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A morphometric analysis of some spatial and topographical characteristics of the Salmana Basin and its secondary basins in Maysan Governorate

By

Zahraa Karim Shrhaan Al-Kinani
University of Baghdad - College of Arts - Department of Geography and Geographical Information Systems/ Iraq
Email: zahraa.kareem1107a@coart.uobaghdad.edu.iq

Suhaila Najm Abd
University of Baghdad - College of Arts - Department of Geography and Geographical Information Systems/ Iraq
Email: suhaila.a@coart.uobaghdad.edu.iq

Abstract

The river basin serves as the natural storage area for rivers and waterways. It comprises all the lands that feed rivers with the water they need to flow, as well as all river networks and channels that transmit surface water to the major channels in the form of surface water flows, even if they are seasonal. The water division regions, a line that circles the basin through the highest points of the surrounding high areas, represent the boundary between one river basin and another and divide it from other basins. In order to examine morphometric measures, mathematical techniques were used in conjunction with topographical maps.

Keywords: (areal properties, morphometric analysis, hypometric integration)

Research problem: What is the morphometric effect of the spatial and topographical characteristics of the Salmana Basin and its secondary basins in Maysan Governorate?
Research hypothesis: The secondary morphometric and spatial characteristics affect the Salmana Basin.
Limits of the study: The study area is located between latitudes (31 35°) and (5 32°) east and longitudes (47 32°) and (42 47°), in Maysan Governorate of Iraq.

First: Spatial Characteristics:

The areas of the river basins vary from one basin to another. Some of them are large in size and others are medium or small in size. The spatial characteristics include a set of variables, which are as follows:

1- Basin's area:

It is the area of the watercourse that feeds the basin with water irrespective of the stream size (Baqir, 143, 2021). By establishing the water division lines using a contour map, topographical map, or spatial data, as well as by using Geographic Information System applications to get the spatial dimensions of the basin, the basin area can be calculated. Table (1) shows the total Salmana basin and its secondary basins, which numbered (4) secondary basins. These basins are (Anashak Basin, Eastern Basin, Kattan Basin, and Southern Basin). They are differentiated by spatial characteristics as noted in map (1) and table (1). The total area of the Salmana Basin was (5.157 km2). The lowest area of the secondary basins of the southern basin (07.7 km2) and the highest area of the main Salmana Basin (34.51 km2), at the level of the secondary basins of the Salmana Basin. The variation in the basin area depends on the length and average of the width. These two dimensions were determined tectonically before the formation of the basin network.

Noticing map (1), it is found that the Salmanah Basin has four lower sides that represent the secondary basins, where all of them represented the total basin. The foot of the Salmana Basin, which represents the largest of the secondary basins in area, can be observed due to its longitudinal extension that exceeds all and the great spread of the water network courses.

Table (1). *Spatial characteristics of the Salmana Basin and its secondary basins*

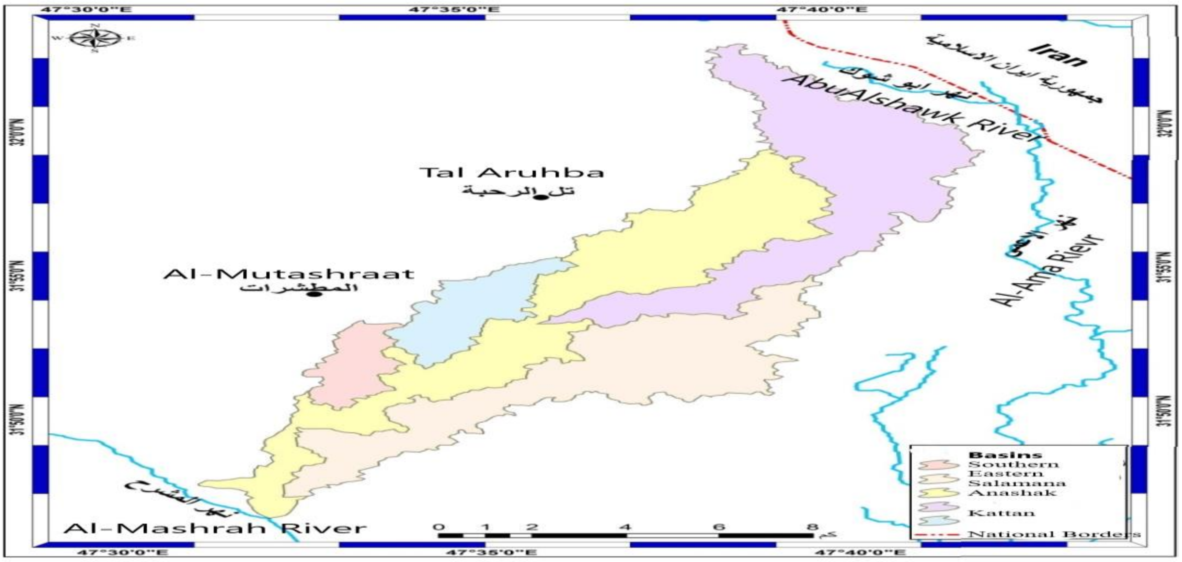
Basins	Average of width/ Km	Length/ Km	Basin area/km2	Circumference/ Km
Salmanah	1.51	34.0	51.34	90.2
Ashnaak	1.77	26.1	46.45	65.8
Eastern	1.77	23.0	40.71	62.8
Kattan	1.45	8.0	11.6	22.6
Southern	1.01	7.0	7.07	17.4

