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Research article

CLASSIFICATION OF WATERSHEDS IN SULAIMANIYAH GOVERNORATE BASED ON DATABASE OF SOME MORPHOMETRIC CHARACTERISTICS

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ABSTRACT: Iraqi Kurdistan Region possesses varieties of watersheds with respect to their shape, size, soils and geology. To assess the potential of each watershed in the region for its development and to discover the problems that are likely to encounter in the process, Classification of watersheds was carried out which is the first attempt in respect of the watersheds of Sulaimaniyah Governorate. Some morphometric characteristics such as (area, stream frequency, drainage density, average bifurcation ratio and slope) were measured to be the data bases of this classification. With the aid of the computer a morphometric map was prepared for the watersheds of Sulaimaniyah governorate. According to this study the watersheds in this region were classified into (Basins, watersheds and micro-catchments). Brief descriptions of the basins and some individual watersheds were demonstrated with particular reference to location, topography and stream flow.
Key words: Watersheds, Sulaimaniyah, morphometric

INTRODUCTION

At the time when the whole world was working on sustainability , watersheds became the reference units for carrying out a wide range of projects such as ; Agriculture , Forestry , Energy , Mining , Transportation , Tour and wild life's.

A watershed or a drainage basin is the entire area drained by a stream or a system of connecting streams such that all stream flow originating in the area is discharged through a single outlet [4]. The basin is necessarily completely bounded by a divide, which separates it from adjacent basins. The divide follows the ridge line around the basin, crossing the stream only at the outlet point. Further, it marks the highest points between basins but isolated peaks within a basin may reach greater elevations than any point on the divide. Moreover the sub-areas or tributary basins are defined by interior divides exactly as in the large basin, [1]. Watersheds come in all shapes and sizes. Some are millions of square kilometers; others are just a few hectares.

A hydrographic catchments can be defined as a geographical area defined topographically, bounded by watersheds, and drained by a drainage line or by a system of drainage lines connected to each other, whose waters converge directly or indirectly into the sea or large lake through a unique control section. The main function of watershed is to receive the incoming precipitation and then dispose it off. This is the essence of soil and water conservation. Garg, 1979 classified watersheds on the basis of size as:

1. Small watersheds: Are those drainage basins which are small in size to such an extent that the rain intensity may be considered as being uniform over the entire area. Such basins are generally encountered in the design of culverts, stream sewers, small bridges, etc.

2. Large watersheds: The large basins are the basins of longer dimensions, and thus larger than those for which the rain intensity may be considered as being uniform over the entire basin. They are generally involved in the construction of flood protection works (such as dams), irrigation and water supply works.

Large basins usually tend to be fan-shaped or pear-shaped, but exhibit great variation in shape depending on the geological structure of the basin.

However they can be classified into 7 classes depending on the shape of the catchment and stream pattern: Tree-like, rectangular, radial, fern-leaf, fan shaped, trellis and parallel-type [7].

[5] classified the watersheds into (River basin, watersheds and micro- catchments), from large area's to smaller ones. Further more a large numbers of terms are very frequently and loosely used to classify watershed in different sizes [based on size], such as:

a. Micro watersheds,
b. small watersheds,
c. large watersheds, etc. Furthermore according to My Agriculture Information Bank (2011), watersheds were classified depending on area as:
i) Sub watershed: 10,000 to 50,000 ha
ii) Multiwatershed: 1000 to 10,000 ha.
iii) Micro watershed: 100 to 1000 ha.
iv) Mini watershed: 1 to 100 ha.

In this study the watersheds of Sulaimaniyah region were classified into (Basin, watershed and Micro-Catchment) regarding that the areas less than (25 km^2) are Micro-catchments, the areas of (25 to 150 km^2) are watersheds, which the watershed may contain several Micro-catchments. While the areas of more than (150 km^2) considered they are basins, and the basins may contain several watersheds or no contain watersheds, besides to individual Micro-catchments which are located out of the watershed boundaries, in condition that the water of all watersheds and Micro-catchments drains to the same main stream of the basin.

The goals of this study is to :

1.Classification of watersheds into (Basin, watershed, Micro-Catchment).
2. Determination of some hydromorphometric characteristics for each basin and individual watersheds.
3. Preparation a morphometric map identifying the boundaries of the watersheds.
4. To develop a data base upon classification of watersheds.

METHODOLOGY

Location of the studied area:
The whole of the studied area located in Kurdistan region at the North-east of Iraq between the latitudes of 35^0 $05^{'}$ and 36^0 $30^{'}$ and between longitudes of '440 $25^{'}$ and 46^0 $20^{'}$.
To recognize (Basins, Watersheds and Micro-Catchments) it's necessary to define each term:
Basin: All the land contributing water to a river system, from the headwaters to the river mouth.
watershed: The land contributing water to a tributary of the river system, may consist of several Micro-catchments.
Micro-catchments: small area contributing water to a specific stream or to a specific feature.
Morphometry; is the measurements and mathematical analysis of rivers and drainage basins. The Main aspects examined in this study, are the: 1- Area. 2- Stream order. 3- Stream frequency. 4- Drainage density. 5- Bifurcation ratio. 6- Slope.

1- Area, (A):
After appointing watershed boundaries on the topographic map, the area of each watershed has been measured on the map by using the planimeter. Area or Size of watershed determines the quantity of rainfall received retained and disposed off [runoff]. Larger the watershed, larger is the channel and storage of water in basin. Large watershed characteristics are topography, geology, soil, climate, land use and vegetation.

2- Stream order, (Nu) :
According to (Strahler, 1957) for stream ranking, the first order will give to the first branches. And , where two of order 1 join, a channel segment of order 2 is formed; where two of order 2 join, a segment of order 3 is formed and so fourth. The trunk stream through which all discharge of water or sediment passes is the stream segment of the highest order [Chow, 1964]. This order of classification is the inverse of the European system, in which the main stream is always classified as first order and the external tributaries as the highest order [Linsley et al, 1975].

3- Stream frequency, (F): Ratio of the number of streams of all orders with watershed area. It is the measure of topographic texture.

$$F = \frac{\sum Nu}{A\ (km)^2}$$

Where: F =Stream frequency, Nu =Number of Streams, A =Area of the watershed in (km^2)

4- Drainage density, (D):

It is the total channel length divided by the total area of the watershed in the units (km/km^2).

$$D = \frac{\sum \mathbf{L}\ (Km)}{\mathbf{A}\ (Km)^2}$$

Where : D =Drainage density in (km/km^2) , L =Length of the Streams.(km)

5- Bifurcation ratio, (Rb) :

Ratio of number of stream of given orders to number of streams of the next higher order. This is an indicator to express the regularity of the climate and rock similarity in the watersheds, and could be limited by (3 - 5) that can be considered as acceptable rate for being the climate moderate and the rocks have affinity.

$$\mathbf{Rb} = \frac{Nu}{Nu + 1}$$

Where: Rb = Bifurcation ratio , Nu = number of stream of given orders , and (Nu + 1) = next higher order.

6- Slope = Elevation difference between two points / the horizontal distance between that two points.

Topographic maps with the scale of 1:100 000 were obtained; enough copies were used for morphometric measurements and in drawing the watershed boundaries.

RESULTS AND DISCUSSIONS

1-Dewana Basin

a- Location: The area of Dewana basin lied between latitudes 35^0 05' and 35^0 20' and between longitudes 45^0 15' and 45^0 43'. The Basin bounded to the north by Basara Basin and to the northeast by Zirguez mountains, by Sagirma to the west and by Darbandikhan city to the south, see Fig (6).

b- Topography: The area in general has a steep to very steep topography with little flat land. The highest point in the Dewana basin is 1873 meters above mean sea level which is located on Sagirma summit. The lower point, which is at the mouth of the Dewana, watershed is (501) meters a bove mean sea level. The Basin contain many geomorphological features, the mountains like (Sagirma, Barzidolan, Kolosh,.and..etc.) and valleys like (Darawian, Lokma, Zair, Tilie, and Darizard).

c- Stream flow: Dewana Basin has a main perennial river stream called Dewana River. Dewana river stream flows to the Diyala (Sirwan river) at the south of Darbandikhan lake. Dewana Basin contains many springs and has (3) watershed and (19) Micro-catchments.see Fig (1).

2-Tanjaro Basin

a- Location: Tanjaro basin lied between latitudes 35^0 15' and 35^0 50' and between longitudes 45^0 15' and 45^0 50'. The basin bounded to the north by Peramagron mountain and Dolarut watershed. To the east by Goizha and Wariska mountains, and Galal watershed. To the west by Dewana Basin and Baranan mountain, and by Darbandilkhan lake to the south east , see Fig (6).

b- Topography: Tanjaro watershed has a steep and moderate slope topography. It has a wide part of Sharazoor fertile plain located inside this basin .

c- Stream flow: Because of Tanjaro Basin occupies a wide area it's ordinary to contain number of watersheds and micro-catchments, where makes up a long main stream in the basin which poured into Darbandikhan lake**,** Fig (2).

3-Basara Basin

a- Location: Basara Basin bounded at the east by Daragha and Baranan mountains and in the south by Dewana Basin and at the west by Hanjira mountains. It lies between latitudes 35^0 20' and 35^0 39' and between longitudes 45^0 00' and 45^0 25' , see Fig (6) .

b- Topography: The area located in high folded zone, it has a wide plain with slightly slope topography called Bazian Plain. It's contain (6) Watersheds and (14) micro- catchments.

c- Stream flow: Basara Basin has many springs, kariezes. Basara Basin has perennial main stream, which consist of the combination of two great streams which are Tilie stream and Chami Tainal stream, Fig (2).

4-Zalum Watershed

a- Location : It is located between latitudes 35^0 15' and 35^0 20' and between longitudes 45^0 55' and 46^0 00', it's surrounded by Iran boundary from the northern east by Shanadary watershed from the west and by Darbandikhan lake from the south.

b- Topography : This basin located in the both high folded and thrust zones, the highest point in this area is (2571) meter above mean sea level. As a result of high velocity of water, the flood plains are exist in these areas. And the flood plain starts below Ahmad Awa village to Darbandikhan lake.

c- Stream flow : Zalum watershed has a perennial main stream, but Khandaq branch which located at the east of Zalum watershed has an ephemeral stream flow, there were about (35) springs in this area. Zalum watershed contain (20) Micro catchments, Fig (2).

