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The Effect of Morphometric Dimensions and River Drainage Network on the Hydrology of Tanjero River Basin in Sulaymaniyah Governorate

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Abstract

The study of the morphometric dimensions and the characteristics of the river drainage network in the basins is considered an important basis in the hydrological studies, as the natural environment factors and the local environment factors play a major role in drawing the engineering features of the water basins. Basically, it is based on data taken from topographical maps and others to determine the optimal use of the basin, which gives a clear vision of the possibility of exploiting and investing in the basin and explains the amount of water supply, the peak reaching the watercourse, the indication of flood risk and its length. Morphometric studies depend on the measurement and treatment of terrestrial features according to the basis of quantitative analysis by applying mathematical equations and statistical methods on data extracted from topographical maps, field measurements, aerial photographs and satellite visuals, in order to use their results in classifying terrestrial features and identifying the factors and processes that led to their emergence and development.

Keywords: *River, basin, Tanjero, Sulaymaniyah, Hydrology, Morphometric.*

1. INTRODUCTION

Drainage networks are the medium in which water moves in river basins and is affected by topographical characteristics. It is a natural reflection of it in its first underground stages, but it soon begins to form the surface again (Al-Ajili, 2015, p. 394). The digital elevation model Diem and topographical maps of scale (1/100000) were relied upon to determine the valley basins within the study area, as well as the use of the Arc Map program. Due to the large number of basins in the study area, reliance was made, and focus was placed on the secondary basins that are suitable to be established. plug it for the purpose of harvesting water in which they numbered 5 All basins flow into the area.

Study area problem: What is the effect of morphometric characteristics on the hydrology of the Tanjero River basin?

On the other hand the hypothesis of the study: Morphometric characteristics have a clear impact on the variability of the hydrology of the Tanjero River Basin.

Studying and classifying morphometric characteristics and identifying the extent of their impact on the hydrology of the Tanjero River basin through analyzing the diversity in the morphological, spatial and topographical characteristics of the basin.

We can determine the geographical and astronomical location of the study area through:

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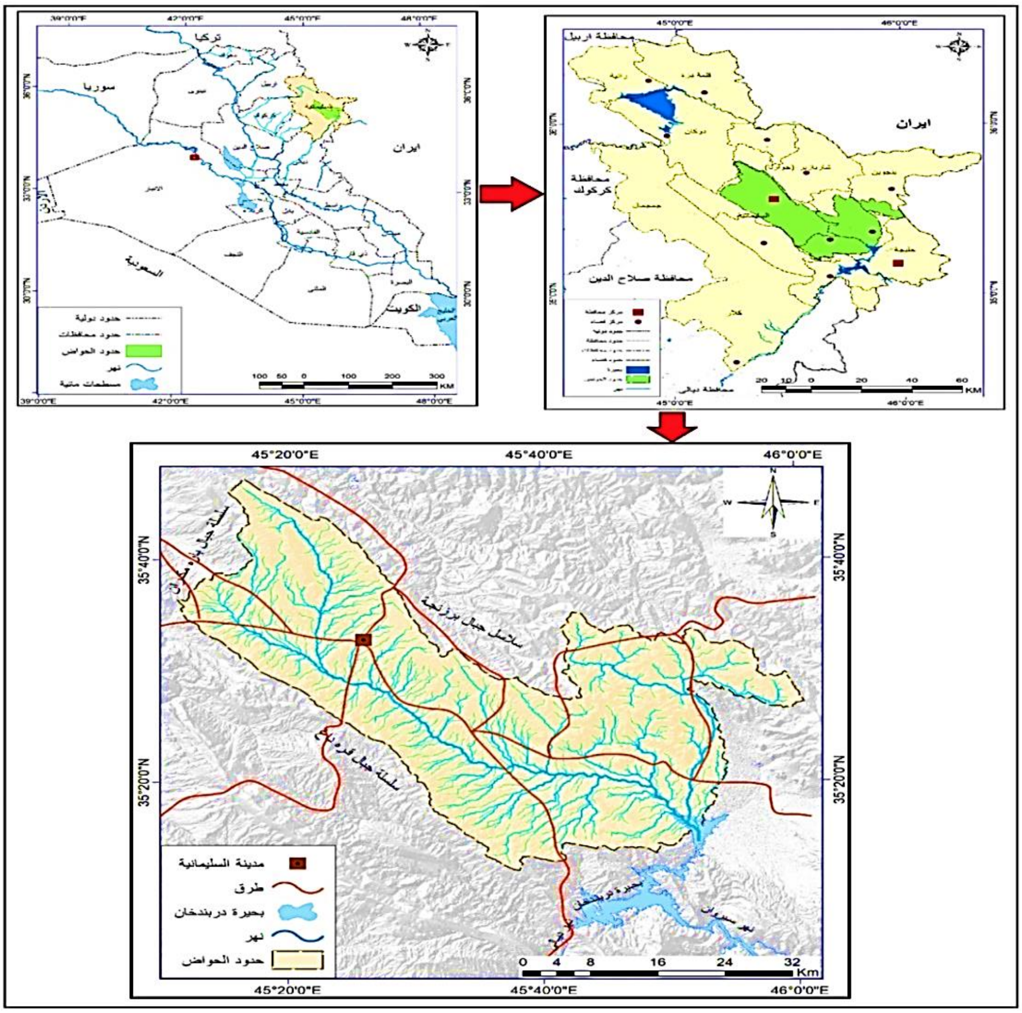
Astronomical location (coordinate): It is confined between latitudes 27"17"35" and 47"46"35 north and longitudes 15" 16" 45 - 23" east, as shown in Map No. (1).

Geographical (spatial) location: The Tanjero River Basin is located within the complex area in terms of topography in northeastern Iraq, east of the Kurdistan Region of Iraq, and southwest of Sulaymaniyah Governorate. From the eastern side, it is surrounded by the plain of Shahrzour, the Surin Mountains, and the heights of Kwiza and Azmar. As for the western side, it is bounded by the Burnan Mountains range, and adjacent to it on the northern side is the starting point of the heights of Doula Root and Mount Bireh Mah Karoon, and it is surrounded from the south by Lake Darbandikhan administratively.

The area of the Tanjero River basin is 18,650 square kilometers. A seasonal stream that is the main tributary of the Tangi Rho River. Or it is done through the intervention of the human element, which includes counting the running water, then collecting it and directing it in order to invest it in the water The target area as well as the use of water harvesting for agricultural purposes and the possibility of developing and using it For humans and animals, in addition to domestic uses , through the construction of small water dams and reservoirs (Younes and Hajim, 2002, p. 4).



Map No. (1) : The location of the Tanjero Basin of Iraq and Sulaymaniyah Governorate.

Source: Digital ramification model (DEM) with a resolution of 30 square meters for the year 2015 and processed using Arc Map 10.8 (GIS).

2. ANALYSIS OF THE MORPHOLOGICAL, SPATIAL AND TOPOGRAPHIC CHARACTERISTICS OF THE BASIN.

2.1. Spatial characteristics:

closely related to the quality of the rocks and the prevailing climatic conditions in the study area. Increasing the degree of slope leads to an increase in the velocity of rainwater flow, and thus leads to an increase in vertical erosion and thus an increase in the basin area, while there is an inverse relationship between the vegetation cover and the expansion of the basin area, as the presence of vegetation in the region leads to a reduction in erosion and erosion processes . Thus, it leads to an increase in leakages into the ground (Al-Ajili, 2015, p. 403).

