water in (river and the Lake of Dukan project), outside the study area, especially for irrigation purposes such as the Hawijah and Kirkuk Irrigation Project.

The purpose of the study is to find out the amount of water reaching Basin Little Zab River and the water in Dukan lake, and to assess the irrigation projects which built top the Little Zab River and the amount of water used , the need of water in the study area and is it possible to plan and developed in order to take benefit of excess water with the outlet of Dokan Dam which suffers from scarcity.

Objectives

The annual revenue discharge incoming to the Little Zab River up to (7) million cubic meters Due to the fact that the Little Zab River, tributaries one of the important feeder of the Tigris River, And because of the lack of revenue water in the Tigris which requires the maximum utilization of water imports , frequent rains in the study area excess and stored in Dukan lake and use when needed outside the study area which suffer from water scarcity and drought , especially in summer season.

The climate of Iraq's semi-desert especially central and southern regions that suffer from lacks of water and rain contrary with the study area is characterized by an abundance of water resources of Little Zab River and rainwater and groundwater.

With the rapid developments taking place in Iraq and in Kurdistan region, the demand for water in the country has increased in many fields. In order to cope with the growing demand there is pressing need not only to exploit the water resources in the country to the fullest possible extent but to find ways and means of water conservation for efficient utilization by proper distribution and elimination of avoidable losses .

Our objectives for this watershed ;

-assess the amount of water available in little Zab river basin in study area and Dukan reservoir.

-assess the need for water in the study area and take advantage of the water sources variety in the wet study area for the purpose of filling a need and store the remaining water in Dukan lake to taking advantage outside the study area, which suffers from water scarcity.

- Trying to find ways to balance needs with the available water resources.

Methodology

Supporting research gained by returned to previous studies and research about Little Zab River to collect information and there is some information required to approach the competent authorities and departments to get , field visits important to complete the information we need to finish the search.

Information needs to research:

-Identify stations which are distributed in the region for collecting the required information.

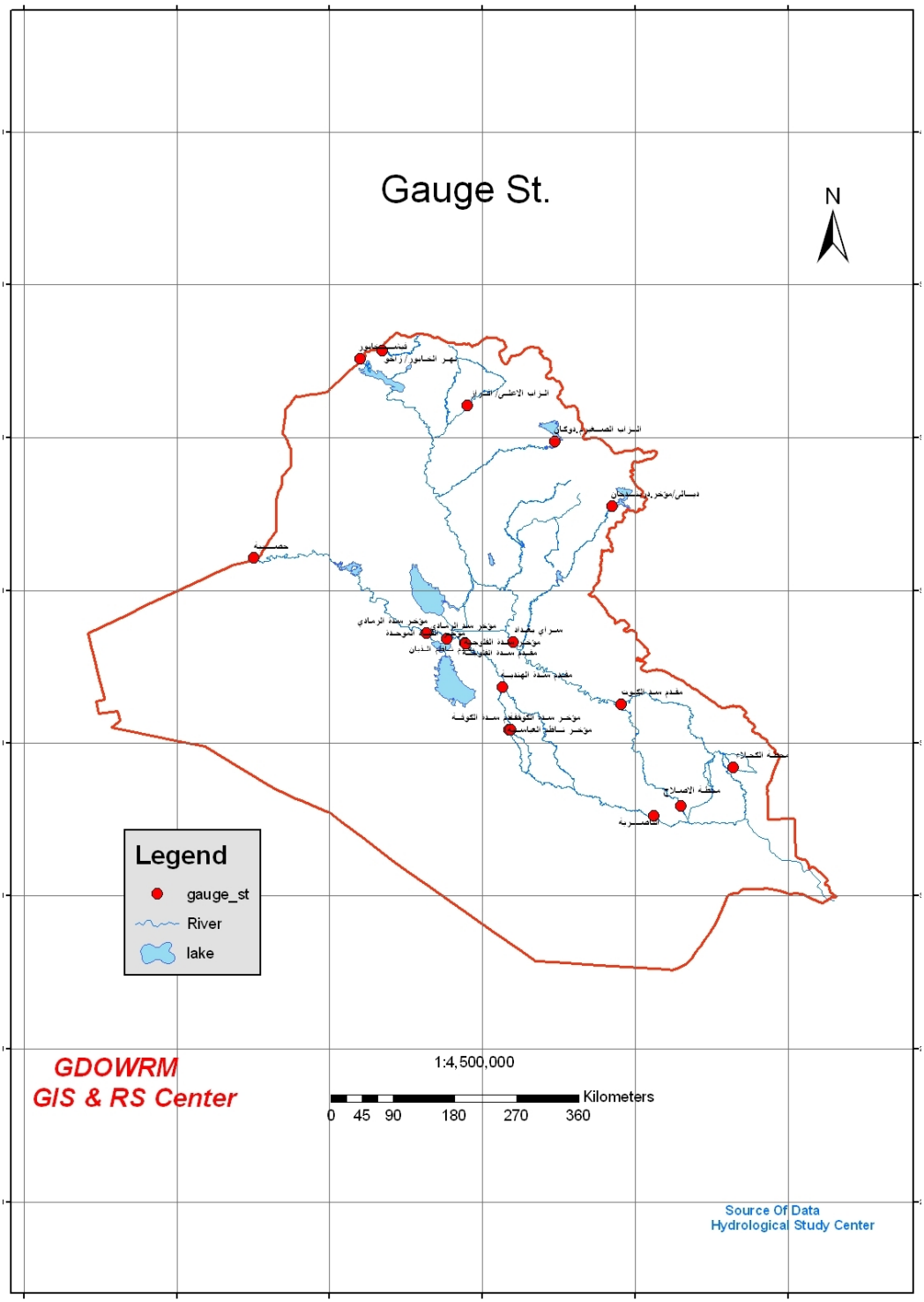
- check the discharge to Little Zab River.