5-Kaolos Basin

a- Location : Kaolos basin located from the east of sulaimaniyah city, situated between latitude 35^0 26' to 35^0 35' and between longitudes 45^0 42' to 46^0 00' . Surrounded from the east by Surien mountains, by Goga sur and Mawakan basins from the north, by Barzinja range lands from the west and by Sharazoor plain from the south, see Fig (6) .

b- Topography : The area has a steep to very steep topography with little flat land between valleys. At Galal watershed the slope becomes moderate. The highest point in this basin is (2208) meters above mean sea level, which is located at Kurakazhaw summit. Structurally divided into four great zones (Low, High, Imbricate and Thrust).

c-Stream flow : Kaolos basin contain (4) watersheds which all combine's together at Kaolos village. The site of Kaolos village was suggested for building a dam. Each of Chaqan and Chawtan watersheds has a perennial stream river. Annual precipitation is about(900 mm**),** Fig (2).

6-Shanadary watershed

Location : It is lied between latitudes 350 15' and 350 30' and between longitudes 450 05' and 45 0 00'. It's bounded by Iraq–Iran boundary from the east, by Kaolos Basin from the north, by Darbandikhan lake from the south and west .

b-Topography: The upper part of this watershed has a steep slope and contain many mountains and valleys, but gradually change this slope to moderate and flatland near said–sadiq.

c- Stream flow : The watershed has an intermittent stream river which flows into Darbandikhan lake in the rainy season. It has 9 Microcatchments.

7-Sirwan Basin:

a- Location: This basin situated between latitudes of 350 05' and 350 10' and between longitudes 450 50' and 460 05', It represents a boundary of Iraq - Iran at the northern east of Iraq.The basin bounded by Biyara watershed at the north and west. By Darbandikhan lake from the south and by Iran from the east, see Fig(6)

b- Topography: It's located within high folded and thrust zones, there were many mountains and valleys in this area especially in Hawraman area.

c- Stream flow: Sirwan river stream is a perennial main stream which supply water to Darbandikhan lake. The main part of the area of this basin lies inside Iran. This basin contains three watersheds inside Iraq, Fig (1).

8-Biyara watershed

a - Location : This watershed located at the east of Zalum watershed, and at the west of Tawela watershed . It's surrounded by Iraq- Iran boundary in the north and by Halabja city at the south , it lies between latitudes of 350 10' and 350 15' and between longitudes of 450 55' and 460 02'.

b- Topography : The watershed located among Hawraman series mountains and this cause steep slope topographically, there was a little plain to moderate slope near Halabja city.

c- stream flow : The watersheds main stream has a perennial flow which pour into Darbandikhan lake, there were many springs in this area which supply the water to the main stream.

9-Sedara watershed

a- Location : It is located between latitudes of 350 10' and 350 15', and between longitudes of 450 40' and 450 45'. Its bounded from the east and south by Darbandikhan lake, from the north by Tanjaro basin and from the west by Dewana basin .

b- Topography : Its located in the high folded zone and has a steep slope topography, has some valleys and surrounded by a sires of mountains.

c- Stream flow : The watershed has a main river stream which called Sedara river. The main stream take the water from (5) micro–catchments and has a perennial flow which fed Darbandikhan lake.

10- Watersheds that are poured directly into Zei-Bichuk river at sharbazher area:

a-Location : The area lied between latitudes of 350 55' and 360 00' and between longitudes 45^0 30' and 45^0 40' . A little part of this area located inside Iraq and other part located inside Iran, see Fig (6) .

b- Topography : The area has a steep slope topography and located in the high folded zone, its mountainous area with many valleys.

c- stream flow : Three watersheds of this basin located inside Iraq. Each watershed contain some springs and Karezes. Zei-bichuk River Basin has a big perennial river stream called (Zei-Bichuk) inside Iraq.

12- Bardasipi Watershed

a- Location : The watershed located between latitudes of 350 50' and 350 55'. And between longitudes of 45^0 25' and 45^0 30'. Its surrounded by Siwail Basin from the east and south , by Zei-bichuk river from north, and by Qalachwalan river from the west, see Fig (6) .

b- Topography : The watershed lied at the high folded zone, which has many mountains, folds and valleys with the little flat lands between mountains.

c- stream flow : Bardasipi watershed has some springs and karezes which are consisting an intermittent stream river which poured directly into Qalachwalan big river.

13 - Dolbeshik Watershed

a- Location : This watershed lied between latitude 35^0 48' and 35^0 55' , and between longitudes 45^0 15' and 45^0 25' . It's bounded by Qalachwalan river from the east and north, by Maluma watershed from the south and by Haladin watershed from the west.

b- Topography : Its located in the high folded zone with existence of mountains and some folds.

c- stream flow : Dolbeshik watershed has a main perennial river stream, which contain many springs and tributaries. This main stream is a one branch of Qalachwalan river.

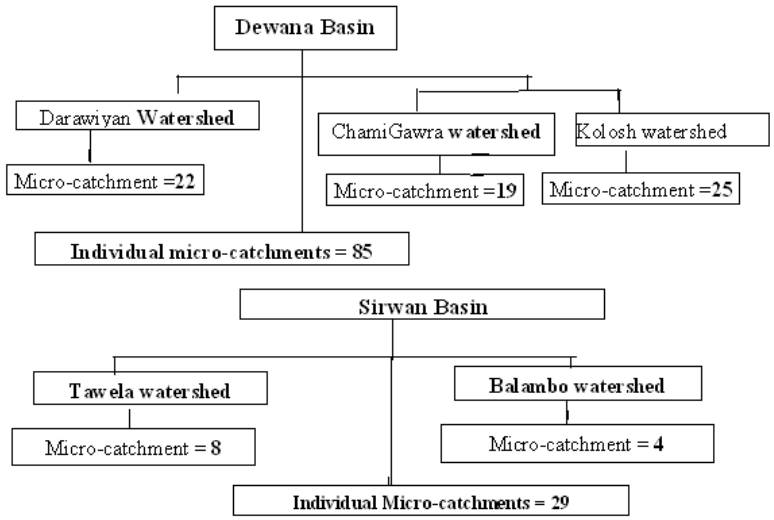

Fig (1) Schematic classification of Dewana and Sirwan basin .

14 -Mawakan Basin

a-Location : Mawakan Basin is surrounded from the north and east by Gogasur Basin. By Goizha and Azmir mountains to the west and by Wariska Mountains in the south. It lies between latitudes of 35^0 30' and 35^0 40'(N), and between longitudes of 45^0 30' and 45^0 45' (E), see Fig (6) .

b-Topography : The area in general has a steep to a moderately slope topography. Many symmetric and asymmetric anticline folds existence in this area which makes the bad land and bad drainage. Structurally located in the high folded zone.

c- Stream flow : There were about (50) Springs and karezes in this area, this refers to the geological formations of the rocks which consist of(Balambo, Kometan, Shiranish and Tanjaro) Formations. Annual precipitation of this area is about (750) mm. This Basin has two watersheds, and has a main stream called mawakan river which combine together with Gogasur river to make Qalachwalan River at Qalachwalan village, Fig (3).

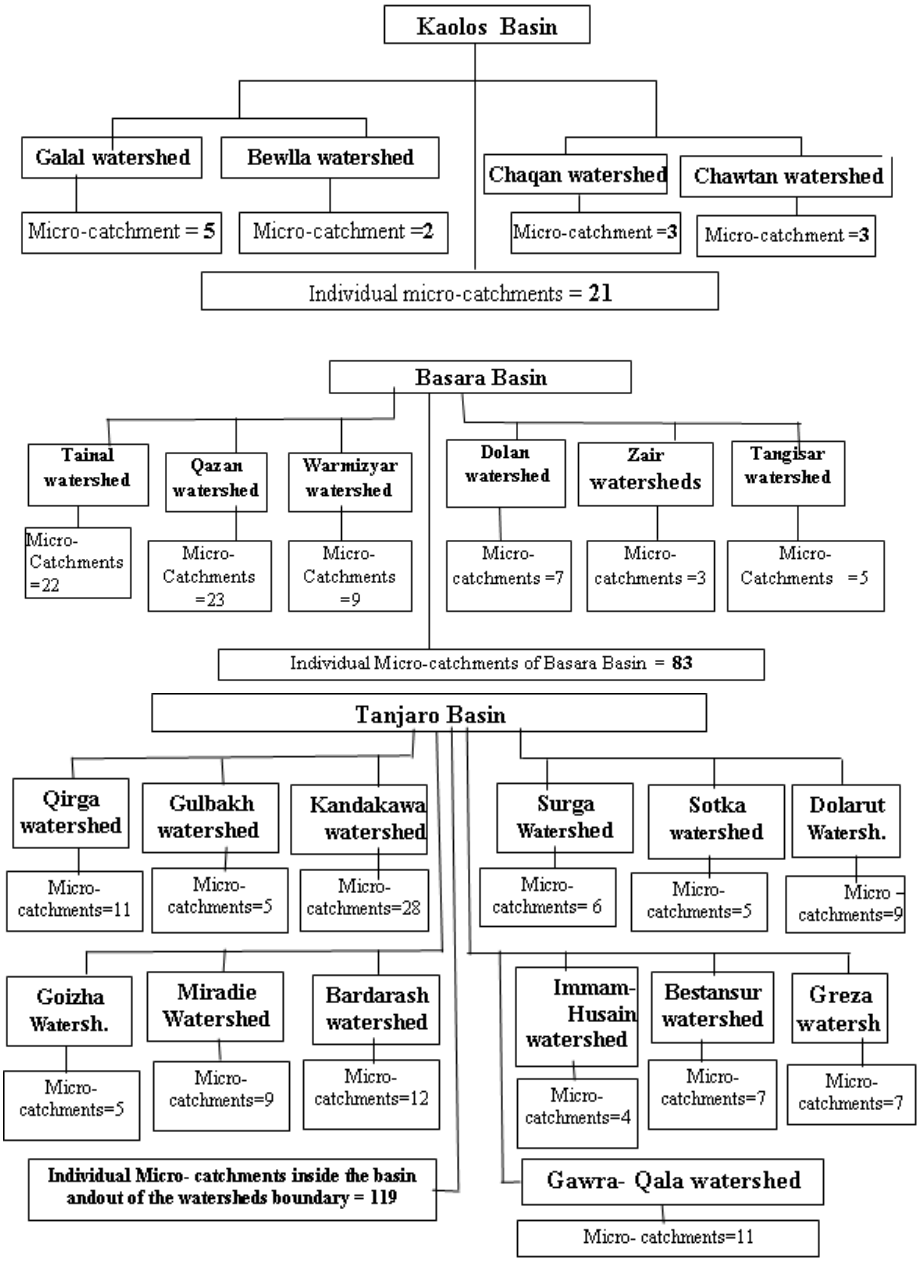

Fig 2: Schematic classification of Kaolos, Basarra, and Tanjaro basins .