Table (1): The spatial and morphological characteristics of the Tanjero Valley basin and its secondary basins

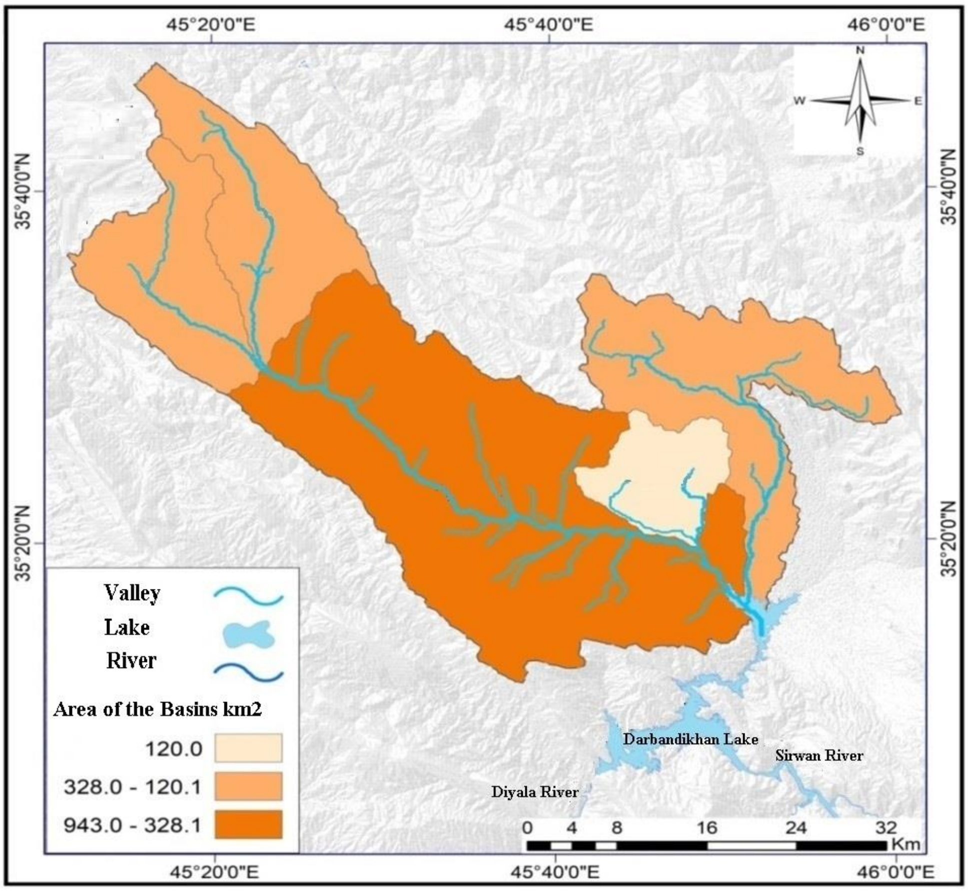
Diffraction index	**Pelvic shape parameter**	**elongation rate**	**peri meter cohesion ratio**	**roundness ratio**	**Maximum hip length/km**	**Circum ference of the basin**	**pelvic space**	**Basin name**	**aquarium number**
1.19	0.21	0.52	2.36	0.18	39.5	149	328	Syed Sadiq	1
0.48	0.52	0.81	1.56	0.41	15.2	60	120	Sarwa	2
0.79	0.32	0.64	2.18	0.21	54.07	235	943	gargoyle	3
1.19	0.21	0.51	1.86	0.30	34.7	102	251	sargnar	4
0.91	0.27	0.58	1.64	0.37	28.59	87	223	Kurdpur	5
1.07	0.23	0.54	4.08	0.06	89.5	633	1865	Tanjero	main basin

Source: Resercher Based on the digital erosion model (DEM) and the GIS program (Arcmap 10.8).

2.2. Basin area:

The basin area is of great importance because it affects the volume of water flow within the basin, and it is known that water basins vary in area, due to the influence of several factors, including the diversity of rocks, structural and topographical structures, prevailing climate and time, as well as the human factor (Al Ibrahimi, 2021: 22). Therefore, the Tanjero Valley basin was divided into five secondary basins, as shown in the Table.

The highest basin area was the Kargol Basin, with an area of 943 km 2, followed by Sayed Sadiq Basin with an area It is followed by 328 km 2 Sarjnar Basin with an area of 251 km 2, then Kurdpur Basin with an area of 223 km 2, then the smallest of the secondary basins is Basin No. S in Saroh, with an area of 120 km 2. As for the total area of the Tanjero Basin, it amounted to 1865 km2. As in Map No. (2).

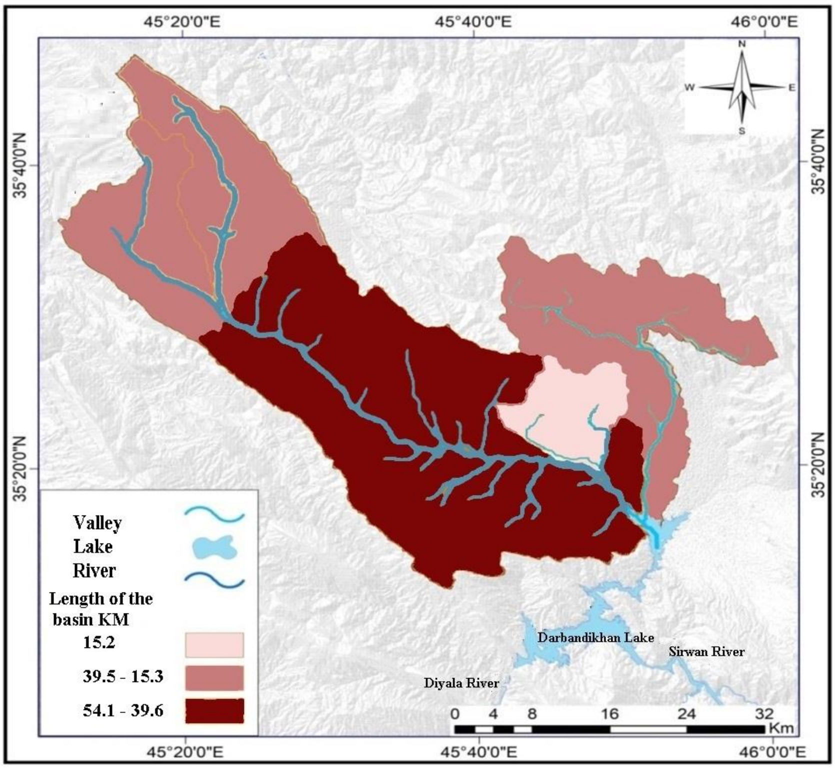


Map (2) Basins area / km 2

Source: Digital erosion model Source: Digital erosion model (DEM) with a resolution of 30 square meters for the year 2015 and processed using Arcmap 10.8 (GIS).

2.3. Basin Length:

The length of the basin is one of the important morphometric factors, as it is the line that extends from the point of the mouth of the valley to the highest point in the basin, which represents the water division line in the upper reaches of the river. a. The rates of leakage and evaporation are directly proportional to the length of the basin, through the slowdown in the velocity of the water flowing downstream due to the dome of the slope of the surface of the basin and the widening of the channels for the waterways with an increase in their mass in the same direction (Al-Atwani, 2015, p. 84).



Map (3) Basin length / km2

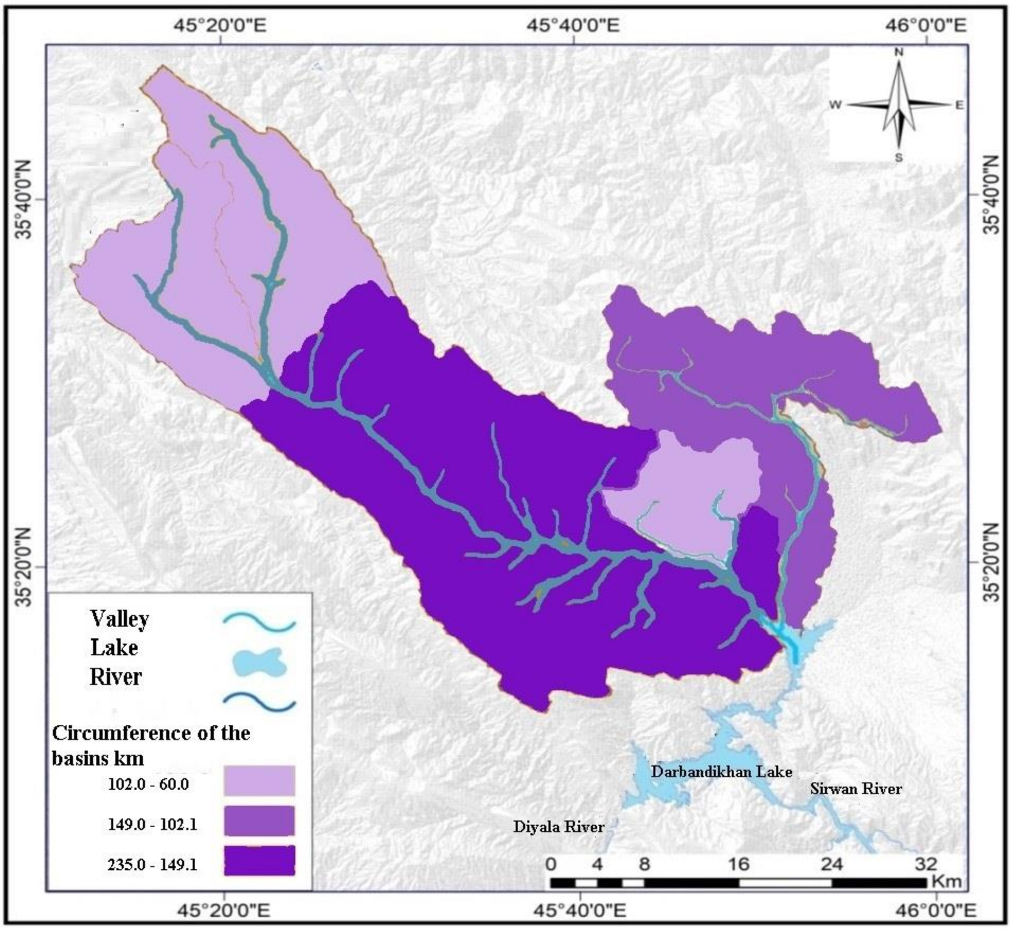
Source: Digital erosion model (DEM) with a resolution of 30 square meters for the year 2015 and processed using Arc Map 10.8 (GIS).