-Gathering information about the amounts of water import to Lake Dukan and the quantities that are discharge from the lake in coordinating with the concerned authorities for the purpose of research.

-Collect information about irrigation projects which implemented at the top of the Little Zab River Basin.

-Fixing the exact position of irrigation project such as small dams and reservoirs and measures the irrigated area of each project and to identify areas of arable land and the amount of water needed by the territory.

- Collecting the necessary information about rainfall, and groundwater in the region.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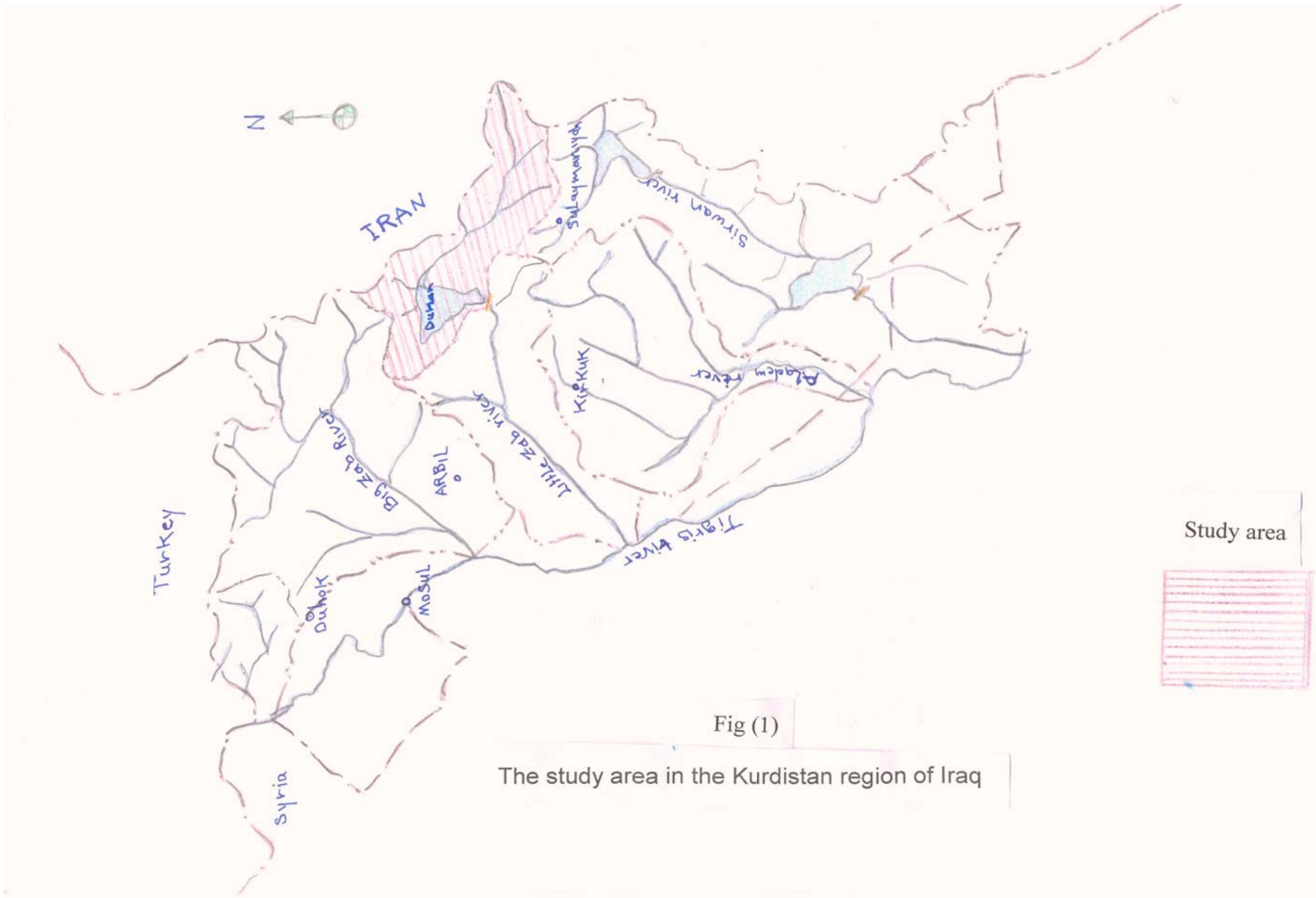


Fig (1)