Table (1) Morphometric characteristics for Bassarra Basin

Watershed	Stream order (Nu)						Total Nu	Stream length, L (km)						Total km	Area km^2	F	D	Rb
	1st	2nd	3rd	4th	5th	6th		1st	2nd	3rd	4th	5th	6th					
Tainal	167	41	12	2	1	-	223	111.8	58.4	23.4	4.6	21	-	219.2	137.4	1.6	1.6	3.8
Qazan	142	40	12	2	1	-	197	100.1	34	21.1	16	2.2	-	173.4	80	2.4	2.1	3.7
Wamyzar	82	16	4	1	-	-	103	69.1	23	9.1	9.6	-	-	110.8	69	1.5	1.6	4.3
Zair	68	20	4	1	-	-	93	76.8	28.6	10.9	8.5	-	-	123.9	57.4	1.6	2.1	4.1
Tangisar	37	10	2	1	-	-	50	43	15.9	2.8	6	-	-	67.7	36.9	1.3	1.8	3.5
Dolan	69	14	4	1	-	-	88	69.5	23.4	6.8	4.7	-	-	104.4	39.9	2.2	2.6	4.1
All Bassarra Basin with Micro-catchments	774	200	46	10	3	1	1034	715	236	56.2	51.6	23.2	12.7	1094.7	572.22	1.8	1.9	3.6

Table (2) Morphometric characteristics for Dewana Basin.

Watershed	Stream order (Nu)						Total Nu	Stream length, L (km)						Total km	Area km^2	F	D	Rb
	1st	2nd	3rd	4th	5th	6th		1st	2nd	3rd	4th	5th	6th					
Chami- Gawra	151	34	8	1	-	-	194	126.5	45.9	14.6	13	-	-	200	93.2	2	2.1	5.5
Darawian	198	55	13	4	1	-	271	167.6	59.3	39.9	6.3	13	-	286	125.1	2.1	2.2	3.7
Kolosh	208	54	9	2	1	-	274	144.1	49.4	20.2	15	6.5	-	235.2	124.4	2.2	1.8	4
rana Basin with Micro-catchments	924	241	50	9	2	1	1227	754.5	261.4	110.5	37.9	37.5	20	1221.8	970	1.2	1.2	4.1

Table (3) Morphometric characteristics for Tanjaro Basin.

Watershed	Stream order (Nu)						Total Nu	Stream length, L (km)						Total km	Area km^2	F	D	Rb
	1st	2nd	3rd	4th	5th	6th		1st	2nd	3rd	4th	5th	6th					
Kandakawa	83	24	5	1	-	-	113	169.4	48.7	12	18	-	-	248.1	134.31	1.1	1.8	4.4
Sotka	37	7	2	1	-	-	47	61.3	38.5	12.5	4.3	-	-	116.6	46.31	1.0	2.5	3.5
Surga	26	7	2	1	-	-	36	56.3	22.2	17.5	4	-	-	100	48.81	0.7	2	3
Goizha	56	12	5	1	-	-	74	85	17.7	14.5	11.5	-	-	128.7	83	0.9	1.5	4
Dolarut	114	33	7	1	-	-	155	169.4	48.7	14.8	19.5	-	-	252.4	134,5	1.1	1.8	5
Qirga	55	13	3	1	-	-	72	61	33.5	16.2	3.3	-	-	104	69.41	1	1.4	3.8
Gulabakh	51	14	3	1	-	-	69	49	19.5	7.1	13	-	-	88.6	43.3	1.5	2	3.7
Immam Husain	43	10	3	1	-	-	57	47.7	14	9.1	5.3	-	-	76.1	34	1.6	2.2	3.5
Gawra Qala	61	18	4	1	-	-	84	57.1	15.4	15.4	14.2	-	-	102.1	60.5	1.3	1.6	3.9
Miradie	120	28	9	3	1	-	161	79.5	40.4	27.4	16.4	3.7	-	167.4	69.2	2.3	2.4	3.3
Bardarash	129	32	10	3	1	-	175	73.5	26.9	18.9	12	6.3	-	137.6	73.7	2.4	1.8	3.4
Greza	130	26	4	1	-	-	161	84.3	27.1	17	10	-	-	138.4	54.8	2.9	2.5	5
Bestansur	79	20	4	2	1	-	106	77.7	28.7	20.7	7.4	2.5	-	137	55.9	1.9	2.4	3.2
All Tanjaro basin with micro-catchments	1510	367	95	17	3	1	1993	1391.1	502.2	254.8	130	36	19.5	2333.6	1286.4	1.5	1.8	4.4

Table (4) Morphometric characteristics for Sirwan Basin, Sedara, Biyara, Shanadary and Zalim watersheds

	Watershed Name	Stream order's (Nu)							Stream length (Km)							AreaK m^2	F (Km)$^{-2}$	D (Km)$^{-1}$	Rb $_{av}$
		1st	2nd	3rd	4th	5th	6th	*Total*	1st	2nd	3rd	4th	5th	6th	*Total*	–	–	–	–
Sirwan Basin	Tawella	112	24	11	1	–	--	148	153.3	60.2	35.7	19.8	--	--	269	62.65	2.3	4.2	5.9
	Balambo	71	16	4	2	1	..	94	81.3	31.7	21.2	5.7	4.1	..	144	27.26	3.4	5.2	3.1
	All Sirwan Basin with micro-catchments	390	93	22	4	1	..	510	419.1	167.6	85.9	30	27.1	..	729.7	191.78	2.6	3.8	4.4
	Sedara Watershed	118	27	9	1	–	..	155	170.2	64.3	32.1	20.3	–	–	286.9	48.88	3.1	5.8	5.4
	Biyara Watershed	130	30	10	3	1	--	174	197.7	70.3	37.6	7.4	28.1	–	341.1	103.5	1.6	3.2	3.4
	Shanadary watershed	135	29	9	3	1	--	177	157.6	76.1	47.4	36	18.3	–	335.4	140.52	1.2	2.3	3.4
	Zalum watershed	110	25	8	2	1	--	146	163.4	58.8	30.3	20.5	19.5	–	292.5	78.15	1.8	3.7	3.3

Table (5) Morphometric characteristics for Kaolos Basins.

	Watershed Name	Stream order's (Nu)							Stream length (Km)							Area Km^2	F (Km)$^{-2}$	D (Km)$^{-1}$	Rb$_{av}$
		1st	2nd	3rd	4th	5th	6th	*Total*	1st	2nd	3rd	4th	5th	6th	*Total*				
	Chaqan	53	14	2	1	–	--	70	80.4	22	21.3	11.1	–	--	104.8	42.92	1.6	2.4	4.2
Kaolos Basin	Chawtan	39	12	4	1	–	--	56	53.4	25.6	6.8	8.2	–	--	94	26.88	2	3.4	3.4
	Galal	74	14	3	1	–	--	92	94.8	39.3	7.8	16.2	–	--	158.1	50.32	1.8	3.1	4.2
	Bewila	40	10	2	1	–	--	53	65.6	17.3	13.3	2.7	–	--	98.9	31.66	1.6	3.1	3.6
	All Kaolos Basin with micro-catchments	346	80	17	6	2	1	452	406.2	130	71.7	46.2	15.2	1	670.3	258	1.7	2.5	3.3

15- Gogasur Basin

a- Location: Gogasur Basin located between latitudes of 35^0 30' and 35^0 45' and between longitudes of 45^0 30' and 46^0 00'. Its surrounded by Siwail Basin at the north, by Mawakan Basin and Kaolos Basin from the south, by Chwarta Town from the west and by Iran boundary from the east, see Fig (6)

b-Topography: Gogasur river basin has a steep slope topography. There were many mountains inside this basin like (kachalpir, Korrakazhaw, Kato, and Kanasir) mauntains. This basin lies in high folded zone, There were many Valleys, faults and folds in this area. There was a good position for constructing a dam for the main stream near swerala village.

c- Stream Flow : Due to the existence of wide area of this Basin which started from Iran boundary to Qalachwalan village, its contain many branches, Micro- catchments and many springs which are fed Gogasur perennial river along the area of the basin, Fig (3).