From the observation of Table No. (1), the total length of the Tanjero Valley Basin is 89.5 km 2. The longest secondary basin is Kargol Basin with a length of 54.07 km 2, which is the longest of the secondary basins, followed by Sayed Sadeq Basin with a length of 39.5 km 2, then Sargnar Basin with a length of 34.7 km 2. Then the Kurdpur Basin with a length of 28.59 km2, then the shortest basin in length is the Saruh Basin with a length of 15.2 km2. Note Map No. (3).

2.4. Pelvic circumference:

It is the water dividing line that separates the basin from its surroundings from other basins. There are several factors affecting the perimeter of the basin, including the development of waterways near the water dividing line (Al Ibrahimi, 2022: 23). There is a direct relationship between the perimeter of the basin and the expansion of its area, as the larger the area of the basin, the greater its geomorphological development, and this is due to Geological structure and climatic conditions (Abdullah, 2011, p. 136).

RP=A/P



Map (4) Basin's perimeter / km 2

Source: Digital erosion model (DEM) with a resolution of 30 square meters for the year 2015 and processed using Arc Map 10.8 (GIS).

Notice:

RP = circumference.

A = area.

P = pelvic circumference.

By looking at Table No. (1), where the total perimeter of the Tanjero Basin reached 633 km 2 , while the secondary basins varied in the values of their perimeter, as the circumference of the Kargol Basin reached 235 km 2 , followed by Sayyid Sadiq Basin, where the perimeter of its basin reached 149 km 2 , then Basin Sarjnar with a perimeter of 102 km2, then Kurdpur Basin with a perimeter of 87 km2, and finally Saruh Basin, which has a basin perimeter of 60 km2, and thus represents the smallest basin in the study area. This discrepancy in the basins' surroundings indicates the variation in formations and geological structures in the basin area. Note Map No. (4).

3. FORMAL CHARACTERISTICS OF THE STUDY AREA BASINS:

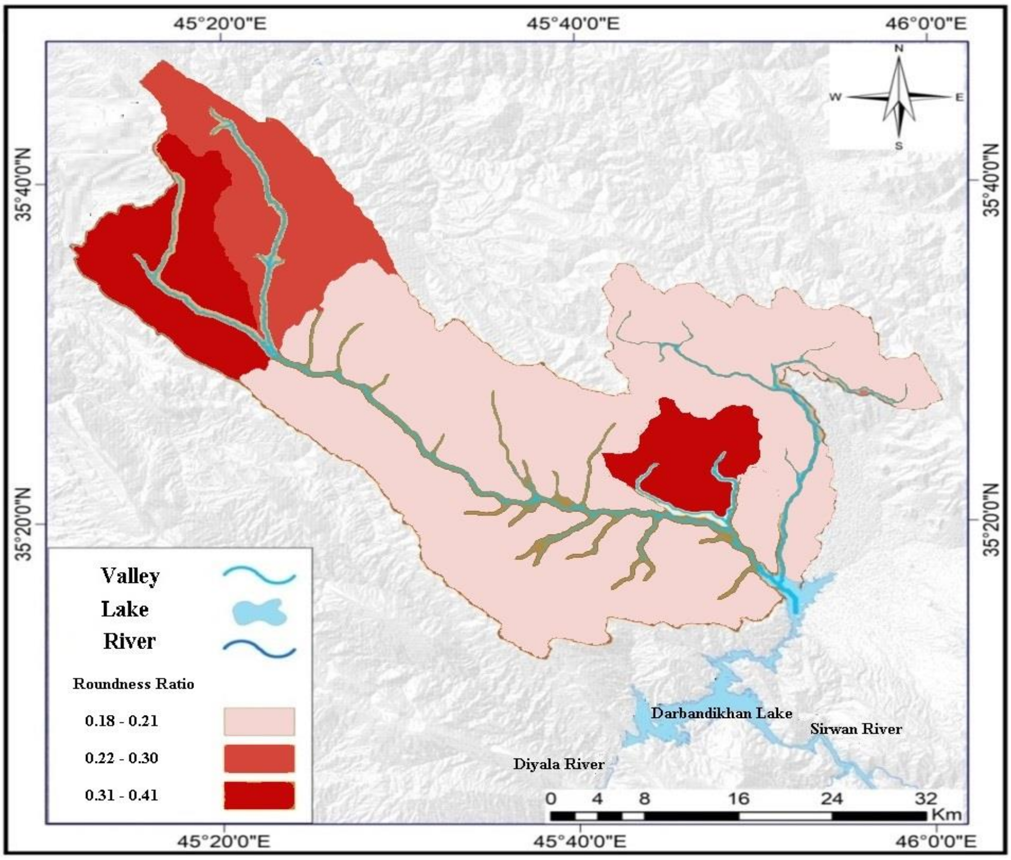
The study of the morphological characteristics of river basins is important in knowing the geomorphological development and the processes that led to its formation and formation, in addition to knowing the effect of shape on the volume of river discharge, which contributes to determining the degree of flood risk and contributes to the possibility of measuring water erosion rates and knowing the amount and quantity of discharge in the main stream as well as that is, the study of the shapes of water basins is of great importance because of its indications related to the prevailing geomorphological processes, as Streller believes that water basins that are similar in their formal characteristics must be similar in their geomorphological characteristics, because such similarity must produce the same geomorphological processes, and the basins differ in their shapes, including the rectangle Including the round (Abu Salim, 2009, p. 146).

Each shape has characteristics that differ from the other, as the rectangular basins are characterized by regular water flow in time, as they reach successively from the nearest point of the main estuary to the farthest point in the basin, with relatively small amounts of discharge, due to the increase in surface water loss due to the process of filtration and evaporation, due to the length of the distance it travels. The valleys in the rectangular basins from the source to the estuary, which reduces the risk of flooding. It happens that a rapid rise in the water level and the water drainage reaches its peak in a short period, which leads to the circular shape being the most vulnerable to the risk of flooding (Al Ibrahimi, 2019:17).

3.1. Turn ratio:

It indicates how close or far the shape of the basin is from the circular shape, and its value ranges between (0-1). This indicates that the basin is far from the circular shape and is close to the oval shape, but if the value is less than (0.4), it means that the basin shape is close to the rectangular shape and away from the round shape, and this indicates that the water division lines do not extend moderately, but extend in twisted and curved lines (Abdul Hussein, 2018, p. 45).

Rc=4 A/P2



Map (5) the ratio of roundness

Source: Digital erosion model (DEM) with a resolution of 30 square meters for the year 2015 and processed using Arc Map 10.8 (GIS).

Since:

- RC = rotation ratio.
- A = area.

P2 = pelvic circumference 2.

The amount of roundness of the secondary basins in the study area ranged (Sayed Sadeq Basin with a roundness ratio of -0.18, Gargol 0.21, Sarjnar 0.30, Kurdpur 0.37) as shown in Table (1). Thus, most of the basins of the study area are close to the rectangular shape, except for Saroh Basin, which is close to the shape The oval, while the ratio of the roundness of the total Tanjero basin is 0.6, and thus it is close to the oval shape. This refers to the tortuousness and bending of the water dividing lines. As shown in map (5).

3.2. Elongation Ratio:

It is a morphometric variable that has great importance in measuring river basins. It is a variable that indicates how close or far the shape of the basin is from the rectangular shape, and its value is between (0-1), where the closer the ratio is to zero, this indicates that the basin is close to elongation, and the greater the value is from the correct one. The shape of the basin is close to the round shape. It describes the extension of the area of the water basin by balancing it in a rectangular shape. This percentage usually rises in long water basins, while it decreases in basins whose width varies with its extension or increases in width towards its equality with the length of the basin. The elongation equation is used to determine how close the basin is to the shape. Rectangular, through which some characteristics of the drainage system can be estimated, such as the time required to drain the water of the basin and the consequent preventive measures against floods or planning for the purpose of irrigation and urbanization. Schum in 1956 developed his equation to describe the extension of the area of water basins in percent) (Al-Luhaibi, 2008, p. 109).

