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A Study of Morphometric Hazards of The Sibneh Basin in Duhok Province

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Abstract

Morphometric quantitative studies are one of the most important trends in the study of spatially different water basins according to climatic and geological conditions in addition to the time factor, and by relying on remote sensing techniques and geographic information systems with statistical methods, the results of morphometric variables, their relationships and their hydrological, climatic and geomorphological indications can be drawn.

Problem of the Study

What are the characteristics of the distinct study area basins?

What is the extent of the relationships and interrelationship of morphometric coefficients for aquariums?

Does the aquarium contain risks and what is the level of risk?

Hypothesis

The natural characteristics have an impact on the emergence and development of the basins, such as the tectonic factor and the climatic factor in the Sabnah Basin, as well as the natural vegetation and soil.

Geomorphological processes have a significant impact on the formation of landforms in the Sabnah Basin. A model of geomorphological risks of various types and degrees can be modeled and their occurrence can be predicted based on the study data base.

Limits of the Study Area

Wadi Sibneh Basin is located in Iraq in the northern part of it within Duhok Governorate in the eastern part of it, in the district of Amadiyah in the district of Burwari Bala and the district of Sir Sinak.

Astronomically, the longitudes 19' 55' 43° and 16' 39' 43° E are located.

and its latitudes 04' 58° 36' and 16' 08' 37° N.

Wadi Sibneh flows into the Great Zab River, with an area of approximately 385 km2, and the northern borders of the basin area bounded by Mount Sir Amadiyah, while the southern borders of the basin area bounded by Mount Kara.

Importance

Lack of detailed geomorphological studies of the area, as well as recognizing the impact of geomorphological factors and processes.

Objectives

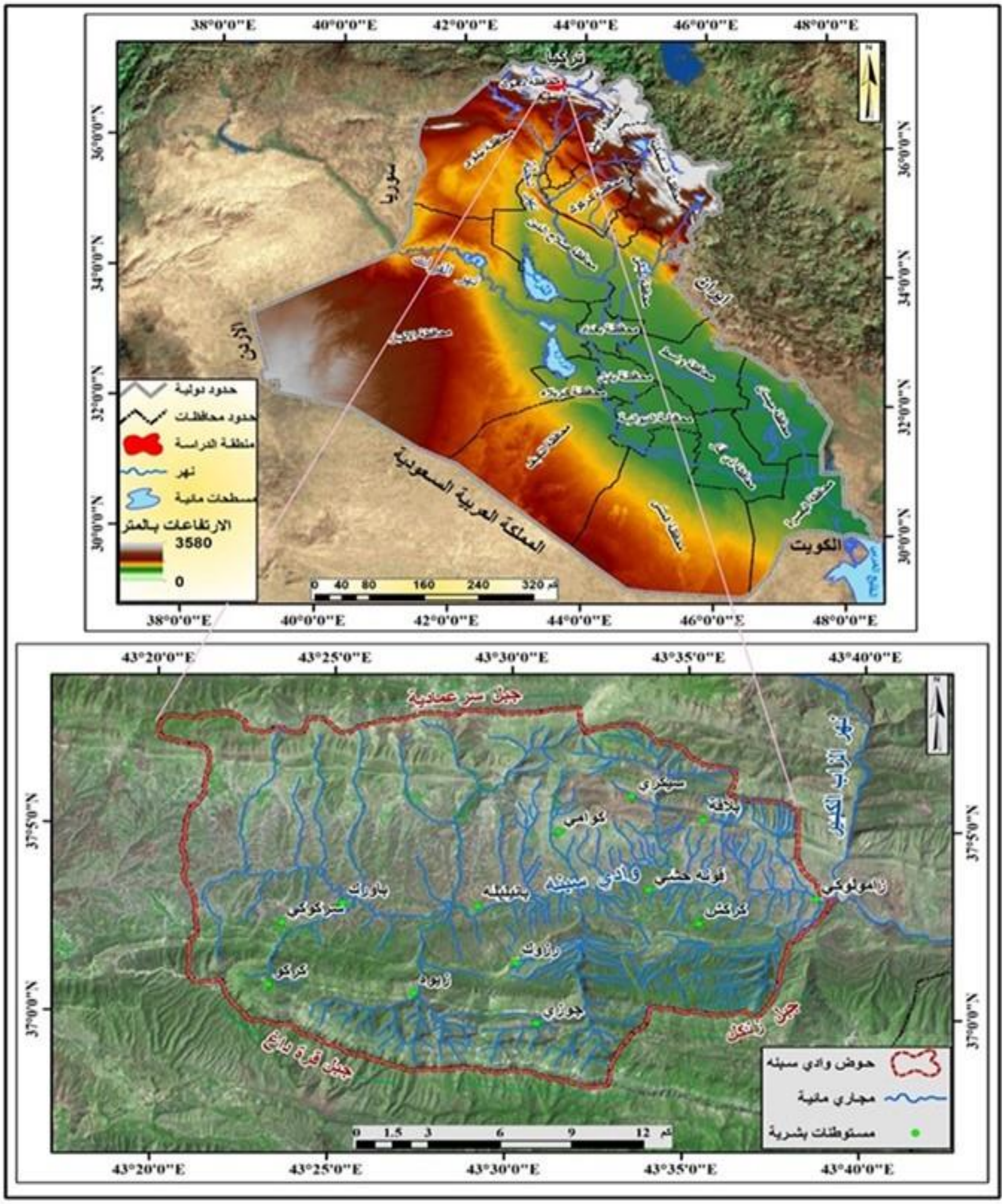
Study and analysis of the natural basin characteristics and their impact on the formation of surface features in the study area