Source 1: The work is made by the researcher depending on the data of the Digital Elevation Model (DEM) and the program (Arc GIS v 10.8.1).

It can be noted that the (Anashak) basin has a large average width, which made this basin the second largest area among the secondary basins. The same applies to the remaining basins.

2- Basins Length

The lengths of the water basins vary due to the different degrees of gradient and severity of the relief. In the topographic and steep parts, the length of the basin becomes small. Therefore, it can be said that the amount of water running in a basin with a long extension is the same, it can pose a great danger if it is carried out in a basin that shortens it by half, as is the case when comparing between the (AlNashak) Basin and the (Southern) Basin. The flood wave reaches faster to the rest of the basin and the capacity of the underground water and erosion is greater and the probability of flooding is also greater in the basin (AlNashak). The lengths of basins are measured in various ways, including (Srahler, 1985; Jakavonytė-Staškuvienė, 2021) (Schunn method, Potter method, Ongley method and Maxwell method).



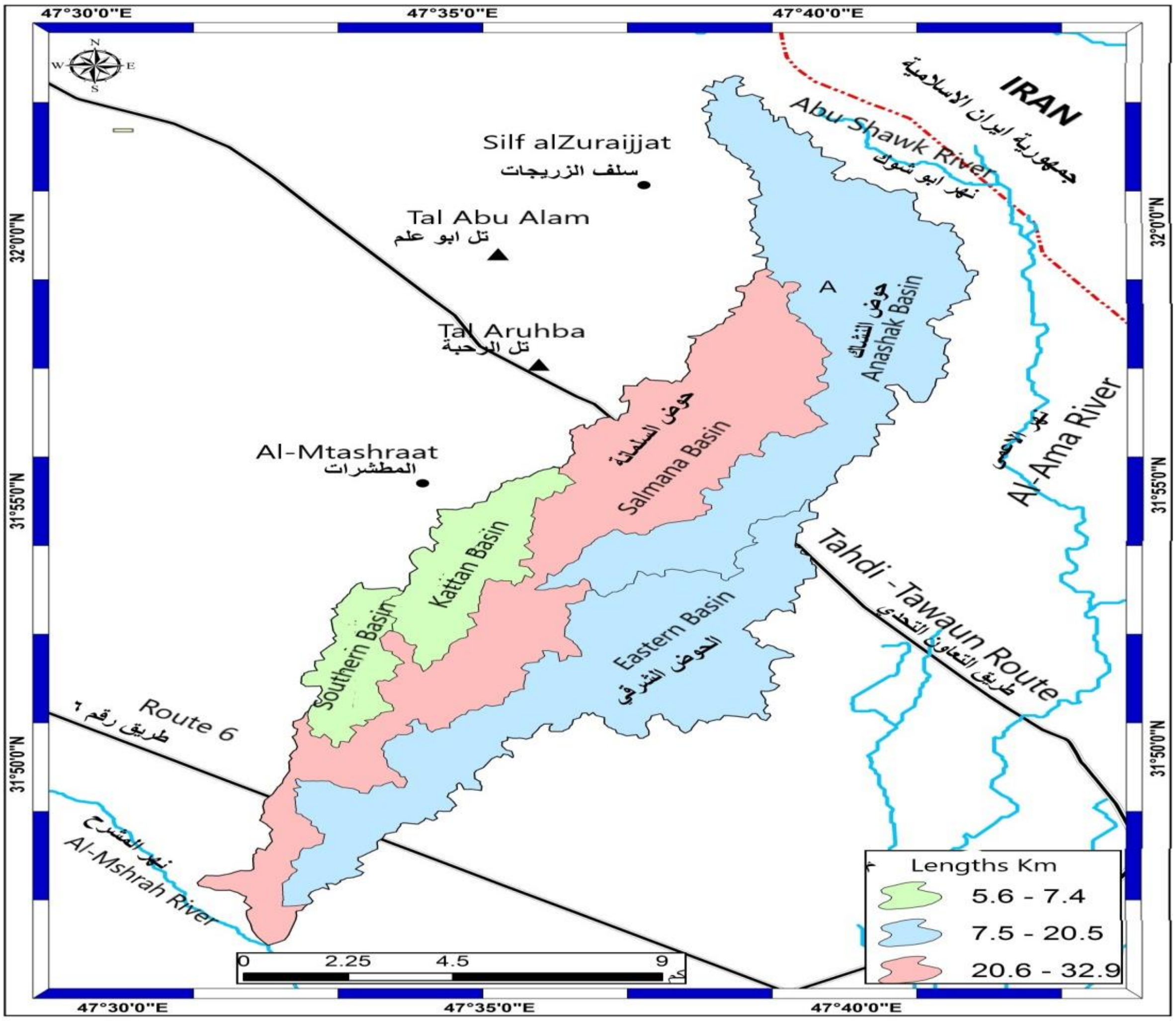
Map (1). The area of the Salmana Basin and its secondary basins
Source 2: The map is made by the researcher by depending on the data in Table (13) using the Arc GIS 10.8.1 program & Gregory and William method.