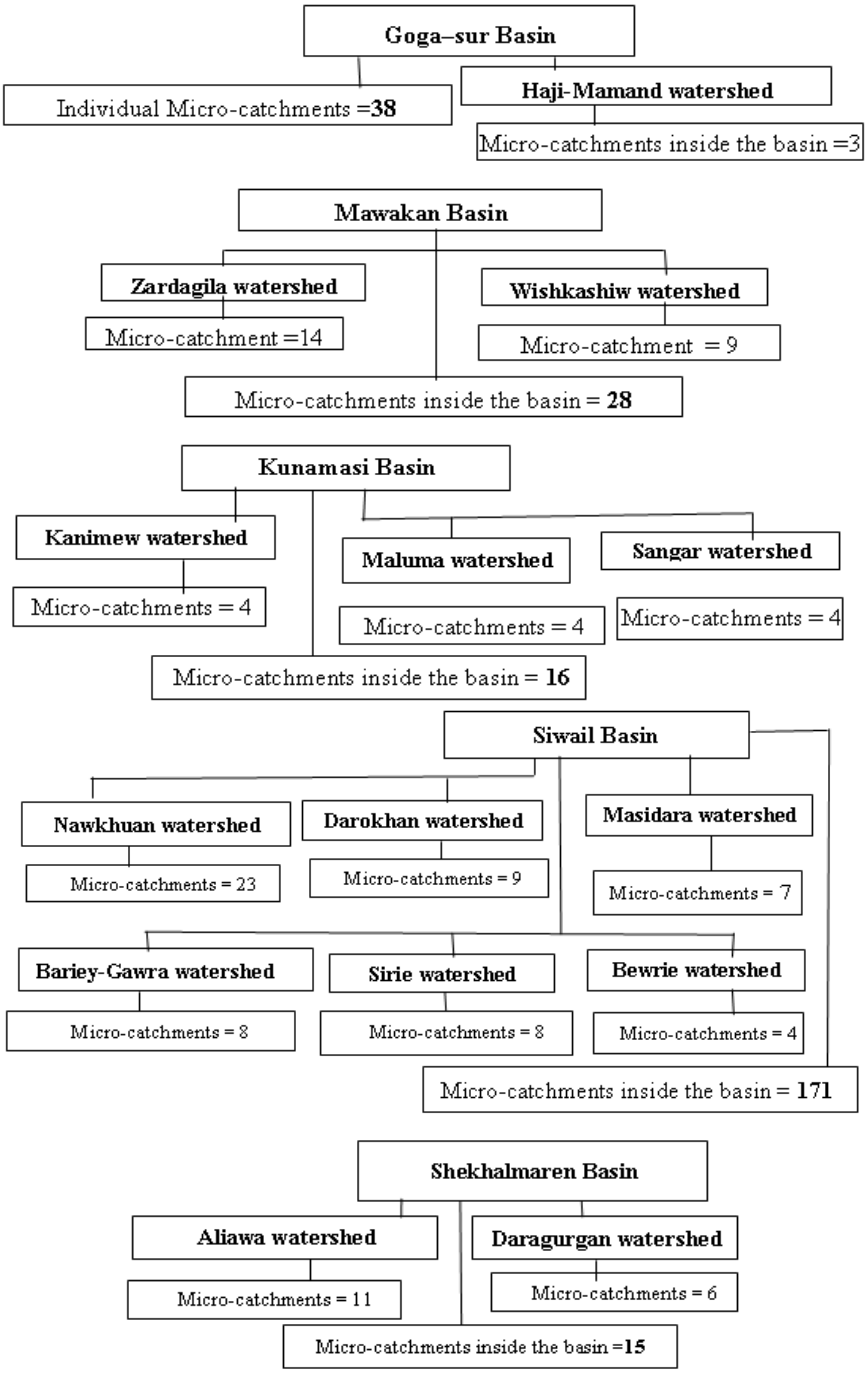

Fig 3: Schematic classification of Gogasur, Mawakan, Kunamasi, Siwail and Shekhalmaren Basins .

16 - Siwail Basin

a- Location : Siwail basin is the greatest basin in Sharbazher region. Its start's from Iran boundary to Suraqalat village where it combine together with Qalachwalan river in this situation. It lies between latitudes of 35^0 30' and 35^0 50' and between longitudes of 45^0 30' and 46^0 05'. Its surrounded from the east and north by Iran boundary, and from the south by Gogasur Basin, see Fig (6).

b- Topography : The area in general has a steep slope, structurally located in high folded zone. Many mountains, valleys and other geomorphologic features are existing in this basin. The highest point is (2217)m. above mean sea level.

c- Stream flow: Siwail Basin has two perennial river streams (Shekhalmaren and Shler). Shekhalmaren perennial stream take its water from two watersheds and 15 Micro-catchments and according to this classification is considers a basin which its main stream combine together with Shler river at Suraban village to make Siwail perennial river. Annual precipitation amount is a bout (>1000) mm, Fig (3).

17 - Kunamasi Basin

a- Location : Kunamasi Basin bounded at the east by Mawakan Basin, and by Dolbeshik watershed from the north, by Dolarut watershed from the south, by Haladin watershed from the west. It lies between latitudes of 35^0 47' and 35^0 57', and between longitudes of 45^0 10' and 45^0 25', see Fig (6).

b- Topography: Its located in the high folded zone. It has a steep slope topography and has many Hills, Mountains and Valleys. The highest point is (2175)m above mean sea level and its located on (Gojar) summit.

c- Stream flow: Kunamasi main stream consist of three perennial streams which are Maluma river, Kanimew river and Sangar river. Each stream has many branches ,many springs and Karezes. Annual precipitation in this Basin is about (800)mm, Fig (3).

Table (6) Morphometric characteristics for Siwail Basin

	Watershed Name	Stream order's (Nu)							Stream length (Km)							Area Km^2	F $(Km)^{-2}$	D $(Km)^{-1}$	Rb_{av}
		1st	2nd	3rd	4th	5th	6th	Total	1st	2nd	3rd	4th	5th	6th	Total				
Siwail Basin	Nawkhwan	292	65	15	1	-	..	373	335.7	112.3	48.9	34.9	-	-	531.8	130.06	2.8	4	7.9
	Darokhwan	96	25	6	1	-	--	128	75.1	25.9	11.6	15.2	-	-	127.8	37.03	3.4	3.4	4.6
	Masidara	69	17	4	1	-	..	91	78.2	27.5	13	12.9	-	-	131.6	38.45	2.3	3.4	4.1
	Bariey-Gawra	122	30	8	2	-	..	162	117.6	49.3	24.5	26.4	-	-	217.8	47.06	3.4	4.6	3.9
	Sirie	110	25	8	2	1	--	146	163.4	58.8	30.3	3.8	28.1	-	284.4	91.83	1.5	3	3.3
	Bewrie	43	7	2	1	-	..	53	79.6	16.2	4.3	18.1	-	-	118.2	32.24	1.6	3.6	3.8
All Siwail Basin with micro-catchments		1465	344	79	12	4	1	1905	1447.4	568.2	222	143.9	69.3	43.2	2494	967.68	1.9	2.5	4.4
Shekhalmaren Basin	Daragurgan	85	26	9	1	-	..	121	80.8	29.7	21.9	12.7	-	-	145.10	57.93	2	2.5	5
	Aliawa	67	17	2	1	-	..	87	100.5	19	12	6.5	-	-	138	45.02	1.9	3	4.8
All Shekhalmaren Basin with micro-catchments		238	61	13	2	-	..	314	264.8	72.8	39.4	19.2	-	-	396.2	168.45	1.8	2.3	5

Table (7) Morphometric characteristics for Mawakan and Gogasur Basins .

	Watershed Name	Stream order's (Nu)							Stream length (Km)							Area Km^2	F $(Km)^{-2}$	D $(Km)^{-1}$	Rb_{av}
		1st	2nd	3rd	4th	5th	6th	Total	1st	2nd	3rd	4th	5th	6th	Total				
Mawakan River Basin	Wishkashiw	117	18	4	1	-	-	140	90	32.3	5.9	14.5	-	--	142.7	83.52	1.6	1.7	5
	Zardagila	191	35	10	2	-	-	238	286.5	59.3	18.1	21	-	..	384.9	146.84	1.6	2.6	4.6
	All Mawakan Basin with micro-catchments	366	68	18	3	-	-	455	451.5	123.1	32.2	35.5	-	--	642.3	318.34	1.4	2	4.4
Gogasur Basin	Haji Mamand watershed	55	17	4	1	-	-	77	44.8	11.4	10	6.2	-	..	72.4	34.71	2.2	2	3.8
	All Gogasur Basin with micro-catchments	534	123	28	6	1	-	692	887.2	274.6	138.4	24.7	89.6	..	1414.5	383.67	1.8	3.6	4.8

Table (8) Morphometric characteristics for Zei-Bichuk watersheds .

	Watershed Name	Stream order's (Nu)							Stream length (Km)							Area Km²	F (Km)⁻²	D (Km)⁻¹	Rb_{av}
		1st	2nd	3rd	4th	5th	6th	Total	1st	2nd	3rd	4th	5th	6th	Total				
Zei-Bichuk Basin	Darie	26	8	3	1	-	-	38	45.4	23.4	9.9	6	-	-	847	25.54	1.4	3.3	2.9
	Shanakhsie	24	8	3	1	-	-	36	44.5	17.9	6.3	9.2	-	-	77.9	23.63	1.5	3.2	2.8
	Awakurtie	33	8	2	1	-	-	44	81.5	27.6	15.5	7.1	-	-	131.7	39.41	1.1	3.3	3.3
	All Zei-Bichuk River Basin with micro-catchments	126	33	11	4	-	-	174	231.5	91.1	40	25.9	-	-	388.5	135.45	1.2	2.8	3.3

Table (9) Morphometric characteristics for Bardasipi and Dolbeshik

Watershed Name	Stream order's (Nu)							Stream length (Km)							Area Km²	F (Km)⁻²	D (Km)⁻¹	Rb_{av}
	1st	2nd	3rd	4th	5th	6th	Total	1st	2nd	3rd	4th	5th	6th	Total				
Bardasipi	112	22	7	1	--	--	142	189.5	58.8	35.2	33.4	--	--	316.9	97.57	1.4	3.2	5
Dolbeshik	27	3	1	--	--	--	31	71.5	11	18.9	--	--	--	101.4	25.73	1.2	3.9	6

Table (10) Morphometric characteristics for Kunamasi Basin

	Watershed Name	Stream order's (Nu)							Stream length (Km)							Area Km²	F (Km)⁻²	D (Km)⁻¹	Rb_{av}
		1st	2nd	3rd	4th	5th	6th	Total	1st	2nd	3rd	4th	5th	6th	Total				
Kunamasi Basin	Kanimew	24	5	1	-	-	-	30	48.9	18.2	25.1	--	--	--	92.2	49.45	0.6	1.8	4.9
	Maluma	18	6	2	1	-	-	27	47.7	17.4	5.3	8.9	--	--	79.3	32.81	0.82	2.41	2.6
	Sangar	19	6	2	1	-	-	28	46.7	15.6	6.2	9.1	--	--	77.6	26.78	1	2.8	2.7
	All Kunamasi Basin with micro-catchments	85	22	5	2	1	-	115	188.3	62.7	36.6	24	3.2	-	367.1	140.54	0.81	2.6	3.1

18 - Tabeen Basin :

a- Location: Tabeen Basin located between latitudes of 35^0 36' and 35^0 52' and between longitudes of 45^0 00' and 45^0 15'. It's bounded by Daban- Halaj mountains from the north, from the east by Dolarut watershed and Yakhian mountains , by Bardazaro and Tawarkhao mountains from the south and by Qashan mountain and Zei-Bichuk river from the west, see Fig (6).

b- Topography: This Basin occupies two zones from the north and from the east it lies within High Folded zone. At the west and south located within Low Folded zone. Has a steep to moderate slope topography. The highest point is (2609) meters above mean sea level which is located on Shakharukhao summite and the lowest point is (778) meters above mean sea level at Tabeen site. Many mountains such as (Piramagroon, and Shakharukhaw) and valleys such as (Khrai-Zewe, Mir-Qurie, Taramar, Qazan and Shurnakh) with two wide plain between the mountains (Mergapan plain and Charmaga plain).

c- Stream Flow: The Basin consists of two large watersheds which are (Mergapan watershed) and (Charmaga watershed) Mergapan watershed has a perennial stream flow and trellis drainage pattern, but Charmaga stream has intermittent flow and dendritic drainage pattern. Both two river streams combine together at Tabeen site to make Tabeen river which poured into Zei-Bichuk river at Surqawshan village in Aghjalar area. The Basin contain many springs and Karezes, which are all recharged yearly by an annual precipitation (snow and Rain fall) of (800-825) mm, Fig. (4).