$Re=1.129 \sqrt{A}/L$

Since:

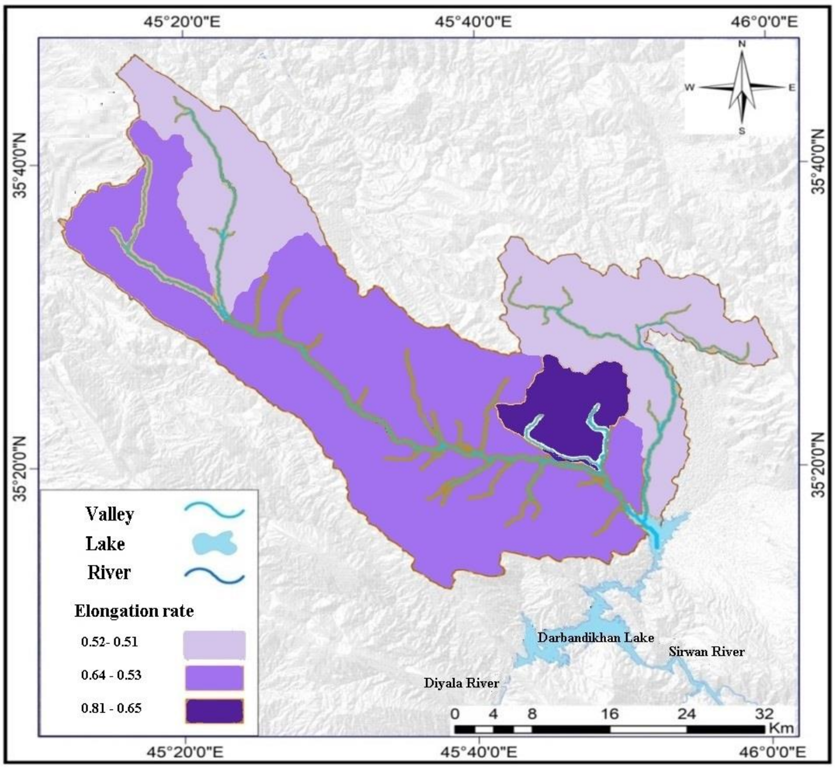
Re = elongation ratio.

1.129 = constant.

A = area.

L = the length of the pelvis.

By observing Table No. (1-1), the basins of the study area moved away from the rectangular shape and approached the oval shape, as in the Sayed Sadiq basin, the average was 0.52, the Kurdpur basin 0.58, and the Sargnar basin 0.54, while the Saroh basin 0.81 and Gargol 0.64 moved away from the shape. Rectangle As for the basin of the Tanjero River, its average elongation was 0.54, and thus it approached the oval shape, as in Map No. (6), where by observing the above proportions, it is clear that the basins of the study area are oval or close to the circular shape, which indicates the speed of the arrival of water currents from the source to the estuary because of the close distance between them and the lack of water loss by leakage and evaporation.



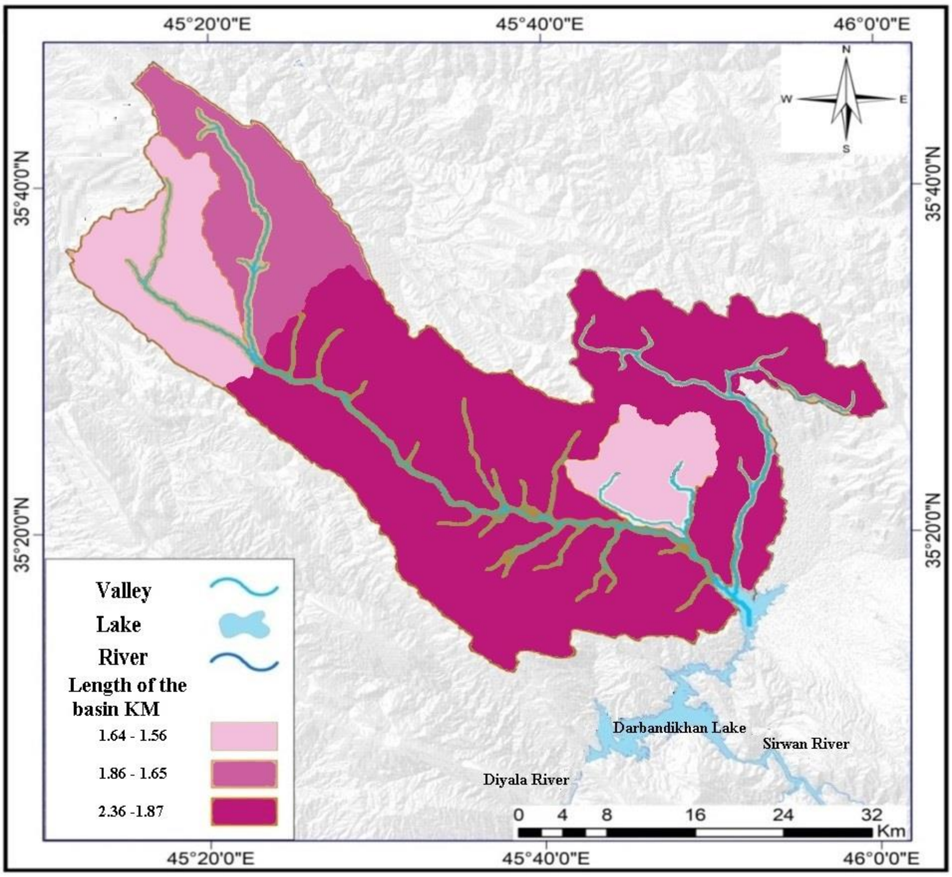
Map (6) elongation rate.

Source: Digital erosion model (DEM) with a resolution of 30 square meters for the year 2015 and processed using Arcmap 10.8 (GIS).

3.3. Perimeter Cohesion Ratio:

It is another measure to confirm the extent to which the shape of the basin is close or far from the circular shape, as the higher the coefficient is from the correct one, the farther the shape of the basin is from the circular shape, and it was more elongated. In the drainage basins and the homogeneity of its forms (Mohsen, 2018, p. 56). High values that are close to the correct unit indicate that the basin is moving away from the regular round shape, which is explained by the weak interdependence between the parts of the basin and the irregularity of the water dividing line. homogeneous, which makes the basin take a regular shape (Maleh, 2019, p. 149).

$$\mathrm{Cc} = 0.282 * \frac{P}{\sqrt{A}}$$



Map (7) perimeter cohesion ratio.

Source: Digital erosion model (DEM) with a resolution of 30 square meters for the year 2015 and processed using Arc Map 10.8 (GIS).

Notice:

- Cc: perimeter coefficient of cohesion / km / km 2.
- P: pelvic circumference / km.
- A: the total area of the basin / km2.

By observing table No. (1) and map (7), it is clear that the basins of the study area are moving away from the circular shape, with rates of Sayed Sadiq 2.36, Sarwa 1.56, Kargol 2.18, Kardbul 1.64, and Serjnar 1.86. A What is the rate of cohesion of the ocean for the Tanjero Valley Basin is 4.08, and thus it approached the rectangular shape and moved away from the round shape. This is due to the tortuous lines of water division as well as the presence of tectonic activity in the region.

3.4. Basin shape parameter:

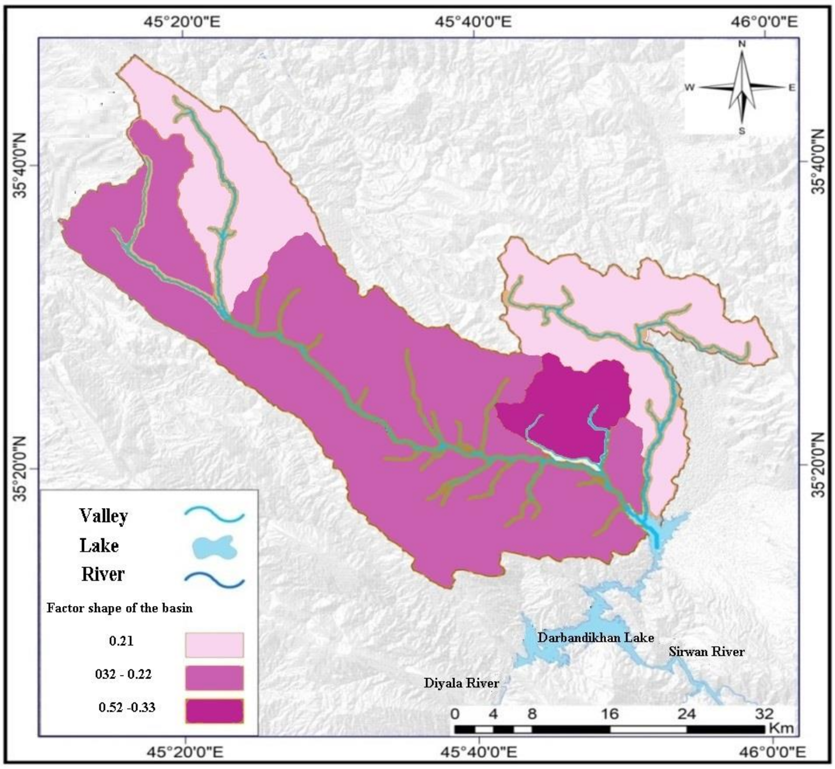
The importance of this measure is due to the knowledge of how fast the water waves reach the peak, as this factor indicates the consistency of the shape of the general basin, through the relationship between each of the area of the basin and the length of the basin, low values that move away from the correct one indicate that the shape of the basin is close to the triangular shape, in which the base is at the source and the head at the mouth, indicates a small basin area and an increase in its length, which leads to the successive arrival of water waves over a long period of time, while high values close to the correct one indicate that the basin is close to roundness. The distance and shape of the triangular basin has the base at the mouth. The head is at the source and the large area at the expense of the length, which leads to the arrival of water waves quickly and at once in a short time, and this is a result of the change in the width of the water basins from the source to the downstream, to increase one of the dimensions of the basin over the other dimension (Aswad, 2014, p. 148) .