The accurate and ideal length of the Salmanah Basin and its secondary basins (4 basins) were measured using the method suggested by Gregory and Walling. The accurate length of the main Salmanah Basin, which represents the course of the river with all its meanders and torsions, is (00.34 km). As for the ideal length, which is represented as a straight line from the estuary reaches the farthest point of the basin circumference, is (9.32 km), while the ideal and real secondary basins have the same length. The longest basin is the (Anashak), with its real length (1.26 km), while the ideal is (20.5 km). The shortest basin is the (Southern) basin, with accurate length (00.7 km), while its ideal length is (6.5 km), as shown in Table (2) and Map 2. The Southern and Kattan basins fall within the categories of short lengths, while Eastern and Anashaak were among the middle basin groups. Salmana Basin was unique in the long category (Kasalak & Dagyar, 2020; Susilawati, Khaira, & Pratama, 2021).

Table (2). *Real and ideal lengths and length categories for the Salmana basin and its secondary basins*

Basins	Real length /Km	Ideal length / Km
Salmana	34.0	32.9
Anashak	26.1	20.5
Eastern	23.0	18.3
Kattan	8.0	7.2
Southern	7.0	5.6
Basins	Length	Length categories
Kattan ،Southern	Short	7.4 – 5.6
Anashak, Eastern	Mid	20.5 – 7.5
Salmana	Large	32.9 – 20.6

Source: the researcher's work depended on the data of the digital elevation model (DEM) and the program (Arc GIS v 10.8.1)



Map (2). categories of basin lengths (Salmana and its secondary basins)
Source: Based on the data in Table (2), using Arc GIS 10.8.1 software.

3- Basin Width

This variable is used to measure the length/width ratio mainly to indicate the shape of the basin. The width of the basin is defined as the length of the distance between two points on the perimeter of the basin that intersect completely perpendicular to the main course of the basin. The width of the basin affects the amount of water that can be absorbed by the river basin, which leads to its impact on the surface run-off and its patterns. There is a direct relationship between the width of the basin and the amount of water. That is, the greater the width of the basin, the greater its water revenue and the greater its water runoff. It was adopted to measure the width of the total Salmana basin and its secondary basins through the following equation (Kazem, 2012, 96):