19- Chamawishk Basin:

a- Location: The Basin located between latitudes of 35^0 50' and 36^0 00' and between longitudes of 45^0 00' and 45^0 15' .Its bounded by Daban –Halaj mountain from the south, by (Asingaran, Zhilwan and Qalauga) mountains from the east . By Sharsten village and Banabarik mountain from the north and by Dukan lake from the west, see Fig (6).

b- Topography: The area located in the High Folded Zone. The trend of the mountains (NW- SE). It is consist of different sizes of valleys with local plains, it has a steep to moderate slope .The main mountains in this Basin are Gorzan, Daraqugan Qamarkhan and Qarasard, and the valleys are (Gomawa , Bahardaw , Khr-Khra and Sedar) valleys.

c- Stream flow : This Basin consists of two main watersheds (Haladen watershed) and (Homarbag watershed). Each watershed contain several streams, and each has a perennial water flow which combine togather at Kwerakani village, and then poured into Dukan lake directly. Annual precipitation in this region is about (750-850) mm there are many springs which supplied water to the streams, Fig. (5).

20 -Basins and watersheds Of Zei-Bichuk river inside pishdar area:

20.1 - Zaroon watershed:

a- Location: The watershed situated between latitudes of 35^0 55' and 36^0 05' and longitudes of 45^0 15' and 45^0 22'. It is bounded from the east by Qalachwalan River, by Zei-Bichuk river from the north, by Ahmad–Romi summite and Galala village from the south and by Serok, Bnabarik and Gazo-Razi mountains from the west, see Fig (6).

b- Topography: The watershed located in the Thrust Zone. It has a steep slope. Topographically it is a mountainous area which contain several mountains such as (Bardasur, Grdarash, and Welana) mountains .The highest point elevation is (990) meters above mean sea level.

c-stream flow : The watershed has some valleys and many branches of small streams which all are receives water from the springs and Karezes in this area ,all small streams collect's the water to the main stream called (Safra-Zaroon) river stream which has a perennial stream flow poured into Zei-Bichuk River at Harzina village at Iraq-Iran boundary. Annual precipitation is about (800) mm.

20.2- Shayan watershed

a- Location: The watershed situated between latitudes of 36^0 00' and 36^0 03' and between longitudes of 45^0 15' and 45^0 20'. It is bounded from the north by (Bna) summite, from the east by Iraq –Iran boundary, from the south and west by Zei-Bchuk River, Fig. (6) .

b-Topography : The watershed located in the thrust zone. It has a steep slope. Topographically it is a mountainous area .It contains two Main Valleys, which is (Rasheed and Shayan valley) .The elevation is (1280) meters above mean sea level.

c- Stream flow: Shayan watershed has an intermittent main stream which poured into Zei-Bichuk river. The water resources in this watershed consist of springs and karezes, which are recharged by annual precipitation (Rain fall and snow) of about (750) mm.

20.3- Hero watershed:

a- Location : Hero watershed located between latitudes of 36^0 05' and 36^0 10' and longitudes of 45^0 12' and 45^0 20'. It's bounded by Balfat Mountain from the north, by Iraq-Iran boundary from the east, by Shayan watershed from the south and by Zei-Bichuk river from the west.

b- Topography: The watershed located within Thrust Zone. Topographically it's a mountainous area which contains several mountains such as (Balfat, Malagoz and Bna) mountains and has several valleys such as Kani Rash and Daroona valley. The elevation is (1595) meters above mean sea level .The trend of the watershed is (NE-SW).

c- Stream flow : The watershed has a perennial main stream because it supplied by many springs in the area .The main stream consist of two main branches which combine together at Hero sub-district to consist Hero main stream which poured in to Zei-Bichuck river and the later poured into Dukan Lake.

20.4- Darashmana watershed

a- **Location :** Darashmana watershed located between latitudes of 36^0 05' and 36^0 12' and between longitudes of 45^0 10' and 45^0 20' .Its bounded by Malgoz mountain from the north, by Iraq –Iran boundary from the east, by Hero watershed from the south and by Zei-Bichuk river from the west.

b- Topography: The watershed located within Thrust Zone .It has a steep to moderate slope. Topographically it's a mountainous area .Its contain mountains, valleys and a wide Agricultural plain near Darashmana village. The elevation is (1592) meters above mean sea level.

c- Stream flow: Darashmana watershed has a main perennial stream flow which consists of two main branches which are Julakan valley and Dubza valley, this two branches combine together at Bamosh village to make the main stream of Darashmana watershed which poured into Zei-Bichuk river at pishdar area. Annual preception is about (750) mm, and there are many springs and Karezes inside this watershed.

20.5- Qaladiza basin

a- Location: Qaladiza basin situated between latitudes of 36^0 10' and 36^0 15' and between longitudes of 45^0 05' and 45^0 20' .It is bounded by Iraq-Iran boundary from the east ,by Darashmana watershed from the south, by Zei-Bichuk from the west and by Zharawa basin from the north see Fig (6).

b- Topography: The watershed located within Thrust Zone. The slope is steep to moderate. Topographically the watershed consist of very high mountains and associated valleys with some intermountain plains .The highest point is (2111) meters above mean sea level and located on Babringe mountain .The Quaternary sediments are composed of stream deposits which form many hills around Qaladiza District and west of Halsho sub-district. There is river terraces .The basin has a dendrite drainage pattern.

c- Stream flow: Qaladiza basin has a perennial main stream which poured into Zei-Bichuk river. Halsho basin onsist of two watersheds (Halsho and chmikhrka). Halsho watershed has two stream valleys (Haspijar and Halsho) each of them has intermittent stream flow which combine together to consist Halsho main stream. Also chamikhrka watershed has two stream valleys (Shekhawdalan and Shewdan) which combine together to consist the main stream of chamikhrka watershed. The two main streams of Halsho and Chamikhrka watersheds combine together at the west of Qaladiza district to consist the main stream of Qaladiza basinwhich poured directly into zeibichuk river. Water recourses in the basin represented by many springs and Karezes (more than 80 springs and Karezes). Average annual precipitation is about (750) mm, Fig. (5).

21 - Watersheds and basins that are poured directly into Dukan Lake:

21.1 Kanikhan Watershed

a- Location: Kanikhan watershed situated between latitudes of 35^0 52' and 35^0 55' and between longitudes of 45^0 00' and 45^0 05' it is bounded by Kotal village and Surdash Sub- district from the east, and by Sara mountain from the north, by Kani Hanjir mountains from the south and Qachan mountain from the west.

b-Topography: It is located within High Folded Zone, and it has gentle slope topographically can be called mountainous area, it contains a plain of alluvium type in between mountain ranges .The elevation is about (800) meters above mean sea level.

c- Stream flow: There were many springs and Karezes inside this watershed which are supply water to small streams which are makes a perennial main stream poured in to Zei-Bichuk river at Qashqoli area near the out let of the Dukan lake. The annual precipitation is about (800) mm.

21.2 Khrisaraw watershed:

a- Location: This watershed situated between latitudes of 36^0 00' and 36^0 05' and between longitudes of 45^0 00' and 45^0 15'. It is bounded by Serok and Bnabarik mountains from the east, by Gazorazi mountain from the north. By Sharsten Sub-district from the south, and by Dukan lake from the west.

b- Topography: The watershed located within Thrust Zone, topographically contains many mountains and valleys with some flat lands between the mountains. The elevation is about (1610) meters above mean sea level. The area contains igneous, metamorphic rocks.

c. Stream flow : This watershed has a main stream called Chami- Khrisaraw which consist of many small streams inside the area. The main stream poured directly into Dukan Lake near Sinajian village, annual precipitation (snow and rain fall) is about (800-1200) mm.

21.3 Jublakh Watershed

a-Location: The watershed situated between the latitudes of 35^0 55' and 36^0 05' and longitudes of 45^0 15' and 45^0 22' .It is bounded by Sara mountain from the south, by Qarasard mountain from the north, by Dukan Lake from the west and by Chama-Wishk Basin from the east.

b-Topography: The watershed located within High Folded Zone. Topographically the watershed consists of valleys and mountains with some small plain. The watershed has a dendritic drainage pattern. The trend of mountain is (NW-SE) direction; the elevation is (952) meters above mean sea level.

c. Stream flow: Jublakh watershed has intermittent stream flows which are collecting the water from the number of springs and Karezies that exists inside this watershed. The main stream poured into Dukan Lake at Topzawa village.

21.4 Marga Watershed

a- Location : The watershed located between latitudes of 36^0 02' and 36^0 05' and between longitudes of 45^0 00' and 45^0 10' .It is bounded by Banabarik mountain from the east, by Gazorazi and Asos mountain from the north, by Dukan lake from the west and by Khrisaraw watershed and Bardaqlisht mountain from the south.

b-Topography: The watershed located within High Folded Zone .The slope is steep to moderate. Topographically contain mountains, valleys and agricultural plain. The plain is alluvial fans. The elevation is (819) meters above mean sea level. The watershed has a dendrite drainage pattern.

c- Stream flow: Marga watershed has an intermittent main stream which poured directly into Dukan Lake at Bingird sub–district. The water resources represents by springs and Karezes. Annual precipitation is (700) mm.

21.5 Qushkala watershed

a- Location : Qushkala watershed located between the latitudes of 36^0 10' and 36^0 15' and between longitudes of 45^0 02' and 45^0 10' .Its bounded from the north and west by Zharawa Basin, from the south by Zei-Bichuk river,and by Halsho watershed from the east.

b- Topography: The watershed located within Thrust Zone. It has a moderate slope. Topographically contain the valleys such as suera valley and Qushkala valley and has a wide plain .The elevation is (361) meters above mean sea level.

c- Stream flow: Qushkala watershed has an intermittent main stream which poured into Zei-Bichuk River near Dukan Lake; there are few springs in this watershed, so the stream has an intermittent flow (only in rainy season).