$$Sf = \frac{A}{Lb^2}$$

Notice:

- Sf: basin shape coefficient / km 2 / km.
- Lb 2: the square of the length of the basin / km.
- A: the total area of the basin / km2.

From the observation of Table (1) , it is clear that the basins of the study area are close to the triangular shape, such as the basin of Sayed Sadiq, Kurdpur, Kargol and Sarjnar, except for the Saruh basin of 0.52, which is thus far from the triangular shape. In this case, the coefficient approached the correct one, which indicates a higher value of the distance at the expense of the length, and thus the shape of the basin approached the square shape. As shown in map (8).



Map (8) of the pelvic shape parameter

Source: Digital Demolition Model (DEM) with an accuracy of 30 square meters for the year 2015 and processed using Arcmap 10.8. (GIS). 5.2.1 Diffraction Coefficient:

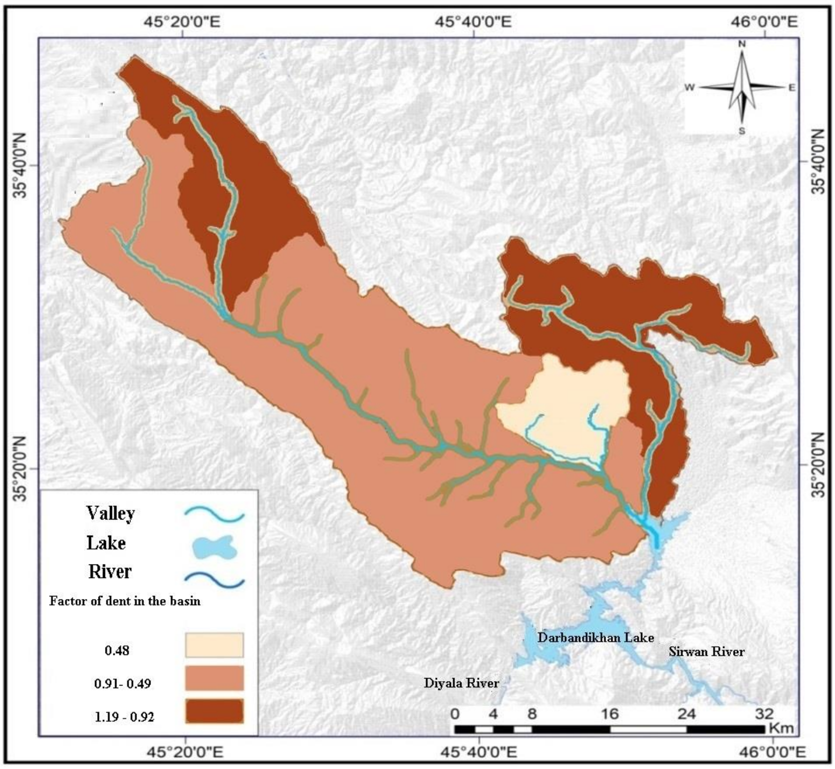
It can be extracted from the quotient of dividing the square of the length of the water basin by four times the area of the water basin. This coefficient expresses the relationship between both the length of the basin and its area. Low values indicate the flattening of the river basin and the increase in its primary and longer streams. This would indicate that I see an increase in the water supply within the headwaters area within the basin also indicates the activity of regressive erosion processes and the tendency of the basin to rotate more than to elongate, which indicates that the basin has come a long way in its life cycle, and the high values indicate the opposite (Al-Tamimi, 2020, p. 150).

$$K = (L)^2 \div (A)^4$$

Notice:

- K = Diffraction index.
- L = the length of the pelvis.
- A = area of the pelvis.

From the observation of Table (1-1), it was found that the value of the indentation in the main Tanjero basin, and thus the value approaches the correct one, as for the secondary basins, which are also close to the correct unit, and this indicates a lack of flattening of the total basin and its secondary basins, in addition to the lack of numbers of primary waterways and weak operations regressive erosion. As shown in map (9).



Map (9) Diffraction index.

Source: Digital Demolition Model (DEM) with an accuracy of 30 square meters for the year 2015 and processed using Arc Map 10.8. (GIS).

4. TOPOGRAPHIC CHARACTERISTICS OF THE STUDY AREA:

The terrain characteristics are of great importance in morphometric and geomorphological studies because through their results it is possible to understand and know the topographical characteristics of the region and the nature of the landforms associated with it. The difference in the height of the basin areas is useful in determining the areas where rainwater collects, and that basins with a small slope increase the chance of water loss due to leakage and evaporation, and on the contrary, when the slope is severe (Muhammad, 2016, p. 13). The indentation of the river basin is affected by the activity of the slope's retraction processes, the weathering processes and the prevailing landslides, and their impact on the formation of the surface of the basin land, as it is considered a good indicator to know the development of the basin and its life cycle. As shown in Table (2).

Table (1-2) Topographical characteristics of the Tanjero Valley Basin

Hipsometric integration	Roughness value	Degree of molarity	Elevation difference / meters	Lowest point in the basin / metre	highest point of the basin / metre	Basin name	aquarium number
0.19	1.26	42.3	1709	462	2171	Syed Sadiq	1
0.18	0.56	43.8	667	482	1149	Sarwa	2
0.80	0.93	21.7	1175	457	1632	Gargoyle	3
0.21	1.26	40.7	1413	672	2085	Sargnar	4
0.17	1.34	44	1258	673	1931	Kurdpur	5
0.85	2.03	24.4	2186	396	2582	Tanjero	main basin

Arc Map 10 geographic information systems program.

4.1. Total wear ratio:

It is the vertical difference between the highest and lowest points of the basin, and the higher the total erosion value, the greater the ability of water to erode and remove, especially if the distance between them is short, which is positively reflected on the slope (Al-Waeli, 2022, p. 74).

$$H = Z - z$$

Since:

- H: the total indentation (the difference between the highest and lowest height) / m
- Z: the highest height of the basin / m.
- z: the lowest height of the basin/m.

By observing Table (1-2) , the highest point in the Sayed Sadiq Basin is 2171 meters and the lowest point is 462 meters. meters, while the total erosion rate is 1709, while the Saroh Basin has the highest point at 1149 meters and the lowest point at 482 meters, with a total erosion rate of 667, and the Kargol Basin with the highest point at 1632 meters, the lowest point was 457 meters high, and the total erosion rate was 1175, and the Sarjnar Basin reached the highest height in the basin 2085 meters, and the lowest point is 672 meters, so the percentage of its impaction is 1413 Kurdpur, its highest point is 1931 meters, while its lowest point is 673 meters, sea level, and its dentation rate is 1258. The highest point in the Tanjero Valley basin, the main basin, is 2582 meters above sea level, while the lowest point is 396 meters above sea level, and its total erosion is 2186. The value of total erosion It is high in the main Tanjero basin and its secondary basins, and this indicates the intensity of the techno-structural processes, the activity of erosion and erosion processes, and the intensity of rock hardness.

4.2. Degree of molarity:

The erosion of the basin is related to the climate and geology of the region, to the quality of the rocks in the drainage basin, and to the responses of these rocks to the active erosion processes in the valley basin. Its influence extends over long distances and contributes to the formation of different geomorphological forms, and contributes to increasing the speed of the arrival of the water wave, and this is reflected in the increase in the effectiveness of river erosion and the associated transport of large amounts of sediment (Al-Atwani, 2015, p. 98).

$$RHI = H / LB$$

Notice:

- RHI = molarity ratio.
- H = total terrain.
- LB = the length of the pelvis.