The study area in the Kurdistan region of Iraq

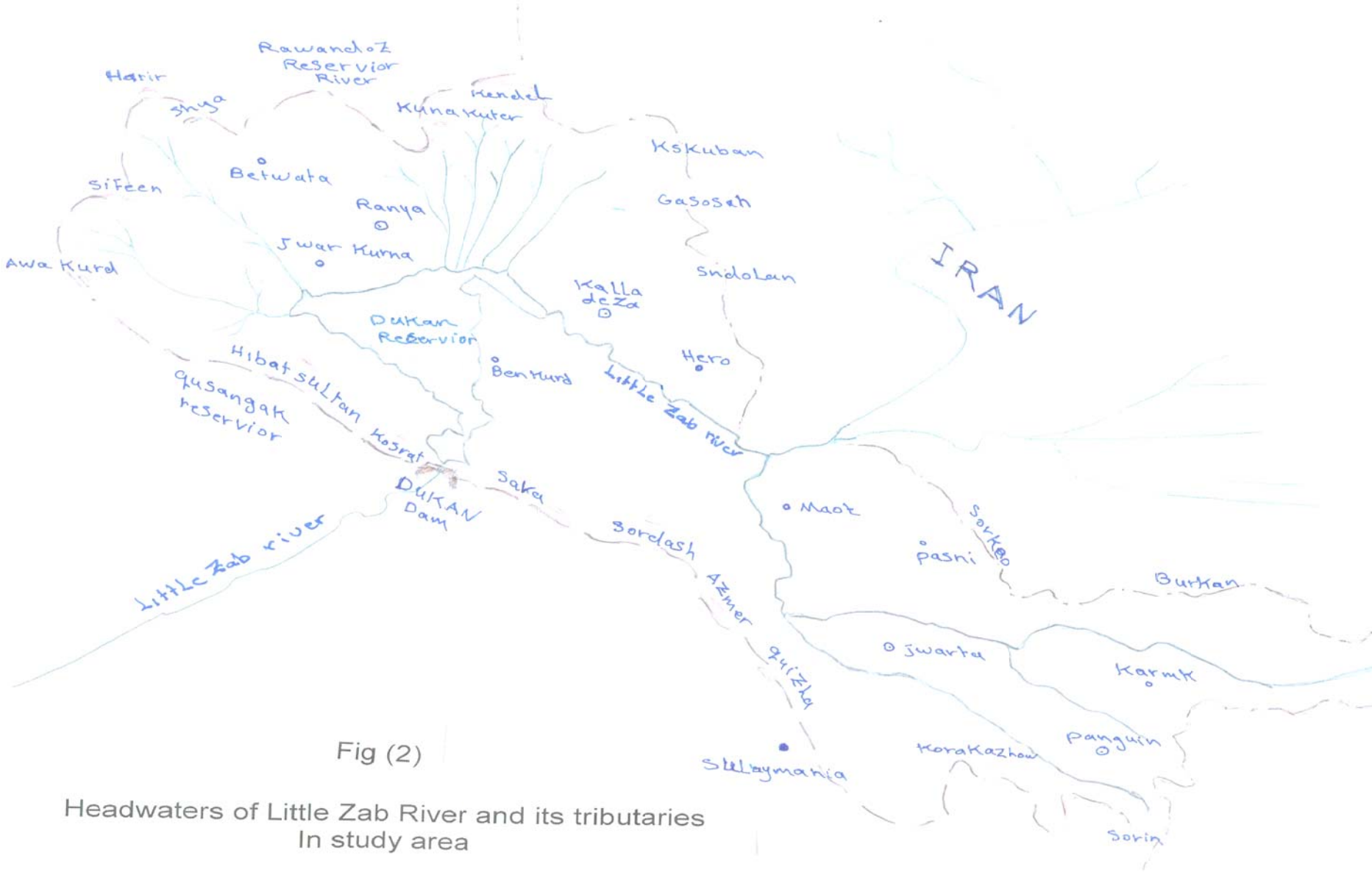


Fig (2)

Headwaters of Little Zab River and its tributaries
In study area

1-Characteristic of watershed

Climatological features

This watershed and Iraq in general located in southern position of the temperate zone of the northern hemispheres, the closer body is the Arabian gulf in the south east, the most important large water body which effects the climate of this area is the Mediterranean sea lying a little away to the west .It will be seen from fig (2) that this area is having a series of mountains .

During the different seasons this watershed affecting by the following air masses with the characteristic noted against them .In winter season polar maritime (mp), these are cool but moist air from the Mediterranean sea which are brought in by the depressions from west.

In summer season , tropical continental (ct),this is a land air mass originating from Saudi Arabia and African continent it is extremely dry and hot ,in spring and autumn early spring and late autumn have more or less the same characteristic air masses as in winter.

Rainfall is most important for all human activities ,the distribution of average annual rainfall over this area as a whole is shown in table (1) (reference- baker 2003) .

Vary the amount of rain falling from one area to another in spite of its small size because of the great diversity in the space where the increase in the mountainous regions of high and less than in the plain areas wetlands as does not exceed the amount of rain falling in the station Dukan of (766 mm) height 860 meters above sea level, while up the quantity in Banjwen station to more than (1263 mm) and a height of 1136 meters above sea level.

The rainfall is highest in the extreme north over the watershed and rainfall occurs from (November to May) the rest of the year its practically dry .

Vary the amount of snow falling from year to year. snow is considered an important source of water resources especially in periods of rainy winter and heavy snow.

Table (2) (reference-baker 2003) showing the amount of snowfall in different years.

Out of these months, the winter season , comprising of December to February gets about 50% of the annual rainfall when spring (march to may) and autumn (October and November) seasons get 25% to 35%and 10%to 20% of the annual rainfall respectively ,it will be noted that the rainfall varies immensely from year to year ,the variability or annual rainfall can be as high as 30% with high intensity of rain falling .

The temperature of the area is controlled by both the meteorological situations and the altitude above the sea level except mentioning that the winter is longer and produces very much low temperature and often below the freezing and that the summer and autumn seasons are more or less pleasant if the altitude of the place at least (two kilometer) above sea level.