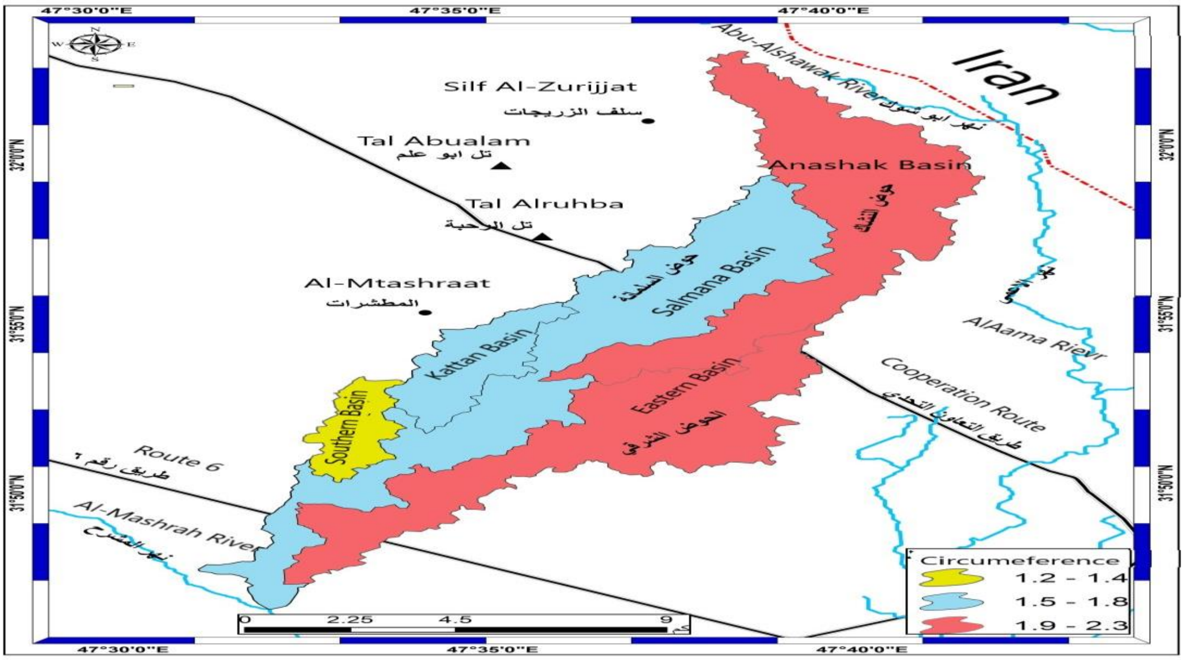
Average width = area of the basin in km2 / length of the basin in km

By applying the equation, by Table (3) and Map (3), it becomes clear that there is a discrepancy in the average width of the secondary basins and the main Salmanah Basin, whose average width reached (51.1 km), while the highest average width between the secondary basins is in the (Anashak) and (Eastern) basins. The average width in each of them reached (77.1 km). The lowest average width is in the (southern) basin (01.1 km). As for the categories of basins, it is evident from Table (15) that the southern basin falls within the category of short width, while Al-Salmana and Kattan were within the medium-width basins. Eastern and Anashak were within the large width basins.

Table (3). *Categories of the width of the basins for the Salmana basin and its secondary basins*

Basins	Average width	Categories
Southern	Short	1.4 – 1.2
Salamana, Kattan	Mid	1.8 – 1.5
Eastern, Anashaak	Large	2.3 – 1.9

Source: the researcher's work by depending on the data of the digital elevation model (DEM) and the program (Arc GIS v 10.8.1)



Map (3) Categories of basin widths for the Salmana Basin and its secondary basins
Source: The map is made by the researcher by depending on the data in Table (13), using the Arc GIS 10.8.1 program.

4- Basin circumference

The circumference of the basin is an essential morphometric variable that is related to a large number of other morphometric characteristics such as the ruggedness, elongation and shape factor of the basin, as well as its direct relationship with the area, because it represents the water dividing line for the basins that separates them. The circumference of the basin is used to determine the width of the basin. The greater the circumference of the basin accompanied by an increase in the breadth of the area, the greater its breadth. This indicates the activity and development of geomorphological processes, where the circumference of the basin varies according to shape and the straightness of the water division lines (Mubarak, 2009, 130). Through Table (1), it can be seen that the length of the total circumference of the Salmana Basin has reached (90.2 km). A slight discrepancy can be observed between the secondary basins, where the longest perimeter of the secondary basins is the (ANashaak) basin, with a circumference of (65.8 km). The shortest circumference of the secondary basin is the (Southern) basin (4.17 km). The reason for the discrepancy in the spatial dimensions is due to the tectonic origin of the slope as a spatial frame with length and width. As for the circumference, it depends on the extensions of the water network, which is related to the bedrock, its dimensions, and the structural and structural characteristics of the rock structure.

Second: Topographical Characteristics

The study of the topographical characteristics of river basins is of great importance to the researcher in applied hydrology and geomorphology by enabling him to understand the type of processes that contributed to the formation of the basin and the effectiveness of these processes. It also contributes to determining the stage that the river has crossed in its underground cycle, and knowing the processes that affect river courses, even if the flow is seasonal. This is done through the difference (even if it is minor) in the levels, which represents an important point for determining the possible paths of water (Gouda, 1991, 91).