From the observation of Table (1-2) , the rate of erosion for the secondary water basins (Sayed Sadeq 42.3, Saroh 43.8, Kargol 21.7, Sarjnar 40.7, and Kurdpur 44) , while the main Tanjero Basin is 24.4. total. As in map (1-10).

4.3. Roughness value (surface roughness factor):

It is the criterion through which the percentage of basin indentation is known, which results in an increase in the strength and speed of water flows as a result of the increase in slope and ground gravity. Roughness is a good indicator of the ability of the water network to transfer rock fragments from the upper parts to the lower parts , and thus the percentage of water benefit is reduced by leakage, as the water basin at the beginning of its erosion cycle has a low ruggedness value and gradually begins to rise until it reaches maturity, and then the ruggedness value begins to decline At the end of the erosion cycle (Abu Al-Enein, 1995, p. 455).

It was found that the value of ruggedness is the relationship between the activity of erosion processes and the tectonic differences of the rocky basin formations, as it determines the extent of the basin’s erosion, and then the extent of the slope of the watercourse in it. Low values indicate that the roughness value is at the beginning of the erosion processes of the running water. The high values indicate an increase in the value of ruggedness, which explains the high erosion processes carried out by the watercourses from the upper parts to the outfalls, depositing with them the rocky materials resulting from the erosion processes in the outfalls of the basins (Mahsoub, 1989, p. 204)).

$$Rn = Dd \times H / 1000$$

Notice:

- Rn = roughness value.
- Dd = drainage density.
- H = pelvic molar.

From the observation of Table (1-2) , the value of ruggedness varies between the basins of the study area, as the highest value of ruggedness was in the Tanjero Basin in the Kurdpur Basin. As for the value of the ruggedness of the main Tanjero Basin, it amounted to 2.03, and the reason for the decrease in the ruggedness value in the Tanjero Basin and its secondary basins is that these basins are located within the lands of little erosion and that they are located within the lands of medium slope, which indicates that the waterways are still at the beginning of their underground cycle.

4.4. Hypsometric integration:

It is one of the accurate morphometric characteristics that expresses the degree of erosion of the river basin and the time period that the basin traveled in its geomorphological cycle, as it expresses the relationship between the area of the basin and the total erosion. The high hipsometric integration values indicate the large area of the basin as a result of the increase in the length of the lateral streams and the increase in the number of the river network, which It leads to an increase in the water discharge density of the basin as well as a decrease in the proportion of topography, meaning that there is a direct relationship between the values of hipsometric integration and the time period that the river b asin travels in its geomorphological cycle.

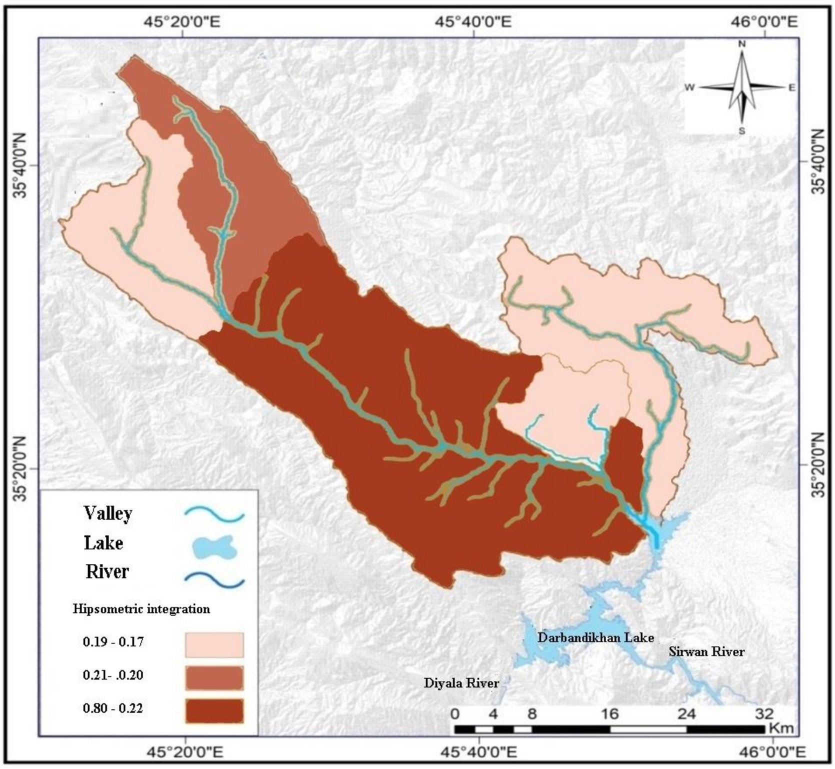
$$Hi = A \div H$$

Since:

- Hi = hyposometric integration.
- A = area of the pelvis.
- H = pelvic topography.

By applying the equation of hipsometric integration to the Tanjero basin and its secondary basins, it was found that the integration of the Sayed Sadeq basin reached 0.18 and the Saruh basin amounted to 0.19, while the value of integration for the Kargol basin was 0.17 and the Sargnar basin 0.21. As shown in the map (10).

As for the value of the hypsometric integration in the main Tanjero basin, it amounted to 0.82. By observing the values for the main basin and the secondary basin, it is clear that the values of the hypsometric integration in them are low, and that the basin is still at the beginning of its life cycle, i. its movement.



Map (10) of hyposometric integration

Source: Digital erosion model (DEM) with a resolution of 30 square meters for the year 2015 and processed using Arc Map 10.8 (GIS).

5. CHARACTERISTICS OF THE WATER DRAINAGE NETWORK:

The study of the characteristics of the water network of the basins is one of the important studies that have a very important role because it reflects a clear picture of the hydrological situation of the waterways and its role in the formation and development of sedimentary landforms. Allah, 2017, p. 99).

1.2 River ranks: It is the numerical gradation of the collection of watercourses and tributaries that make up the river basin as a result of the gathering of very small tributaries, which are the beginnings of streams and streams that gather with each other. The rank is defined as the watercourse in relation to the rest of the watercourses in the same basin. Therefore, the rank of river streams gives a clear picture. On the size of the drainage river network and the stage of development of the waterways, Fatimah Al-Waeli, and the Strahler method was adopted in classifying the water basins in the study area into ranks, which states that every stream that does not connect to another stream is a first-order stream, and if two first-order streams are connected, they become a second-order stream. The connection of two streams of the second order forms a stream of the third order. When two streams of the third order come into contact, they form a stream of the fourth order, and so on. It is clear from table (2-1) and map (2-1) the number of ranks in the river basin and the number of waterways.

Table (3): Characteristics of the river network in the Tanjero Valley basin

Bifurcation ratio	Length of valleys / km	Number of valleys	River mattresses
-	960.07	642	1
5.31	428.77	121	2
3.56	185.3	34	3
3.78	109.7	9	4
4.50	53	2	5
2.00	3	1	6
-	1739.83	809	Total

Source: Depending on the satellite visualizations of the region and the GIS program (Arc Map 10.8)

Where the number of ranks in the total Tanjero basin reached (6) ranks, and the number of valleys in the first order reached 642, in the second order 121, in the third order 34, in the fourth 9, the fifth 2, and the sixth 1 stream. the second. Where the total number of total watercourses for the Tanjero basin reached 809 watercourses, and this value is low. The reason is due to the geological structure, such as the linear structures that determine the path of the valleys, the quality and hardness of the rocks, in addition to the lack of erosion, which indicates that the basin is still at the beginning of its life cycle, i.e. at the beginning of the youth stage. As for the secondary basins, the number of ranks is 5 ranks per basin. Where the watercourses in the Sayed Sadiq Basin reached 101 streams in the first order, 22 streams in the second class, 7 streams in the third class, and the fourth class 2 streams and the fifth 1 stream, as the total watercourses in the basin are 133 streams, as in Table of the characteristics of the river network in Sayed Sadeq Valley Basin (4).

Table (4) Characteristics of the river network in the Sayed Sadeq Basin

Bifurcation ratio	Lengths of valleys / km	Number of valleys	River mattresses
-	110	101	1
4.59	51.8	22	2
3.14	38.47	7	3
3.50	18.29	2	4
2.00	25.7	1	5
-	244.26	133	Total

Source: Depending on the satellite visualizations of the region and the GIS program (Arc Map 10.8).

As for the secondary basin, the Saroh basin consists of 4 ranks, the number of watercourses in the first rank is 37 streams, the second rank 10 watercourses, the third rank 3 streams, and the fourth rank 1 stream, as the total number of watercourses in the Saroh basin is 51 watercourses.

Table (5): Characteristics of the river network in the Wadi Saroh basin.