21.6 Dolabakher watershed

a- Location: Dolabakher watershed located between latitudes of 36^0 12' and 36^0 20' and longitudes of 45^0 00' and 45^0 08' . It's bounded by Zharawa Basin from the east and north, by Dashtwan watershed from the west and by Dukan Lake from the south.

b- Topography: The watershed located within thrust zone and has a steep to moderate slope. Topographically contain mountains, valleys and plains. Quaternary sediments are composed of stream deposits which forms many hills. The plain can be considered as its alluvial fans .The elevation is (651) meters above mean sea level. The watershed has a dendritic drainage pattern.

c- Stream flow: The main stream is a perennial stream flow, it consist of some small valleys which has perennial streams. The main stream is poured directly into Dukan Lake. There were many Springs and Karezes inside this watershed, which were recharged by Annual precipitation of about (750) mm.

21.7: Dashtwan watershed

a- Location: The watershed located between latitudes of 36^0 13' and 36^0 25' and between longitudes of 45^0 00' and 45^0 08'. It is bounded from the north by Iraq-Iran boundary, from the east by Zhrawa basin and Dolabakher watershed, by Dukan lake from the south and by DoliShahidan basin from the west.

b- Topography: Generally located within Thrust Zone, the southern part of the watershed located within high folded zone. The area is mountainous which contain the mountains such as (Shekh mamand, Galala, Korak and the famous mountain is Qandil). The main valley is erosional. The trend of mountain is (NW-SE) direction. The flood plain existence near the out let of the watershed. Quaternary sediments are usually covered by a relatively thin layer of alluvial sediments (soil). The elevation ranges from (600m) to more than (2734m) above mean sea level.

c- Stream flow: Dashtwan watershed has a perennial main stream which called Wali river, has supplied by water from springs and Karezes, with snow melts from the mountains. The main stream poured directly into Dukan Lake at Kharjo village, annual precipitation about (700-950) mm.

21.8: Twasuran watershed

a- Location: Twasuran watershed situated between latitudes of 36^0 15' and 36^0 22' and between longitudes of 44^0 48' and 45^0 00'. It is surrounded by Saribash summite from the north ,by DoliShahidan Basin from the east, by Dukan lake from the south and by Kewa Rash mountain from the west.

b- Topography: The watershed located within high folded zone. Topographically it's mountainous area which consists of mountains like Sari Zardakew Summite, Sari Salwan Summitte, and Sari Khoshnawa Summitte the mountains are anticline while the valleys are syncline. The drainage pattern is dendritic and the elevation ranges from (528-2409) m. above mean sea level.

c- Stream flow: The watershed has three micro-catchments (Dolapiran, Darziwa and Dolakalw). Each has an intermittent main stream. The three branches are combine together to make the main intermittent stream of Twasuran watershed. The stream received the water from annual precipitations (Rainfall & snow) and from the springs and Karezes which are existing inside this watershed .Annual precipitation about (700-750) mm.

21.9 Rania watershed

a- Location: Rania watershed situated between latitudes of 36^0 15' and 36^0 20' and between longitudes of 44^0 50' and 45^0 00' .It is bounded by Kewa Rash mountain from the east, by Sariqopirash summite at the north, by Shawr watershed from the west and by Dukan lake from the south.

b- Topography: The watershed located within high folded zone. Topographically consist of mountains such as (Kewa Rash, and Sari-Khartalan) mountain and valleys with a wide agriculture plain. The elevation ranges from (22 to 1532) meters above mean sea level. The drainage pattern is dendritic and the mountains are anticline while the valley is syncline.

c- Stream flow: The main stream of Rania watershed passes through Rania District and poured into Dukan Lake. It is consist of several branches which receive water from the springs and Karezes which are existing in the area and the annual precipitation is about (700-800) mm.

21.10 Shawr basin

a- Location: Shawr basin located between latitudes of 36^0 25' and longitudes of 44^0 38' and 44^0 54' . It is bounded by (Karookh and Chnarashkan) mountains from the north, by (Kewarash and Ahmawa) mountains and Rania district from the east, by Dukan lake from the south and by (Kajust and Sarimakok) mountains from the west.

b- Topography: The upper part of the basin located within thrust zone. But the southern part located within high folded zone. The area is mountainous and the main mountains such as (Karookh, Kewa Rash and Sari Makok) mountains. The valleys are (Diman and Gulan) valleys. The small plain located at the south east of the basin. The trend of mountain is (NW- SE) direction. Quarternary sediments consist of stream deposits . The basin has a dendritic drainage pattern. The elevation is (550-1400) meters above mean sea level.

c- Stream flow: The basin has two main valleys (Diman and Gulan) valleys which each has an intermittent stream flow. The main stream of the basin which called Shawr river is also an intermittent stream, which poured into Dukan lake. Water resources consist of springs, and snow melt from the mountains. Annual precipitation about (700-750) mm.

21.11 Khdran watershed

a- Location: The watershed situated between latitudes of 36^0 03' and 36^0 08' and between longitudes of 44^0 37' and 44^0 50' .The watershed bounded by (Zawa-buk and Ziwka) mountains from the north, by Haji-Qala summit from the east, by (Lakasur) and (Haibatsultan) mountains from the south , and by Bestana watershed and (Surell)mountain from the west.

b- Topography: The watershed located within high folded zone. Topographically it's mountainous area which consists of mountains and valleys. The trend of mountain is (NW-SE) while the trend of the watershed is (NE-SW) direction. The drainage pattern is dendrite. The elevation ranged from (550-1088) meters above mean sea level.

c-Stream flow: Khdran watershed has a main intermittent stream flow poured into Dukan Lake directly. It is supplied by fresh water from the springs and Karezes which exists inside the area. Annual precipitation is about (700-800) mm.

21.12 Khalakan watershed

a- Location: Khalakan watershed located between latitudes of 36^0 03' and 36^0 08' and between longitudes of 44^0 37' and 44^0 50' .It is bounded from the north by Dukan Lake, from the east by the mouth of Dukan Dam, from the south by Elaalla summit and from the west by Bardaqlisht and Hajiwaise summits.

b- Topography: The watershed located within high folded zone. Topographically contain mountains and valleys .The Mountains are anticline while the valleys are erosionals. The drainage pattern is dendrite and the elevation ranged from (700-1000) meters above mean sea level.

c- Stream flow: The watershed has an intermittent stream flow which poured into Dukan Lake. The stream receives the water from numbers of springs and Karezes o this area. Annual precipitation is about (700-800) mm.

22- Zharawa Basin

a- Location: The Basin situated between latitudes of 36^0 12' and 36^0 25' and between longitudes of 45^0 00' and 45^0 08'. It's bounded by Iraq-Iran boundary from the east and north ,by Dola bakher and Dukan lake from the west, and by (Akhura, Klka) summits and Qaladiza district from the south, see Fig (6) .

b-Topography: The Basin located within thrust zone and has a steep to moderate slope. Topographically it's a mountainous area, and contain many high and rough mountains such as Sarymarsta, Sarykela, Akhura and Klka mountains .And contain many valleys such as (Khraymarda, Totma, Susta Jarrawa and Duba) valleys and has an alluvial agricultural plain near Zharawa village. The highest point elevation is (1925) meters above mean sea level. The Basin has a dendritic drainage pattern.

c-Stream flow: Zharawa Basin consist of two watersheds (Garrawa and Galgala).Which each watershed has a perennial stream flow, because of existence of many springs and Karezes in this area. The two main streams combine together at Rashian village to consist Zharawa River stream which poured in to Dukan lake directly. Water resources in this basin represented by springs and Karezes, and some streams which located inside Iran and flows towards this basin, Fig. (5).

23- Doli-Shahidan Basin

a- Location: The Basin located between latitudes of 36^0 13' and 36^0 25' and between longitudes of 44^0 52' to 45^0 00'. It is bounded by Dashtwan watershed from the east, by Iraq – Iran boundary from the north, by Dukan lake from the south, and by Rania district and Twasuran watershed from the west, see Fig 6.

b- Topography: The Basin located within Thrust zone and has steep slope topography. The mountain is anticline and the famous mountain in the Basin is Qandil Mountain.The valleys are erosional. The trends of mountains are (NW-SE). Quaternary sediments are composed of stream deposits which consist of pebbles and boulders which are igneous, metamorphic type with some sedimentary ones. The elevation is (2471) meters above mean sea level. The basin has a dendrict drainage pattern.

c- Stream flow: Doli-Shahidan contains two main watersheds which are (Ashkaro and Pshtashan) watersheds. Each has an intermittent stream flow which both combines together to consist Doli Shahidan main stream which has also perennial flow and poured directly into Dukan Lake. The water resources consist of springs and Karezes with snow melts during the year, Fig. 5.

24 - Qashan Basin

a- Location: Qashan Basin located between latitude of 36^0 13' and 36^0 28' and between longitudes of 44^0 33' and 44^0 33' and 44^0 47'. It is bounded by Sarimakok mountain and Chuarqurna sub-district from the east, by Mahmoodbag summitte, (Kchawast, Shekhwassan, and Shwani) mountains from the north, by Dukan lake from the south and by (Sardol, Kamusak, and Rutak) mountain from the west, see Fig 6.

b- Topography: Qashan Basin located within high folded zone. Structurally is consist of synclines and anticline, but the main valley is anticline. The trend is (NW-SE) direction. There are many geomorphological features in this basin (Joints, Faults and folds). The Quaraternary sendiments are colluvium, Talus and alluvial deposits. Topographically consist of mountains (Sarimakok , Pashascort, Sarigrapa, Karate, Shekh Wassan, Sarzin, and Sarshana) mountains, and valleys such as (Totme, Karwesh, Zilan, Shoraw, Khryashkaftan and Betuata)valley , and the basin has a wide agricultural plain called (Bitwen plain) .The Basin has an elevation range from (529m) to (2127)meter's above mean sea level. The drainage pattern is dendritic pattern.

c- Stream flow: The Basin consists of (Tatok, Kora, Betwata, Chamiawa, Galiharmk and Saruchawa) watersheds. Qashan basin has a perennial main stream flow called Rubari Qashan. Saruchawa main stream is a perennial stream because the Saruchawa watershed has three great springs. Chamiawa and Gali-Harmk watersheds have an intermittent stream flow. Betwata watershed has a perennial stream flow. So the main stream of the basin is a perennial stream which poured into Dukan lake. Annual precipitation is about (700-750) mm, Fig. 5.