The topographical characteristics are a measure of erosion activity, weakness and strength, and it shows the characteristics of the river networks of the basins. There is a direct relationship between the slope of the surface and the amount of water runoff. The topographical characteristics will be represented by the most accurate scales that have been developed for their study through quantitative rates in light of the following data:

1- Maximum relief

It is one of the simple morphometric parameters or criteria that refer to the relationship among the lowest and highest levels of water basins. It provides a clear picture of the extent of the change in the rise and fall of the water level of the basin surface. It is extracted through the following equation (Kazem, 2012, 108):

Max relief = maximum height of the basin (m) – minimum height of the basin (m(

By applying the above equation, it becomes clear from Table (4) that the average topography of the main Salmana basin reached (10.00m). This indicates that the basin is topographical or is of terrain. As for the secondary basins, the average topography of the (ANashak) basin and the (Southern) basin reached (29.00) m for each. This rate is the highest rate among the secondary basins, and it is also topographical. The (Kattan) Basin, where the average topography reached (20.00) m. As for the average topography of the (Eastern) basin, it reached (13.00) m. It can be said that the maximum topography of the basins of the study area ranges between the maximum topographical difference of the total Salmana basin (10.00) m. The minimum topographical difference for the two basins (ANashak and the South) is (29.00) m. This discrepancy is due to the topographical difference between the maximum height of the basin and the minimum height reached by the basin waters at the estuaries. It appears that it is a small topographical difference but given the longitudinal extension of these basins. It is noted that this topographical difference dissipates during the longitudinal distance between the highest and lowest elevation in them. Of this parameter, it is possible to detect at the level of the level of the sources and estuaries of all basins.

Table (4). *Topographic features of the Salmana Basin and its secondary basins*

No.	Basins	Total lengths of stream/km	Max topography	lower basin height	higher basin height	Relief ratio	ruggedness ratio	Drainage density of basins
1	Salamana	95	10	8	18	29.0	0.0005	1.85
2	Anashaak	83	29	5	34	1.11	0.0019	1.78
3	Eastern	70	13	10	23	0.56	0.0009	1.71
4	Kattan	18	20	5	25	2.5	0.0038	1.55
5	Southern	15	29	12	41	4.14	0.0087	2.12

Source: The researcher's work by depending on the data of the digital elevation model (DEM) and the program (Arc GIS v 10.4)

2- Relief Ratio

The erosion ratio is one of the most important factors closely related to the topography of the river basins, and it shows the extent of the topography of the basin, up and down. It has an impact on the hydrological characteristics through its effect on the speed of flow, river discharge, the amount of precipitation, the nature and quantity of sediments, as well as the ratio of the topography reflects the surface slope of the river basins.

The gear ratio is extracted through the following equation (Ritter, 1982,182):

(Relief ratio) = the difference between the highest and lowest point of the basin (m) / length of the basin (km)

By applying the above equation and as shown in Table (4), it is clear that the total relief ratio of the Salamanah Basin amounted to (0.29) m/km. This ratio indicates that the basin has a slow slope due to the characteristics of the tectonic factor and the characteristics of the specific composition of the rocks. This ratio of the relief indicates slow water flow and flooding when the water increases, as well as the high percentage of sediments transferred in the main Salmana Basin. This low rate of relief indicates the lack of activity of water erosion and water erosion in the case of hardness and resistance of rocks. Most of the rock formations are rocky structure with poor resistance to water flow and the accompanying hydraulic, chemical and mechanical erosion. Thus, despite the low ratio of the relief, which reflects the slow rate of decline, the running water in large quantities has a great ability to dismantle rocks and turn them into sediments to form a thick cover of soil as a flood plain. As for the secondary basins, they vary in the ratio of relief. The (southern) basin recorded the highest rate of relief than the secondary basins (14.4 m / km), as well as the (Kattan) basin, which showed a high rate of relief by (2.5 m / km). This percentage indicates a very rapid and turbulent water flow associated with high activity even and erosion. As for the rest of the secondary basins, they recorded a similar relief ratio, which was in the (ANashak) basin (11.1 m/km) and in the (Eastern) basin (56.0 m/km) it is noted in Table (4).