Bifurcation ratio	Lengths of valleys / km	The number of valleys	River mattresses
-	50.57	37	1
3.70	27.32	10	2
3.33	16.68	3	3
3.00	8.44	1	4
-	103.01	51	Total

Source: Depending on the satellite visualizations of the region and the GIS program (Arc Map 10.8).

As for the Kargol Basin, the number of ranks in the basin reached 5 ranks, as the number of watercourses in the first order reached 354, while the number of watercourses in the second order reached 58 streams. As for the third rank, 18 streams, the fourth rank, 4 streams, and the fifth 1 Stream and total watercourses of Kargol Basin 435 watercourses as shown in Table (6).

Table (6) Characteristics of the river network in the Kargol Valley basin.

Bifurcation ratio	Lengths of valleys / km	The number of valleys	River mattresses
-	544.4	354	1
6.10	226.2	58	2
3.22	104.5	18	3
4.50	39	4	4
4.00	27	1	5
-	941	435	Total

Source: Depending on the satellite visualizations of the region and the GIS program (Arc Map 10.8).

As for the Kurdpur Basin, it contains 4 ranks, the number of watercourses in the first order reached 37, while in the second order the number of waterways reached 17, while the third order has 2 watercourses and the fourth order has 1 watercourse.

Table (7) Characteristics of the river network in the Kurdpur Valley Basin.

Bifurcation ratio	Length of valleys / km	Number of valleys	River mattresses
-	129.7	73	1
4.29	63.25	17	2
8.50	16.25	2	3
2.00	15.06	1	4
-	224.26	93	Total

Source: Depending on the satellite visualizations of the region and the GIS program (Arc Map 10.8).

As for the Sargnar Basin, the number of ranks reached the entire basin 4 Rank The number of sewers in the first rank was 77 As for the number of sewers in the second order 14 And the number of sewers was in the fourth order 1 The number of watercourses of the Sargnar Basin as a whole is 96. As shown in Table (2-6)

Table (8) Characteristics of the River Network in Srinagar Valley Basin

Bifurcation ratio	The lengths of the valleys / km	The number of valleys	River mattresses
-	125.4	77	1
5.50	60.2	14	2
3.50	9.4	4	3
4.00	28.9	1	4
-	223.9	96	Total

Source: Depending on the satellite visualizations of the region and the GIS program (Arc Map 10.8).

5.1. Bifurcation ratio:

It is one of the important morphometric variables because it is one of the factors that control the rate of river discharge after the occurrence of severe rain showers. It is meant by the ratio that shows the number of waterways belonging to one of the ranks and the number of waterways belonging to a higher order directly. If the value of the bifurcation ratio is high, this indicates an increase. Discharge density, and then the water is distributed over a large number of waterways, where when it reaches the main stream, the water is dispersed. Which increases the water loss, and then the risk of flooding decreases, and the opposite happens if the bifurcation rate is low, as the discharge density decreases, and then rain water collects in few and limited streams, so the risk of flooding increases, and river basins are affected by the bifurcation rate according to their shapes. In basins that tend to rotate, the bifurcation rate increases and increases It has a discharge density, which leads to an increase in the risk of flooding, as a result of an increase in the velocity of water in the watercourses, and the opposite occurs in the basins that tend to elongate and in which the bifurcation rate is reduced (Jaafar, 2018, p. 103).

$$Rb = Nu / Nu + 1$$

Notice:

- Rb = bifurcation ratio.
- Nu = the total number of streams in each rank.
- Nu+1 = the number of streams in the next rank.

By applying the bifurcation ratio equation, it was found that the bifurcation ratio of the Tanjero Basin ranked second (5.31). As for the percentage of the third rank, the percentage of bifurcation reached (3.56) , the fourth rank, the percentage of bifurcation reached (3.78) , the fifth rank (4.50) , and the sixth rank, the percentage of bifurcation reached (2.00). The third rank is 3.14, the fourth rank is 3.50, and the fifth is 2.00. As for the Sarwa Basin, the bifurcation percentage reached the second rank (3.70) , the third rank (3.33) and the fourth (3.00). In Kargol Basin, the bifurcation rate came second (6.10) , third (3.22) , and the fourth bifurcation percentage reached (4.50). As for the fifth rank, it reached (4.00) , and the Sarjnar Basin reached the first rank () , the second rank (5.50) , the third rank (3.50) , and the fourth rank (4.00).

As for the Kurdpur Basin, the bifurcation ratio came in second (4.29) , third (8.50) , and fourth (2.00).

5.2. The lengths of the water valleys:

The length of the waterways represents a reflection of the geological and climatic characteristics of the region, by observing Table (1-2) and a map (2-4) The total length of waterways for the total basin is (1739.83 km). As for the secondary basins represented by

Sayed Sadiq basin, the total lengths of the water valleys reached 244.26, the Saruh basin 103.01, the Gargol basin 941, the Kurdpur basin 244.26, and the Sargnar basin 223.9, as the large basins included most of the lengths. As the lengths of the river beds increase on the basis of increasing the number of river beds according to Horton's law according to a geometric sequence , the river beds are clear from this that the relationship between the river beds and the lengths of the waterways is an inverse relationship , as it is noted that the lengths of the waterways are few compared to the area of the basin.

5.3. Discharge density:

It represents the total lengths of watercourses per unit area. It is an indicator that expresses the degree of branching and spread of the river network of the basin within a specific area unit. It indicates the nature of the surface water runoff of the river basin and is affected by climatic factors. The discharge density of watercourses located in the semi-arid regions increases and the discharge density decreases in the humid regions, due to the fact that the vegetation cover in the humid regions constitutes a hindrance factor to the surface water runoff. Hence, a large part of it leaks into the ground, and the drainage density increases in water basins with heavy rainfall, with a rock structure with weak permeability, with a lack of joints, cracks, fractures, and the presence of steep slopes, while the opposite occurs in water basins with rocky characteristics that are characterized by high permeability (Al-Waeli, 2022, p. 84).

The discharge density is divided into two types

5.4. Longitudinal drainage density:

The longitudinal drainage density is calculated from the ratio of the sum of the lengths of the river tributaries to the total area of the basin. The high values of the longitudinal density indicate the severity of the basin's vulnerability to erosion factors, to an increase in the lengths and numbers of watercourses in the basin. While the low values indicate that the basin is less vulnerable to water erosion processes and the lack of numbers and lengths of rivercourses. The longitudinal drainage density is related to the nature of the prevailing climate in the region, especially the amount of rain and temperature, as it represents a direct relationship with rain and an inverse relationship with temperature.

$$Dd = \sum_i^k = 1 \sum_i^k = 0 \; Lu \; / \; A$$

Notice:

- Dd = longitudinal drainage density.
- Lu = total lengths of streams in the riverine class.
- A = Area km 2.

Table (9) Longitudinal and numerical drainage density of the Tanjero Valley basin and its secondary basins.

Basin name	longitudinal density km/km2	Numerical density wadi/km2	Total lengths of valleys / km	Total number of valleys
Syed Sadiq	0.74	0.41	244.26	133
Sarwa	0.85	0.42	103.01	51
Gargoyle	0.97	0.46	951.9	439
Sargnar	0.89	0.38	223.9	96
Kurdpur	1.1	0.41	224.26	93
Tanjero	0.93	0.43	1747.33	812

Source: Depending on the satellite visualizations of the region and the GIS program (Arc Map 10.8).

Through the application of the longitudinal drainage density equation, it was found that the drainage density of the total Tanjero Valley basin was 0.93 km / km 2. As for its secondary basins, the lowest longitudinal drainage density was in the Sayed Sadeq basin 0.74, followed by the Saruh basin 0.85, then the Sargnar basin 0.89, and the highest longitudinal drainage density was in the Kurdpur basin , which reached 1.1 km / km 2 Note Table (3-1) and Map (3-1).

The longitudinal discharge density can be divided according to the standard:

1. (3-4 km 2) Low drainage density.
2. And (5-12 km 2) medium discharge density.
3. (13 km 2) high drainage density.

Through this criterion, it is clear that the values are very low due to the hardness of the rocks of the study area.

Numerical discharge density:

It is the sum of the number of river ranks in all their ranks within the basin divided by the total area of the basin and has a relationship to the geological sequence, topography, climate and the extent of natural vegetation density. / km 2) Therefore, the change in the area of water basins over time is reflected in the increase or decrease in the recurrence rate of waterways (Al-Tamimi, 2019, p. 125).

$$F = \sum_{1}^{n} Nu / A$$

By applying the numerical drainage density equation and observing Table (3-1) and Map (3-2) It turns out that the numerical drainage density of the main Tanjero basin is 0.43 km 2 , while its secondary basins had the lowest numerical drainage density in the Sarchenar basin of 0.38, followed by the Sayed Sadiq and Kurdpur basins of 0.41, then the Saroh basin of 0.43, and the highest numerical drainage density among the basins is the Gargol basin of 0.46.