Table number (1)

Climate water balance (rainfall and the amount of evaporation station Dukan for the period (1970-2001)

The total evaporation	December	November	October	September	August	July	June	May	April	March	February	January	
766.3	134.8	92.6	27.67	-	-	-	-	26.9	93.1	135.9	125.3	127.3	Rain\mm
1088.09	37.53	64.97	103.47	136.19	153.04	158.33	138.6	111.65	77.0	48.60	31.76	26.95	Energy Evaporation transpiration\mm
422.19	97.27	27.63	-	-	-	-	-	-	16.1	87.3	93.54	100.35	Surplus of water \mm
746.71	-	-	75.8	136.19	153.04	158.33	138.6	84.75	-	-	-	-	Water deficit\mm

Table number (2)

Maximum accumulation of snowy\cm and density %and the level of water \cm of snow monitoringStations in the basin of Dukan

Number of years Of observation	The date	Density%	Water content \cm	The maximum Thickness\cm	Height\cm	The station
11	59\3\1	28	40.25	142.5	1665	Mayan mamk
9	59\3\2	26	25.3	97.5	1575	Mula khoh
13	64\3\12	23	27.5	120	1230	Halsho
15	78\3\11	46	87.5	187.5	1860	Slara
9	57\2\16	36	20.5	56.5	1320	Tursta

Evaporation

Evaporation is great importance element to the rainfall in the water balance. With the relationship between rainfall and evaporation counter productive, they completed each other and evaporation is influenced by heat and Solar radiation, wind and relative humidity. Evaporation reach the highest level in summer, with the percentage during the summer to % 41.3 of the total annual evaporation from the reservoir the quantity of water lost by evaporation from Dukan reservoir is about 0.4 billion m3 in the year.

Table (1) (reference- baker 2003) represents the climatic water balance.

2- Water resources

2-1 surface water

Little Zab is one of important tributaries of Tigris river, and stems from Iranian territory and was hurt by several tributaries from the outside and inside Iraq. Due to the large number of its tributaries, and to controlling the water flow in order to maintain and take advantage in drought times at central and southern regions of Iraq, thus Dukan dam was constructed.

Dukan lake is formed from several small rivers which are the south western tributary of upper little Zab and the rivers are the following;

1-Sewail river which have two tributaries Shalar and Qislaja.
2- Joga soor river which have only one tributary called Mawakan .

This two tributary Sewail and Jaga soor combine together contributing Qala jolan river and drain to little Zab river near the Iraq –Iranion border .

There are many other small rivers at northern part of this watershed drain directly to Dukan reservoir such as ;Hizob ,Qashan ,Dara -siw, Sulana and Zara wa ,fig no (2).

There is a difference in the annual average discharge of the Little Zab river, primarily due to the basis for the different climatic conditions from year to year especially the amount of rain and snow as shown in table (3) following the years of drought and wet, and the amount of excess water stored in Dukan lake , especially Iraq climate has frequent drought years.

2-2 Ground water

The most important factors effecting G.W is geology (parsons1955) the oldest rock belong to Triassic rocks and the newest are Qaturnay rocks. more than 60% of the area occupied by kritasic rocks (limestone and dolomite rocks) most of these rocks are karstic rocks which are very good water bearing for springs . Groundwater is of critical natural resources because it is an important water reservoir can be invested without the risk of losing as a result of evaporation or pollution as it provides a source of water for does not require significant transportation costs. there are many forms of groundwater in the study area such as:

a- Springs

Springs are important sources of water and spread in most parts of the study area. The amount of water flowing from springs depend on the amount of rain and melting snow and leaked into groundwater, where the increase of water flowing from springs in the season excess water and less when lack of rainfall. A water springs emerge from the earth to the surface when the water table intersects with the ground surface .The springs located within the basin based on the amount of dissolved salts divided to (freshwater springs) and springs that are not fresh (metal).The freshwater springs is characterized by low amount of chemical elements dissolved in water, a table's number (4) represents some of the springs in the area, the advantage of being fresh water springs are therefore valid for all uses, whether domestic or agricultural . There is great difference in amount of discharge of springs from site to site it reach about (5250 l\min) in Serjawa spring in (Rania) and (0.1l\min)in (asen kolin spring) in (Banjwen).

The springs of mineral water is characterized by special chemical characteristics, as affected by the features of the rock which groundwater go through , and most of it are calcareous rocks therefore, the water features of high proportion of calcium carbonate and Magnesium. These mineral springs are used for therapeutic purposes, so it is linked to tourism, therapeutic, and has not seen the study area developed in the exploitation of this wealth to the lack of knowledge of the benefits and get advantage of these springs because there are few studies in this area where there are hot mineral water in (kalat Daza) and sulfur in the Boskin Rania water.

b- Wells

The number of wells drilled in the study area until 2003 is 110 wells. , Concentrated in Bashdr , Rania and smaller numbers in district Banjwen, varying in depths ranging between (8) meters in (Geoar Korna well) in Rania and (220) meters in Istralan well the other wells are located between these depths. Characterized well water as a base light and vary in the percent of the dissolved salts (145-446) ppm, production capacity of the wells in the region vary disparity is between (15) L \ sec and (250) L \ sec and in general, the average production capacity of the wells is about (165) l \ s, Advantage of the region where the abundance of groundwater, and increasing groundwater in low-lying areas formed by concave folds or layers formed by erosion and are fragile and longitudinal valleys, such as Khalkan pool, Rania, and kalat Daza pool, characterized of water of the well which is safe for drinking , household use and agriculture.

c- Alkhariz

Drilling alkhariz old ways that are common in the study area for water to be used for drinking and irrigation in areas with limited water resources. The idea built on the basis of the transfer of water with quantities abundant and good quality parts of the mountains to the plain areas that suffer from shortages.