3- Ruggedness Value:

This value is one of the morphometric parameters that show the relationship between the basin topography, the length of the streams, and the area of the water basin. It indicates the extent to which the topographic stream of the basin is interrupted by the action of river valleys. The ruggedness value increases with the increase in the basin drainage density, especially when the basin relief ratio increases, and the lengths of the waterways increase at the expense of the basin area. Thus, this indicates an increase in the activity of erosion and water sculpting processes, as well as the sedimentation process. The value of the ruggedness and the drainage density are extracted from the following (Strahler, 1958, 289):

Ruggedness value = basin topography (m) x basin drainage density (km) (km2) / 1000

The drainage density is extracted through the following equation:

Drainage density = the total of the lengths of the riverbeds in different grades (lengh m) ÷ the total area of the basin (area by meter)

By applying the above equations, the results of which appear in Table (4), it is noted that the roughness value of the total Salamana Basin has reached (0.0005 m/km). The ruggedness value in the secondary basins reached relatively different values, as it reached (0.0019 m/km) in the (ANashak) basin, in the (Eastern) basin to (0009.0 m/km), and in the (Kattan) basin to (0.0038 m/km). The (Southern) Basin reached (0.0087 m/km). These low rates indicate the low ruggedness of the water basins due to the low topography and short lengths of their waterways. These basins still have a lot of time to reach the base limits through retrograde erosion processes, it is noted in Table (4).

4- (Hypsometric Integral):

It is one of the important morphometric criteria, and it aims at an important comparison between the size of the current topography and the size of the old topography of the basin, and then measuring the degree of topographical surface of the basin and determining the duration of the drainage basins in their subsurface cycle. The high values of the Hypsometric integration indicate the large basin area as a result of the increase in the lengths of the waterways of the river basin, and the increase in the number of the river network. This, in turn, leads to an increase in the water density of the basin, as well as a decrease in the proportion of basin topography. The hypometric integration can be extracted through the following equation (Al-Jabri et al., 2018, 183):

Hypsometric integration = basin area (km2) ÷ basin topographic difference (the difference between the maximum and minimum height of the basin (m) (maximum topography of the basin)

By applying the above equation, it is clear that the hypometric integration of the total Salmana basin has been (0.51). As for the secondary basins, they were hypometrically integrated with relatively different values, where the hypometric integration of the (Al-Nashak) basin reached (0.05 m/km), the (Eastern) basin reached (0.24 m/km), and in the (Kattan) basin to (0.02 m/km). And the (Southern) Basin to (0.008 m/km). These values of the hypometric integrity of the main Salmana basin and its secondary basins are low. It approaches zero and indicates that the basins are small in size due to the short lengths of the waterways and the small number of the river network. They are still at the beginning of their geomorphological cycle represented by the processes of water ruggedness and erosion. There is still time for these basins to complete their geomorphological work (its life cycle) to form the water networks of these basins. This is noted in Table (5).

Table (5). *Hypsometric integration of the Salmana basin and its secondary basins*

No	Basins	Max topography	The difference between the highest and lowest height	Basin area / km2	Max variance X	Hypsometric integration
1	Salmana	10	10	51.34	100	0.51
2	Anashaak	29	29	46.45	841	0.05
3	Eastern	13	13	40.71	169	0.24
4	Kattan	20	20	11.6	400	0.02
5	Southern	29	29	7.07	841	0.008

Source: This work is made by the researcher depending on the data of the digital elevation model

Conclusions

1. The spatial morphometric measurements confirmed the existence of a discrepancy in the spatial dimensions (length, width, perimeter, and area). It appeared from top to bottom in order. The total basin area reached (329.49 km2), the (Southern) valley basin (81,209 km2), the Wadi (Al-Nashak) basin (94.72 km2), the Wadi (Kattan) basin (78.39 km2), and the (eastern) Wadi basin (96.6 km2).
2. The hypometric integration of the total Salmana basin was (0.51), while the secondary basins were hypometrically integrated with relatively different values. The hypometric integration of the (AlNashak) basin reached (0.05 m/km), and the (Eastern) basin reached (0.24 m/km), (Kattan) basin to (0.02 m/km), and in the (Southern) basin to (0.008 m/km).

Recommendations

1. The Ministry of Transport and Meteorology and the Ministry of Water Resources shall work on meteorological monitoring of climatic characteristics, follow up their development and locations, and forecast, identify and evaluate the amounts of rain falling within the river basin.
2. An integrated geo-climatic station and hydrological stations for each of the studied basins shall be established to determine the amount of rain, the degree of its abundance and its locations, and to assess the amount of flow of running water.

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