The discharge density can be numerically classified according to the standard criterion:

1. (0-4) Low numerical discharge density.
2. (4-12) Average numerical discharge density.
3. (13 over) High numerical discharge density.

Morphometric measures through which it is possible to detect the hydrological and geomorphological characteristics, as it reflects the abundance of watercourses. per square kilometer and its role in the severity of the basin discontinuity, which increases with increasing the frequency of the number of sewers per square kilometer. Thus, the numerical drainage density is low in the main Tanjero Valley basin and its secondary basins, due to the severity of the rock hardness in the region (Abboud, 2016, p. 62)..

6. RESULTS:

It is meant by the general shape or image in which the river appears with its main and secondary tributaries, and it is considered the main result that links the nature of the prevailing climate and development. The geomorphology of the waterways on the one hand, and the rock structure and its construction system on the other hand, as many natural factors affect the drainage patterns, the most important of which are the nature of the rock structure, the layered structure system, the extent of the homogeneity of the rocks, the impact of tectonic lifting movements, and the resulting twists and fractures, whose effects are reflected in the general appearance of river discharge and the renewal of activity Watercourses (Hassan, 2017, p. 114). In addition to the type of climate prevailing in the region, the nature of the topography, the slope of the surface, and the geomorphological development of the basin itself, which makes the drainage patterns vary from one place to another depending on the main factors that led to its formation.

In the study area, there are four patterns of discharge, which are as follows:

1. Arboreal drainage pattern: It is the most common type of pattern, and the presence of this pattern of drainage is related to areas whose rocks are homogeneous and have rocky layers at the top that are horizontally extended or slightly inclined , and the surface is characterized as having a low topography, as if it is a plain or a plateau. The density of the river branch varies, and whenever the rocks are of little hardness, as in sedimentary rocks. As for the branching in the igneous rocks, it is less because they are very resistant and hard. This pattern is characterized by the branching of the river tributaries, as the rivers appear in this pattern as the branches of tree branches, and the tributaries of these rivers meet with the main stream at sharp angles. As in the western part of the Sayed Sadiq Basin.

2. Parallel drainage pattern: This shape is controlled by the structural factors and the nature of the slope of the basin surface. This pattern of drainage appears over the wide, inclined areas. Where it operates and this type of drainage is characterized by the extension of long streams parallel to each other, which helps to form regular separating distances between parallel valleys or close to the parallel pattern, as the landforms in the region direct the waterways in their extension , This pattern of drainage appears in the north of the Kargol Basin.

3. Perpendicular drainage pattern: It is originally a tree pattern that changed with the passage of time due to the Turkish ground movements that the bedrock was exposed to and concentrated in places whose rocks are characterized as fragile and exposed. The sewers are affected by the joints and fractures that exist in the formations that penetrate them This pattern of drainage appears at the beginning of Sarchinar Basin.

4. Radial drainage pattern: This form of drainage crosses the opposite of the surface drainage pattern, as it consists of river streams descending over convex rock domes, heading from top to bottom towards the slopes, then appearing in the form of solar rays that radiate in all directions. This type of drainage is over domed areas or the surfaces of volcanic cones or over rounded hills (Fulaih, 2019, p. 89). This pattern appears south of the Sayed Sadiq Basin.

Through what has been done, the hypothesis has been proven, which confirms that the morphometric characteristics have a clear impact on the variation in the hydrology of the Tangero River Basin in Sulaymaniyah Governorate.

References

Al-Ajili Abdullah Sabbar Abboud (2015). Morphometric analysis of Wadi Al-Ghanami Basin, Journal of Arts, University of Baghdad, Issue 110 (published research).

Younes, Theeb Owais, and Hajim, Ahmed (2002). Water Harvesting - Traditional Techniques for Improvement in Drier Environments, International Center for Agricultural Research in the Dry Areas.

Digital erosion model (DEM) with an accuracy of 30 square meters for the year 2015 and processed using Arc Map 10.8 (GIS).

Atwani, Zainab Ibrahim (2015). Good spatial variability of hazardous geomorphological phenomena in Erbil Governorate, College of Education, Al-Mustansiriya University, PhD thesis (unpublished).

Abdullah, Hamid Hassan (2011). Morphometric variables for the lower part of the Zab basin using geographic information systems, Diyala Science Journal of Pure Sciences, Volume 7, Issue 2, April.

Abu Salim, Ali Hamdi (2009). Geomorphological analysis of the natural data specific to the phenomenon of river floods in Wadi al-Jarthan, Jordan Journal of Social Sciences, Volume 2, Number 1.

Abdul Hussein, Israa (2018). Geomorphological assessment of the valleys west of Lake Darbandikhan, College of Arts, University of Baghdad, master's thesis (unpublished).

Yarub Muhammad Hamid (2008). Spatial Modeling of the Geomorphological Processes of the Naryn River Basin Using Remote Sensing Techniques and Geographic Information Systems, Unpublished PhD Thesis, University of Baghdad, College of Education, Ibn Rushd.

Improver, Sari Hussain (2018). Geomorphology of the Neidush Valley Basin, PhD thesis (unpublished), College of Education for Girls, University of Baghdad.

Maleh, Abdul Hussein (2019). Algebra hydrogeomorphology of Wadi Jada basin and its economic investments using modern geographical techniques, master's thesis (unpublished), College of Arts, University of Baghdad.

Black, pure (2014). Harvesting Water for Waste Basin in Salah Al-Din Governorate, PhD thesis, (unpublished), College of Education, University of Tikrit.

Tamimi, Sanaa Abd Shahd (2020). Hydrogeomorphology of the eastern valleys of Wadi Jaramka in Sulaymaniyah Governorate and their investments using geographic information systems, PhD thesis (unpublished), College of Arts, University of Baghdad.

Mohammed, Awad Abdel Wahed Awad (2016). Morphometric Characteristics of the Drainage Basins in Al-Makhaili Region, South of the Green Mountain in Libya, unpublished Ph.D. thesis, College of Education for Girls, Ain Shams University.

Al-Waeli Fatima Ali Abdel Zahra (2022). Hydrology of Wadi Al-Sharhani Basin in Maysan Governorate and its economic investments using geographic information systems, master’s thesis (unpublished), College of Arts, University of Baghdad.

Abou El-Enein, Hassan (1995). The Fundamentals of Geomorphology, Study of the Topography of the Earth's Surface, Al-Intisar Printing Press, 11th edition, Alexandria University.

calculated, Mohamed Sabry (1989). Geomorphology of Landforms ed 5, Dar Al-Fikr Al-Arabi, Cairo.

Abdullah, Wafaa Mazen (2017). Geomorphology of the Tarifawi Valley Basin, Master Thesis (unpublished), College of Education for Girls, University of Baghdad.

Jafar, Ali Mohsen Kamel (2018). Hydrological modeling of the Wadi Basin according to its impact on environmental development, master's thesis (unpublished), College of Arts, University of Kufa.

Al-Tamimi, Rana Faeq (2019). Geomorphological risks of the basins of Bireh Makron Sulaymaniyah using remote sensing and geographic information systems, master's thesis (unpublished), College of Arts, Iraqi University.

Abboud, Nahreen Hassan (2016). Hydrogeomorphology of the Saura Valley Basin in Sulaymaniyah Governorate, unpublished doctoral thesis, College of Education for Girls, University of Baghdad.

Hassan, Bushra Khalil Dakhil (2017). Geomorphology of Wadi Al-Rakash Basin, Master Thesis (unpublished), College of Education, University of Baghdad.

Al Ibrahimi, Suhaila Najem. (2019). The effect of groundwater salinity on the soil in the district of Dhuluiya, Iraq by using (GIS), EM International, 25 (4): 2019; pp. (1871-1884): http://www.envirobiotechjournals.com/article_abstract.php?aid=10151&iid=287&jid=3

Al Ibrahimi, Suhaila Najem. (2021). The Effect of High-Water Salinity Concentrations on the Agricultural Reality in Samarra District, Rige Review of International Geographical Education, Vol. 11 Issue 3 (2021), Pp. 1068-1088. https://rigeo.org/submit-a menuscript/index.php/submission/article/view/313/231

Al Ibrahimi, Suhaila Najem. (2022). The Effect of Water on the Formation of River Bends during the Tigris River in Baghdad Governorate, Res Militaris, (Issue 4) of November-December: https://resmilitaris.net/menu-script/index.php/resmilitaris/article/view/590/399

Falih, Hayam Noman (2019). Hydrogeomorphological Evaluation of Biskandi Valley Basins Using Modern Geographical Techniques, PhD thesis (unpublished), College of Arts, University of Baghdad.