25 - Hiran - Nazanin Basin

a- Location: The Basin situated between latitudes of 36^0 08' and 36^0 27' band between longitudes of 44^0 25' and 44^0 47'. It is bounded from the east by Dukan lake, from the north by (Kamusak, Sardol and Rutak) mountains, by (Haibasultan) mountain from the south, and by Safin mountain from the west, see Fig 6.

b- Topography: The basin located within high folded zone. Structurally the mountain is anticline while the valleys are erosional. Topographically the Basin consists of the mountains with three main valleys (Sactan, Nazanin & Smaquli). The main mountains such us (Sardol, Surak and Awagird) mountains. An agricultural plain existence near the outlet of the Basin such us Smaquli inter mountain plain. The elevation ranges from (636-1675) meters above mean sea level. The basin has a dendritic drainage pattern.

c- Stream flow: The basin contains five watersheds which are (Nazanin, Sactan, Bestana, Grozh and Smaquli) watersheds. Each watershed has an intermittent stream flow. So the main stream of the Basin is also intermittent stream. The water resources in the Basin consist of the springs and Karezes which arefeeds the main stream of the Basin which poured into Dukan Lake directly, Fig. 5.

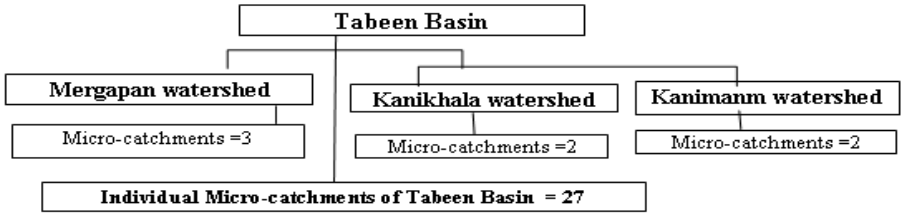

Fig 4: Schematic classification of Tabeen basin

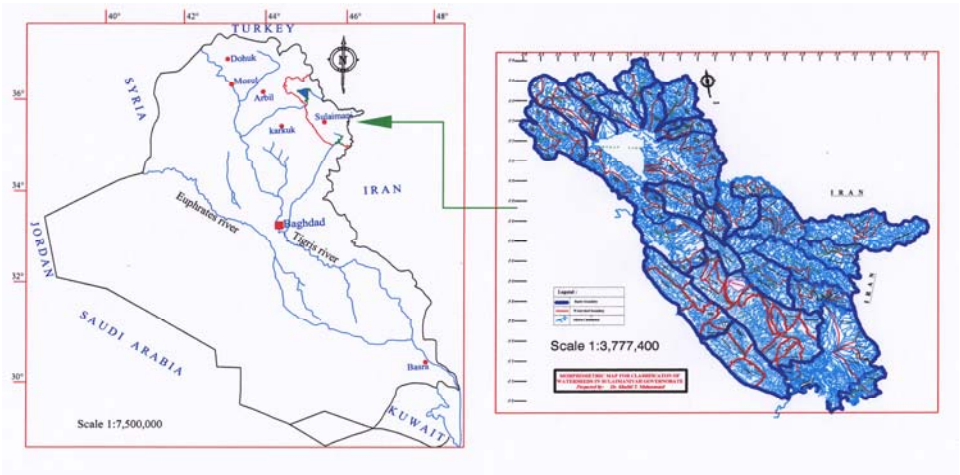

Fig. 6: Location of the studied area on the map of Iraq.

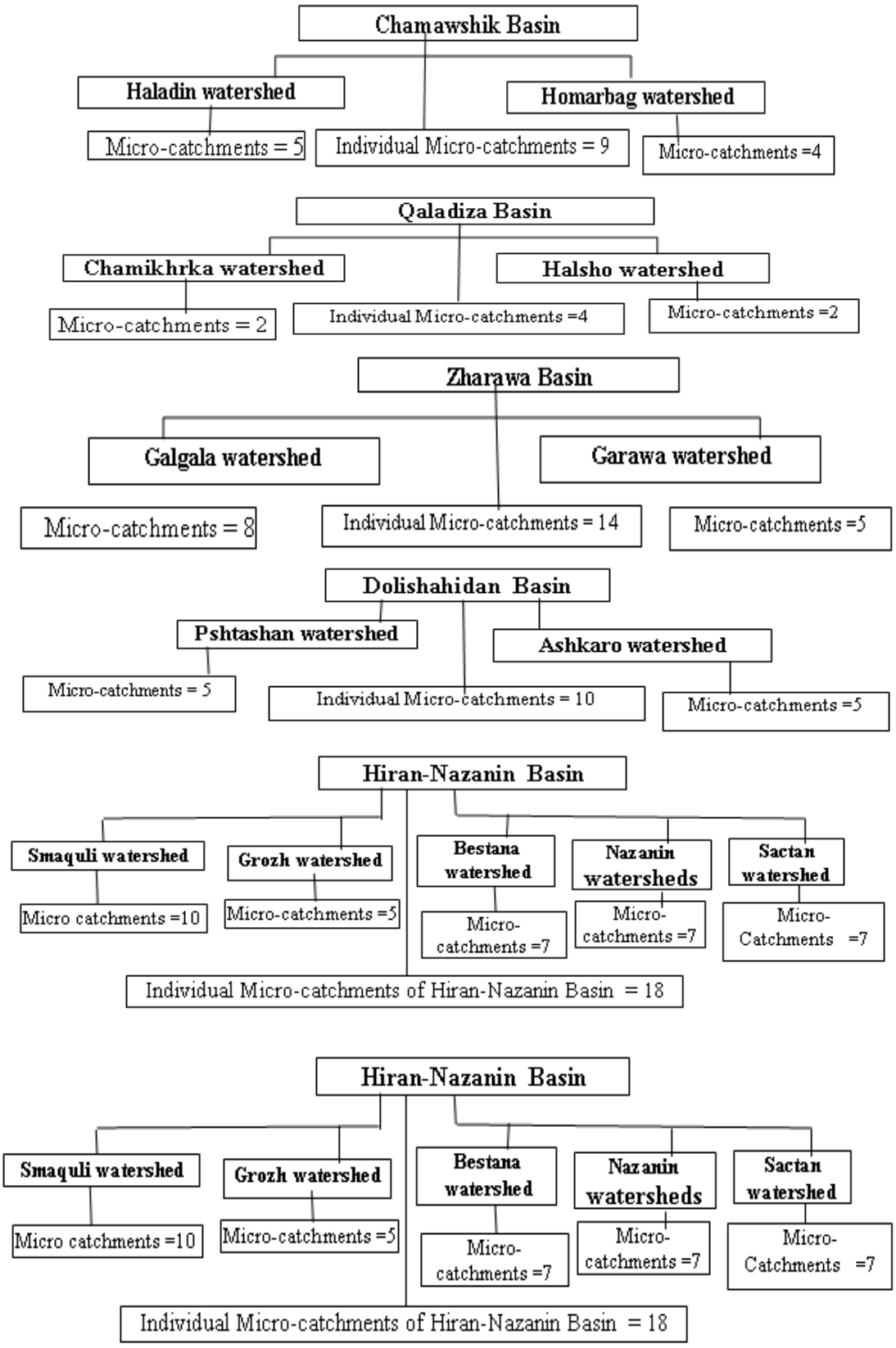

Fig 5: Schematic classification of Chamawshk, Qaladiza, Zharawa, Doli Shahidan, Qashan and Hiran-Nazanin Basins.

Table 11: Morphometric characteristics for **(Tabeen , Chamawshk, Shawr and Qaladiza)** basin and **(Jublukh , Zaroon , Khrisaraw , Shayan , Hero, Darashmana, Marga , Dashtwan , Qushkala , Dolabakher , Twasuran, , and Rania)** Watersheds**.**

Watershed Name			Stream order (Nu)							Stream length Lu. (Km)							Area (Km)^2	F. (1/Km^2)	D. (1/Km)	Rb. Av.
			1st	2nd	3rd	4th	5th	6th	Total	1st	2nd	3rd	4th	5th	6th	Total				
Tabeen Basin	Kanikhala		26	7	2	1	_	_	36	27.5	10	10.5	0.6	_	_	48.6	33.75	1.06	1.44	3.07
	Kanimanm		23	8	3	1	_	_	35	52.9	16.8	5.5	3.5	_	_	78.7	46.32	0.7	1.69	2.76
	Mergapan		67	15	3	1	_	_	86	107.2	27	14.2	5.5	_	_	153.9	83.94	1.02	1.83	4.15
	All Tabeen Basin		327	83	16	3	1	_	430	525.2	216.7	64.7	9.6	38.3	_	854.5	**517.650**	0.83	1.64	4.33
Chamawishk Basin		Haladin	97	22	4	1	_	_	124	194	39.4	8.2	19.5	_	_	261.1	143.49	0.86	1.81	4.63
		Homarbag	84	17	5	1	_	_	107	92.8	24.3	18	12.7	_	_	147.8	93.82	1.14	1.57	4.44
		All Chamawishk Basin	202	43	9	2	1	_	257	309.8	72.5	62.2	32.2	10.5	_	487.2	**259.79**	0.52	1.73	3.99
Jublakh			53	15	1	_	_	_	69	54.8	18.4	8.6	_	_	_	81.8	36.64	1.88	2.23	9.26
Zei Bichuk watersheds	Zaroon		123	25	4	1			153	138.2	41.3	18.8	12.7	_	_	211.0	99.30	1.54	2.12	9.97
	shayan		52	10	2	1	_	_	65	54	23	5.7	8	_	_	90.7	45.51	1.42	1.99	4.06
	Hero		41	8	1				50	49.6	10	10.5				70.1	45.25	1.10	1.54	6.56
	Darashmana		57	15	3	1	_	_	76	66	26.4	20.7	4.6	_	_	117.7	67.12	1.13	1.75	3.93
	Qaladiza basin	Halsho	68	14	3	1	_	_	86	69.5	18.6	12.7	13.4	_	_	114.2	75.86	75.86	1.50	4.17
		Chamkhurka	35	9	3	1	_	_	48	72.2	17.0	4.5	8.0	_	_	101.7	43.09	43.09	2.36	3.29
Dukan Lake Watersheds	Marga		18	4	1	_	_	_	23	37	11.4	12.3	_	_	_	60.7	39.87	0.57	1.52	4.25
	Dashtwan		82	20	2	1	_	_	105	84.2	32.3	19.5	9.2	_	_	145.2	98.92	1.06	1.46	5.36
	Qushkala		22	7	1	_	_	_	30	25	14.6	9.8				49.4	29.06	1.03	1.69	5.07
	Dolabakher		61	14	5	1	_	_	81	83	29.8	12.3	8.6	_	_	133.7	69.99	1.15	1.91	4.05
	Twasuran		73	12	3	1	_	_	89	116.8	36.7	31.5	4.3	_	_	189.3	148.53	0.59	1.27	4.36
	Shawr basin	Diman	46	14	3	1	-	-	64	66.5	22	11	6.2	-	-	105.7	84.24	0.75	1.25	3.6
		Gulan	30	9	1	-	-	-	40	40.3	18.4	8.7	-	-	-	67.4	38.3	1.04	1.7	6.16
		All shawr basin	128	33	5	1	_	_	167	146.6	48.7	20.8	31.7	_	_	247.8	**191.58**	0.87	6.45	5.15
	Rania		17	4	2	1	_	_	24	22.1	2.6	6.2	7.3	_	_	38.2	31.60	0.75	1.20	2.75
	Khrisaraw		48	13	2	1	_	_	64	62.4	18.7	7.4	21.5	_	_	110.0	65.10	0.98	1.68	4.06