Varying lengths alkhariz from one region to another according to the variation in the nature of the surface and the rock type and depth of groundwater in the area that is intended to benefit from its waters, and are often lined with these channels prevented from collapse and contamination of waters, and covers the wellhead and open for the purposes of maintenance and cleaning, and vary the amount of water allkhariz from one season to another depending on the amount of falling water and surface water and groundwater that feed from and depending on the porosity of rocks and slopes, where it reaches the highest discharge in the winter and spring.

Table number (3)

Characteristics of the average annual discharge of the little zab river in the Dukan dam station for year to different water

The average height of the water basin mm\year	Annual revenue Billion\m3	Medium Discharge m3\sec	Properties of The year	The year	The station
812.52 1896.66 245.51 853.90	6.09 14.06 1.82 6.33	193.29 446 58 201	General Wet Dried medium	2001-1958 1988 2000 1996	Dukan dam

Table number (4)

The physical properties of some springs in the study area

Total dissolved ion\ppm	Electrical Conductivity Mm\cm	Discharge l\d	Ph	Temperature	location	The springs
252.8	0.395	799	7.9	19	Rania	Kani maran
219.52	0.343	781	6.8	18	=	Kolh
170.24	0.266	-	7.2	15	=	Betoath
209.92	0.328	8250	7	17	=	Sarjaoh
153.6	0.24	-	7.7	19	Moat	Dolatanka
169.6	0.265	3052	7.4	13.5	Moat	Konamasy
-	0.45	1.2	-	20.5	Penguin	Dolasor
-	0.55	33.4	-	17	=	Kany speaka
-	0.35	1.0	-	13	=	Naushakhan
-	0.38	7.2	-	13.2	=	Balican
-	0.31	0.1	-	13.8	=	Isan colin
-	0.40	5.0	-	13.5	=	Jawarbag
-	0.52	2.0	-	13.2	=	Kilo
-	0.34	1.5	-	13.2	=	Raolican
-	0.33	0.7	-	15.5	Jawarth	Moat
-	0.36	200	-	14	jawarth	Kani masi

Water needs in the study area

1 - Agricultural needs

Due to the fact that the study area is characterized as a wet area where there are frequent rains and groundwater in addition to surface waters of Little Zab River .Arable land in the study area of (489,864 donum), which account for about (16%) of the total land area of the basin, so spread the profession of agriculture in the region are of two types:

a - Winter agriculture

Which is dependent on rain water in the perfusion mainly in addition to the waters of the river and has a total area of about (348 000) donum. which constitute about (71%)of the area of arable land in the region.

b- Summer agriculture

Agriculture is dependent on surface water for the Little Zab River and groundwater , its the irrigation projects are implemented in the study area about (143 000) donum., representing 29% of the area of arable land.

Table number (6)represent The study area with different irrigation way.

Table number (6)

The study area with different irrigation way \Donum

Total area Donum	Irrigation project Area \Donum	Area irrigated by Rainfall \Donum	Region
111904	34795	77109	Rania
109222	20218	89004	Bashder
125761	31868	93893	Sharbajyer
59491	17598	41893	Banjwen
83486	37699	45787	Dukan
489864	142178	347686	Total

Table (6) represents area of arable land in the study area and water requirements.

The annual average of water required to irrigate an area of 575498 donum is about 1.835 billion cubic meter.

Table number (6)
Plantings and water needs in the region

Annual water needs M3	Cultivated area Donum	Region
96213604	77109 Winter agriculture	Rania
204914410	34795 Summer agriculture	
110806667	89004 Winter agriculture	Bashder
123349513	20218 Summer agriculture	
50328234	41893 Winter agriculture	Banjwen
134447910	17598 Summer agriculture	
117488463	93893 Winter agriculture	Sharbajyer
151310370	31868 Summer agriculture	
57243437	45787 Winter agriculture	Dukan
233893150	37699 Summer agriculture	
554051980	85634	Orchards
1834047738	575498	Total

F.A.O representation in Iraq
F.A.O coordination office for the northern Iraq

2-Household uses

Population of the study area in the 2000 Census is 357,332 people, the rural population, representing about 46% of the total (according to data from the World Food Program (wfp) branch of Sulaymaniyah, Sulaymaniyah Population Data).
Adoption of the 2% annual increase in population, the total population of the study area currently has 436,000 inhabitants.
Annual water needs of the individual urban approximately 200 cubic meters per year
Annual water needs of the rural per capita is 75 cubic meters per year.
-The urban population in the study area is currently 235,440 people and average annual water consumption of 200 cubic meters that is to say the annual water needs of urban areas is 47,088,000 cubic meters.

- Rural population in the study area is currently 200,560 people and an average annual consumption of water 75 meters cubic that the annual water needs of rural areas is 15,042,000 cubic meters.
In other words, the annual rate of household needs in the study area is 62130000 cubic meters.

3 - Industrial uses and hydropower

Most of the industries established in the region of the simple kind which is about workshops and factories, small in size with the needs of few water, having been set up power plant on the Dukan dam in 1976 and consists of five units vertical with a capacity of 80 MW per unit and It does not consume water resources.

*Calculate the water needs in the study area of agriculture and domestic and industrial uses, the average annual water consumptions in the region is currently around (1.9) billion cubic meters.