Table 12: Morphometric characteristics for **(Zharawa, Dolishahidan and Qashan)** Basins**.**

Zharawa Basin	Watershed Name	Stream order (Nu)							Stream length Lu. (Km)							Area (Km)^2	F. (1/Km^2)	D. (1/Km)	Rb. Av.
		1st	2nd	3rd	4th	5th	6th	Total	1st	2nd	3rd	4th	5th	6th	Total				
	Galgala	167	38	8	1	_	_	214	173.3	46.5	31.5	26	_	_	277.3	139.28	1.53	1.99	5.83
	Garawa	144	32	6	1	_	_	183	153	40.3	21.5	19.8	_	_	234.6	125.75	1.45	1.86	5.27
	All Zharawa Basin	311	70	14	2	1	_	398	326.3	86.8	53	45.8	5.2	_	517.1	**265.03**	1.50	1.95	4.61
Dolishahidan Basin	Pshtashan	98	22	5	1	_	_	126	112.6	45.5	13.7	10	_	_	181.8	107.73	1.16	1.68	4.61
	Ashkaro	43	8	3	1	_		55	62	20.5	9	5.2	_	_	96.7	68.67	0.80	1.40	3.67
	All Dolishahidan Basin	164	35	8	2	1	_	210	204.5	71.2	22.7	15.2	18.3	_	331.9	**214.40**	0.97	1.54	3.76
Qashan Basin	Betuata	19	5	2	1	_	_	27	28.5	9	9.2	2	_	_	48.7	34.93	0.77	1.39	2.76
	Chamiawa	22	6	1	_	_	_	29	32.4	16	12.7	_	_	_	61.1	59.57	0.48	1.02	4.83
	Korra	32	10	3	1	-	-	46	34.4	14.5	6.5	3.6	-	-	59	39.84	1.15	1.4	3.16
	Tatok	24	4	1	-	-	-	29	26.3	7.6	4.5	-	-	-	38.4	27.94	1.03	1.37	5
	Galiharmek	20	5	2	1	_		28	21.3	9.5	5	3	_	_	38.8	32.37	0.86	1.19	2.83
	Saruchawa	19	4	2	1	_	_	26	22.8	19.3	6.2	5.3	_	_	53.6	30.50	0.85	1.75	2.91
	All Qashan basin	191	47	16	5	1	_	260	269	97.6	63.1	17.2	23.7	_	470.6	**339.75**	0.76	1.38	3.79
Hiran-Nazanin Basin	Grozh	42	9	3	1	_	_	55	46.2	13.2	6.5	4.5	_	_	70.4	36.25	1.51	1.94	3.55
	Smaquli	83	23	5	1	1	_	113	107.9	23.6	10.5	11.0	20.5	_	173.5	89.92	1.25	1.91	3.55
	Nazanin	146	38	7	2	_	_	193	174.0	42.7	21.5	16.0	_	_	254.2	157.21	1.22	1.61	4.25
	Sactan	78	22	3	1	_	_	104	97.6	30.7	18.2	12.0	_	_	158.5	101.16	1.02	1.56	4.62
	Bestana	46	12	3	1	_		62	52.3	22.0	8.0	3.0	_	_	85.3	39.89	1.55	2.13	3.61
	All Hiran-Nazanin Basin	395	104	21	6	1	_	527	478.0	132.2	64.7	46.5	20.5	_	741.9	424.43	1.24	1.11	4.56
	Karikhan	61	17	4	1	_	_	83	72.0	27.5	10.2	11.6	_	_	121.3	57.12	1.45	2.12	3.94
	Khdran	62	15	3	1	_	_	81	70.5	21.6	10.2	10.5	_	_	112.8	63.18	1.28	1.78	4.04
	Khalakan	86	25	4	1	_		116	111.8	28.3	7.4	12.0	_	_	159.5	60.11	1.92	2.65	4.56

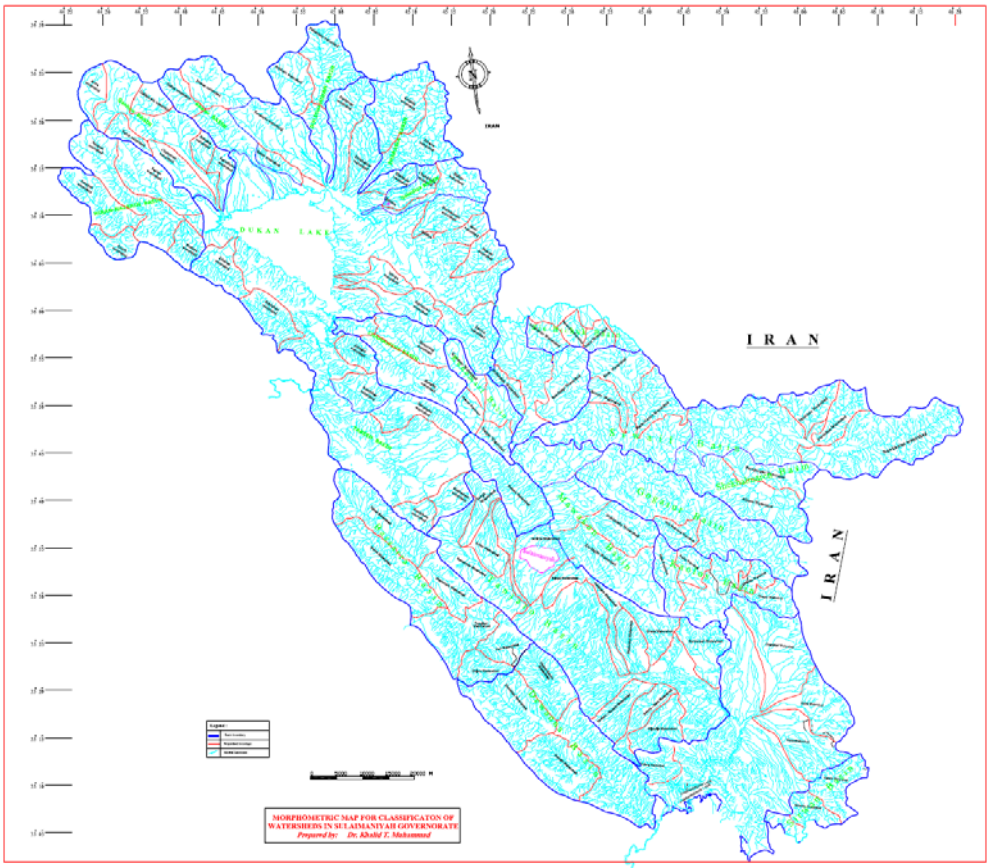

Fig. 7: Morphometric map of the studied area

CONCLUSION

1- Classification of watersheds differs from region to region. In this study the watersheds of Sulaimaniyah governorate were classified into (Basin, Watershed, and Micro-Catchment), regarding that the areas less than (25 km^2) are Micro-catchments, the areas of (25 – 150 km^2) are watersheds, and the areas of more than (150 km^2) considered they are basins. The watershed may contain several Micro-catchments., whereas the basins may contain several watersheds or no contain watersheds, moreover the basin contain individual Micro-catchments that are located out of the watershed boundaries, where the water of all watersheds and Micro-catchments, drains to the same main stream of the basin. Based on this classification the studied region contains 20 basins, 85 watersheds and 1432 micro-catchments.

2- From the descriptions of location and topography of the basins and individual watersheds, appeared that the area under study could be divided into three zones:

- **a-** Mountainous and semi-mountainous region, of elevation (900-1200) meters above mean sea level with high precipitation rate (800-1200) mm, cold winter and temperate during summer. The region including (Penjween, Chwarta, Surdash and Qaladiza) areas.
- **b-** Semi-undulating and plain regions, of low elevations (600-700) meters with low precipitation rate (600-700)mm (cold-temperate) in winter, and (semi hot-hot)in summer.
- **c-** Semi mountainous and undulating regions, including (Darbandikhan and Qaradagh) with elevation of (600-800) meters above mean sea level, and precipitation rate less than (450-600)mm , (temperate-cold) in winter and hot in summer.

3- From field visits appeared that most of the main streams of the study areas have an intermittent flow and this refer to that the water of these streams depends on water of springs, which the flows of those springs reduced during the dried season.

4- Morphometric analysis which were represented by the data base of all the Tables (1 to 12), indicated the following points:

a. Less value of drainage density refers to existence permeable rocks and easily eroded rocks; also it's an indication to the existence of semi-arid climate. In the bad drainage watershed, the value of drainage density is a bout (0.73) while in the good drainage watersheds; the value of drainage density is about (2.74).

b. Less value of stream frequency indicate the existence of limestone and dolomite rocks which have fissures and joints which caused to increase infiltration rate, also existence of vegetation cover and permeable rocks have effects to increase infiltration rate and
the later reduce surface runoff and then reducing numbers of streams.

c. Less value of average Bifurcation ratio indicate to existence permeable rocks which
cause to reduce the number of stream orders.

5. The Morphometric map of the entire studied area, Fig (6) showed that most of the drainage patterns of watersheds under study are dendritic pattern; this is because of existence resistance rocks, where the eroded rocks are very few that does not have any effect on limitation of stream direction.

6. Because of existence numerous Micro-catchments in the study area, their boundaries and their names, could not appears on that small scale map.

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