Amount of water stored in Lake Dukan

a - Dukan reservoir
Dokan Dam was constructed in 1958 for the storage of excess water contained at the top of Little Zab River and its branches To take advantage of the water and launch when needed in times of summer drought periods for areas south of the lake, which suffer from shortages as shown in picture number (1)and fig no (2). Extend the reservoir area in the valley of the Zab River for a distance about 40 km from the front of the dam to site (Darband Rania).

with storage capacity of 6.8 billion m 3 at normal storage levels of (511) m. in which 0.7 billion m 3represent the dead storage, with a surface area of the lake about 270 km 2 at normal water level. Dukan Reservoir is the largest artificial lake in the province with a capacity of 7.2 billion cubic meters and the second largest lake in Iraq after the(low-Thar Thar).
Start of storage in Lake Dukan be in the month of January until May, in this period the amount of water stored more than the amount of water released from the reservoir, where the monthly average water entering the tank about 328 m3\sec while the amount of water released from the lake about 181 m3\sec, and increases the release of water inventories in the other months of the year, as the monthly rate of water entering the tank from June until the end of December is about 83 m 3 \ sec while that which has released about 206 m 3 \ sec, as show in table number (7).

Table number (7)
Rate of water entering Dukan Lake and the rate of released quantities for the period from
(1953-2011)

Monthly released discharge rate m3\sec	Monthly rate of discharge import m3\sec	Month
200	49.38	October
175	110.4	November
170	166.9	December
163	200.8	January
176	327.8	February
209	429	March
188	424.3	April
169	260.1	May
162	114.6	June
223	59.54	July
273	40.65	August
245	39.19	September
196	184.7	The annual average (m3\sec)
6.19	5.82	The annual average (billion m3)

b - Rain

The amount of rain vary in falling from one area to another in spite of its small size because of the great diversity in the space where the increase in the mountainous regions of high and less than in the plain areas wetlands.

Table no (8) represents the rate of rainfall recorded in Dukan station for the period from (1959-2011).

Table no (8)

Average rainfall recorded in Dukan station for the period from (1959-2011)

Monthly precipitation during(52) year mm	Month
1036	October
3800	November
5954	December
6046	January
6022	February
5520	March
4847	April
1361	May
-	June
-	July
-	August
-	September
34589	Total rainfall during(52) year mm
665.17	The annual average precipitation mm

The lower level in the lake adopted to generate electric power is 480 meters and the highest level of normal is 511 meters for that the normal rate of water level in the lake about 495.5 meters.

The adoption of curve shape for (Dokan reservoir – volume).
The amount of stored water at the level 495.5 meters is 3 billion cubic meters, going back to the curve of (Dokan reservoir \storage –area curve). The storage space of the basin (3)billion cubic meters is 17.5 hectares.

- The annual average of rainfall 665.17 mm = = 0.665.17 m
- Area of the basin at the level of 495.5 meters and stock 3 billion cubic meters is 17.5 hectares

* Annual average of rain falling amount
17.5 * 10000 * 0.66517 = 116 404 cubic meters
- Annual average of Dukan lake imports = 5.82 billion cubic meters.

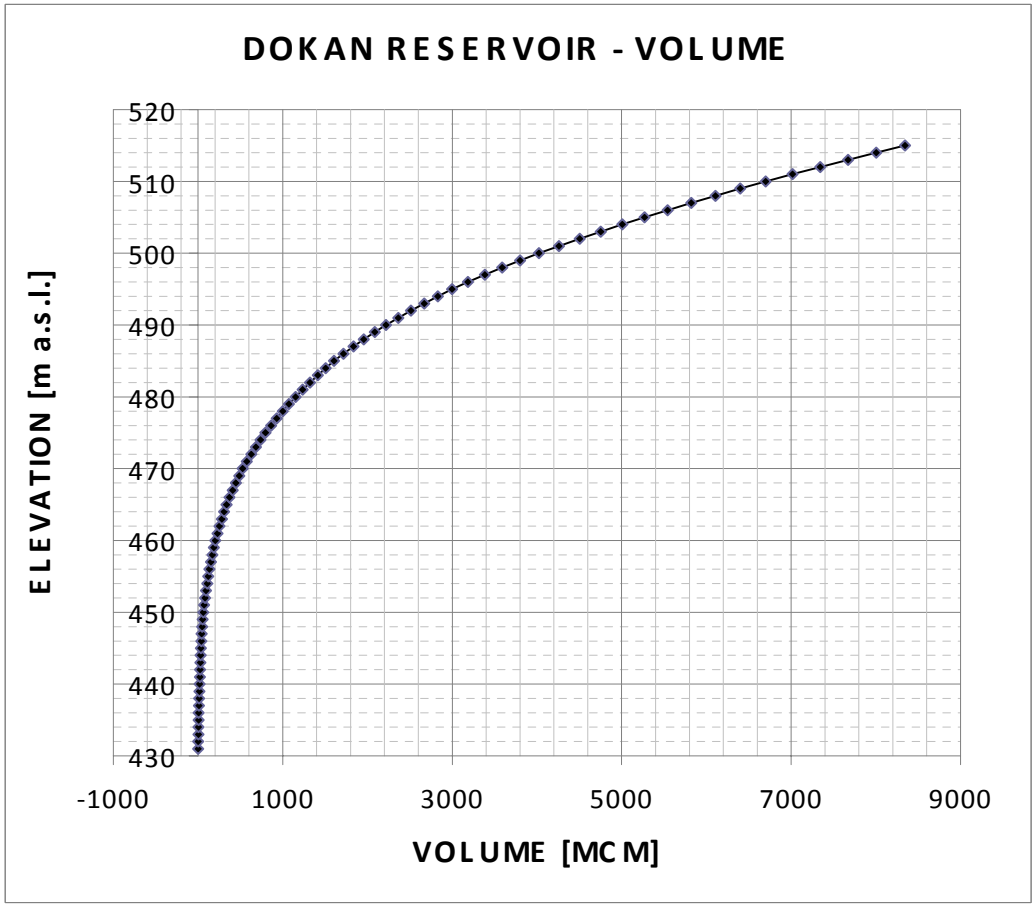
* Conclusion of comparing the amount of water needs in the study area with the amount of water stored in Lake Dukan is the following:

- The Current needs of water in the study area about 1.9 billion cubic meters annually.
- The amount of water entering Lake Dukan from the Little Zab River is 5.82 billion cubic meters per year.

- The annual average of precipitation is 116 404 cubic meters

- The Imports of water from the Little Zab River, about 7.7 cubic meters per year (the adoption of the water needs of the area and the amount of water entering the lake because of the lack of stations deployed in the region to calculate the quantities of water contained in the river).

-The average of annual amounts that are released from Lake Dukan 6.19 cubic meters, more than the amount of water which is contained from Little Zab River to the lake and rain water, except the groundwater that feed the lake and we don't have any information about their amounts.


DOKAN RESERVOIR - VOLUME
ELEVATION [m a.s.l.]
520
510
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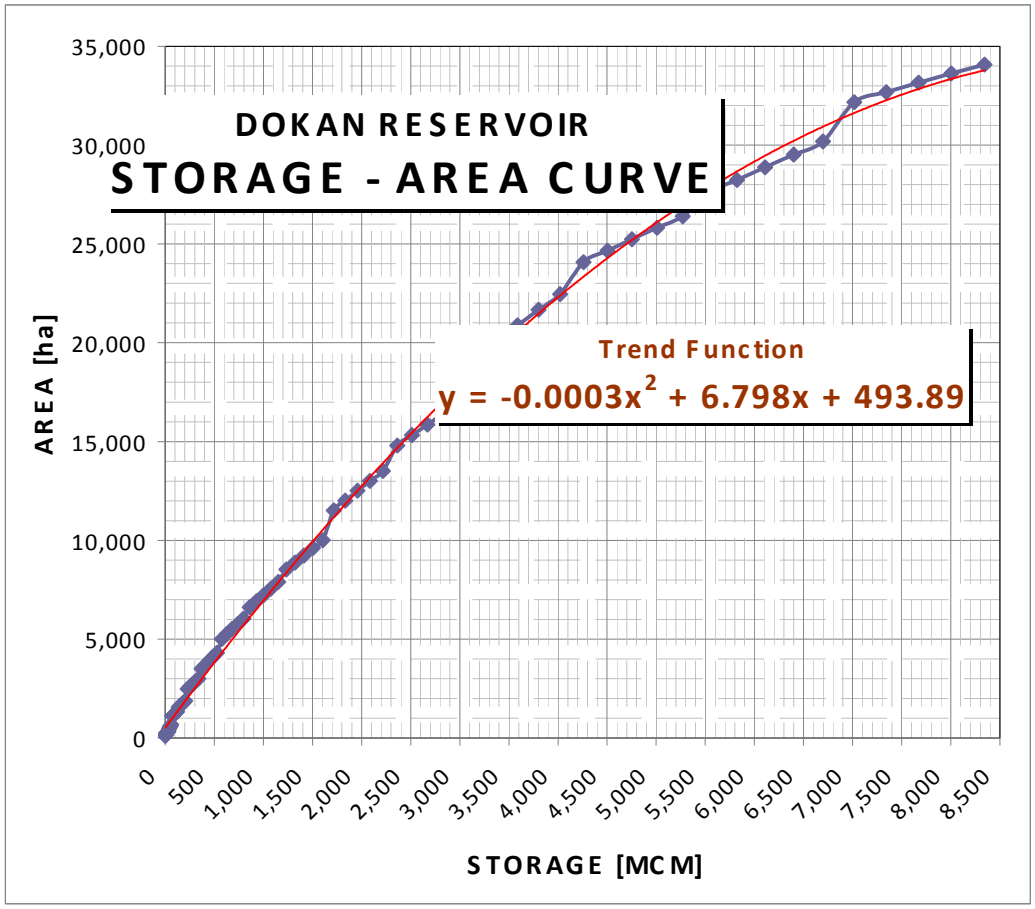
VOLUME [MCM]


DOKAN RESERVOIR
STORAGE - AREA CURVE
Trend Function
y = -0.0003x² + 6.798x + 493.89
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Irrigation projects in study area

The irrigation projects in study area which depend on water of the little Zab river and its tributaries are four main projects:

1-Banjwen project:

Is the biggest irrigation project in the study area and it includes two projects:
-north Banjwen project: the project site on valley Rosh, the irrigation project area site on two sides of the valley with area about 18300 donum.
-south Banjwen project: the irrigation area about 19000 donum,10000 donum irrigated by pumping.

2- Between basin project :

Basin (Between) consists of four projects are located in the region, which occupies the territory of the plains of Rania the greater part of it. The area of land irrigated in the basin (Between) is 27,350 donum, the project Sarajawa largest of these projects in terms of area and irrigate about 18,200 donum of farmland and up discharge water for this project to the (400) l / s, followed by the project (kola) with discharge 150 l / s and irrigate 6000 donum.

Then the project (Kani Maran) with a discharge of 400 l / s and the irrigated area is 3000 donum and smaller projects is a project (Taweya ve project)with an area of approximately 150 donum and the discharge of 150 liters / sec.
The area of the basin (between) is approximately 205,586 donum including 119,754 donum land is arable and the remainder of 85,832 donum of arable land is divided between the land submerged water of Lake Dukan, amounting to 19,422 donum, land irrigated by rain and irrigated land with Surface water an area of 40,810 donum and 25,600 donum respectively.

A table (5) showing the irrigation projects in the basin (between).

Table (5)
Irrigation projects in(Between)basin

Irrigation area Donum	Discharge l\sec	Length km	Water resource	The projects
18200	400	4.8 8.12 3.4 4.8	Khaky zewa,yareka Jwar kwrna, ,krdjan ,kwrny aka, pogasarokwarw, Saktan,dayanan	Sarajawa project
6000	150	3500 2000 4000	Saydawa,posken Shekh hassan Pyaw kwzrawa	Kola water project
3000	400	3 3	Kaja Japa jw	Kany maran Project
150	150	2.5	tawaya	Taweya ve mera batek project
27350				Total

3- Sercan Project

The project lands are located in the district of Dukan (Pennekrd) left Little Zab river with a length of (21) km, and area of (27,100) donum of farmland, including (13,300) donum of exposed lake water immersion when increasing the amount of storage and can be planted after the withdrawal of water.There are other small projects executed at the site of Dukan a total area of (4120) donum.

4-Jarwa project

The project occupies the territory of the right side of the Little Zab river in the district (Bashdr) the total area of (10,000) donum of which (5600) donum irrigated by the river and the rest depending on the rains.

Conclusions and recommendations

* Current water needs in the study area about 1.9 billion cubic meters annually and Imports of water for the Little Zab River about 7.7 cubic meter per year which indicates that the amount of water in excess of the need for the study area more than 5.8 cubic meters per year entering Lake Dukan and the annual amounts average that are released from Lake Dukan 6.19 cubic meters (use outside the study area of central and southern Iraq which suffers from drought) more than the amount of water contained Little Zab River to the lake and rain water . It requires meeting the needs of the study area based on other water resources available in the region include rain, snow and groundwater to increase imports of water from the river to Lake Dukan .

To achieve this requires:

-The study area site in wet region with frequently rain and snow in the winter and spring, which is more than needed, for these two seasons, due to the need for these waters in summer and dry autumn, it requires to built small dams in places appropriate for the purpose of storing sufficient quantities of flood water during the precipitation is rain and snow for use in the summer months as well as it helps to recharge groundwater.

- Non-exploitation of groundwater in the study area in the best way, the water is sweet and it is suitable for domestic uses, agricultural, industrial, and part of them emerge in springs should be utilized more broadly through the organization to take advantage of this water especially in summer and autumn, due to the fact that this water is not deep from the surface of the ground where the wells drilled depths ranging between (8 meters) and not more than (220 meters) accordingly, needing to increase the number of wells drilled.

-Needs to the use of drainage water, after being processed, for the purposes of irrigation.

-Needs to using the modern irrigation methods ,rather than perfusion through opening channels to reduce wasting in water.

*There is no any station in this watershed for measuring discharge and sediments deposition there are only one station lying at dukan (outlet of dukan reservoir).
The need to establish many of the climatic stations in the region to provide data and information necessary about climate , rain and snow, temperature, wind speed and the number of hours of solar radiation because of its impact on the process of evaporation, due to lack of the study area to these stations.

* Water resources in the study area represented in Little Zab River and Lake Dukan and groundwater do not suffer from pollution as in other parts of the river, especially after the Dukan dam except for small amounts of pollution caused by throwing household waste in surface waters, industries located in the region is a mostly simple small workshops are throwing trash directly into the river note that this trash free of toxic substances, there is pollution in the waters of the river by the result of animal waste by drinking water from the river directly. Has been endowed by nature self-purification of river waters after several kilometers ,where the contaminated water become clean water and fresh as a result of photosynthesis and the impact of organic elements in surface waters and constant renewal of the river, the percentage of salts dissolved in the waters of the river and the reservoir to 213 and 412 ppm, respectively (reference - Baker 2003). and the purity and validity of the waters of the river and the reservoir of the uses of household in the study area is high,
Therefore the river maintains the purity until his arrival at the post-dam, where change its properties because of the multiple sources of pollution. To avoid these pollutants requires the establishment of processing units and disinfecting the water before it reaches the river.

*Increasing the amount of sediment in Lake Dukan, which can reduce the life of the tank. Noting is currently acting to do afforestation on the slopes of the lake to reduce erosion of the soil to prevent sliding and reduce sediment. As shown in the picture number (2)

*Population of the study area depend on the profession of agriculture, given the many sources of water which helps agriculture by relying on rain water, groundwater, and the population to remove vegetation and of trees and forests and the use of land for cultivation, and after years of land use also after carrying capacity, they leave, and planting other areas (growing mobile), which shows the soil to erosion, thus reducing the agricultural areas in the region. which requires reliance on the elements of

human and natural resources available in the study area for a reforestation projects, forest and prepares conditions for growth and preservation, thus reducing erosion in the region with public awareness of the need to preserve green spaces .

* interesting in water media and broadcast ads, which calls for the rationalization of water use and refrain from pollution and raising awareness about the increasing scarcity of water.

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