Representation of the basin with a geomorphological map, and analysis of the morphometric characteristics of water networks.

Methodology

The study was characterized by following several approaches, such as regional, historical, descriptive and analytical.

Map (1) Area of the Study



Iraq's administrative map, scale 1:1000000, Map Production Department, General Directorate of Survey, Ministry of Water Resources, Baghdad, Iraq, 2015.

Study of Natural Properties:

First: Geological Features:

The study area dates back to the (second and third time) in its geological formations.

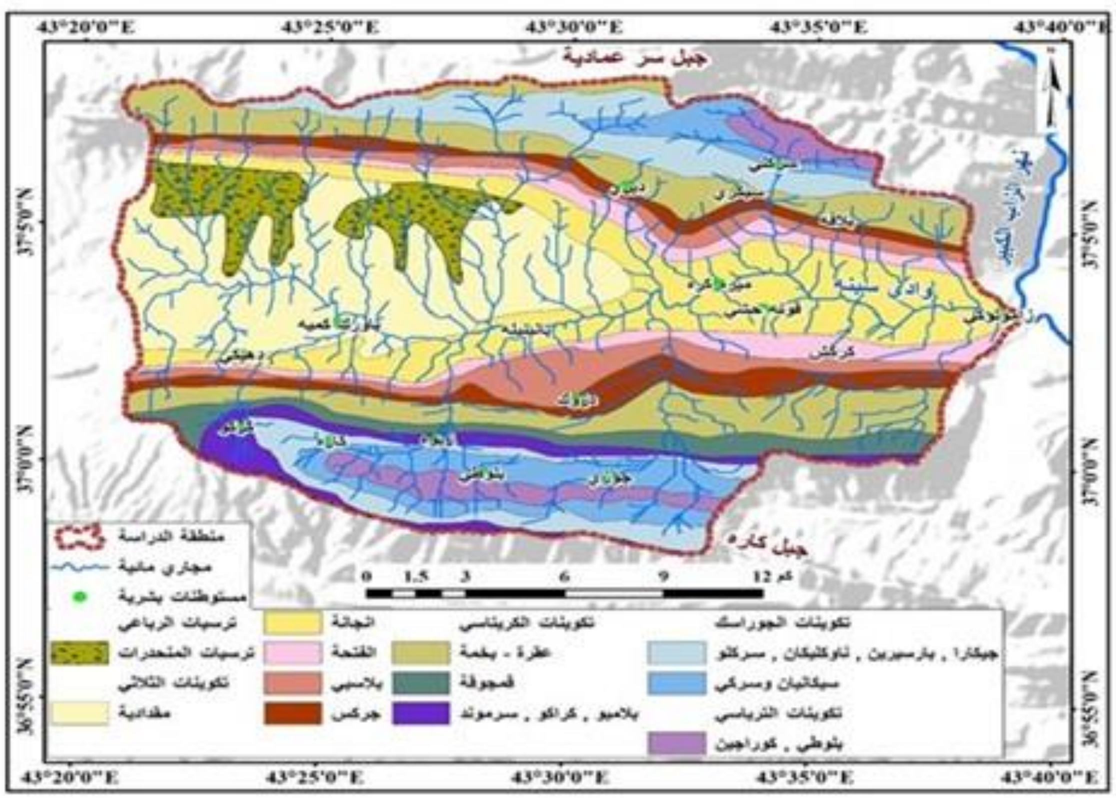
1- Geological Structure:

The land of Iraq represents a transition zone between two types of formations, the first is very old, which some researchers see as part of the continent of Kondwana Land, and the second is relatively recent, dating back to the third time, represented by the Taurus-Zakros mountains in its east and north-east, and it was exposed to two movements that came from the east and explained that It is the presence of some complex formations on some peaks, so it was exposed to the Pliocene movement, which led to the occurrence of torsion and fractures, and the alpine movements also affected the highlands of northern Iraq.

2- Geological Formations:

The most important components of the geological formations in the study area are limestone, pieces of dolomite rock, mudstone, alluvial stone, sandstone, limestone rocks, alternating accumulators of evaporite layers, and sandy clay rocks.

Map (2) Surface Area Distributions of Rock Detectors within the Study Area



Source: Accreditation: Ministry of Industry and Minerals, General Company for Geological Survey and Mineral Investigation, plate (Zakho and Kani Rash), Mahabad plate and Mosul plate, scale 1:250,000.

Table No. (1) Area of Geological Formations and Percentages

Geological Formations	Area/ KM	Percentages
Oak, Coragen	13.39	%3
Aperture	22.64	%6
Jerx	25.47	%7
Sekanyan and Sarki	26.42	%7
Jumbo	14.74	%4
Plasby	26.31	%7
Muqdadiya	66.85	%17
Anjana	59.46	%16
Jikara, Parserin, Nauklikan, Circlo	37.90	%10
Blambo, Krakow, Sarmond	12.75	%3
Aqrah, Bakhma	57.52	%15
Cliff Deposits	19.48	%5
Total	382.93	%100

Source: Based on Map No. (2)

Second: Structural Features:

The study area is within the geologically unstable pavement, where the entire area of the Sabnah Basin is located within the belt (Sulaymaniyah - Zakho), and this can be seen from the map, as it is bounded from the north by a solid convex fold and it has a northwest-southeast direction with a length of (40) km from the south, the convex fold has a northwest-southwest direction, and its length is (56) km.

Third: Climate:

The impact of climate in the study area and its importance is evident through its effect on the processes of erosion and weathering, based on the stations of Amadiyah and Zakho for the period 1987-2017, which represents a climatic cycle, and we will only mention the rates. The average solar radiation for Amadiyah station was (7.7), while for Zakho (7.9), the maximum and minimum temperatures for Amadiyah station were (22.34) (13.66), respectively, and for Zakho station it was (24.4) (13.9), and the wind rates at Amadiyah station reached (2.03) In Zakho station, it reached (1.85) m/sec, and the total annual rainfall was recorded for Amadiyah station (765.4) and for Zakho station (945.9), and the snow annually reached a height of (5) centimeters in Amadiyah and (3.95) in Zakho. It recorded an important impact on the formation of the Basin's appearance and characteristics.

Fourth, Terrain Features:

Terrain Categories:

The 1st Category: its height ranges between (650 m - 1000 m) above sea level, with an area of (143.29 km2). With heights from the north as well as from the south, this category represents sedimentary areas for various erosion activity.

The 2nd Category: It is located within an altitude between (1001 m - 1500 m) above sea level and an area of (167.01 km2). It is spread over two parts in the north and south of the basin, separated by terrain.

The 3rd Category: its height ranges between (1501 - 2000) meters above sea level, and it occupies an area of this category (72.66 km2). It is represented in the upper basin in the far north and south, and it forms the first sources of the water basins, with steep slopes and showing the geomorphological risks at their highest.

Map No. (3) Terrestrial Units

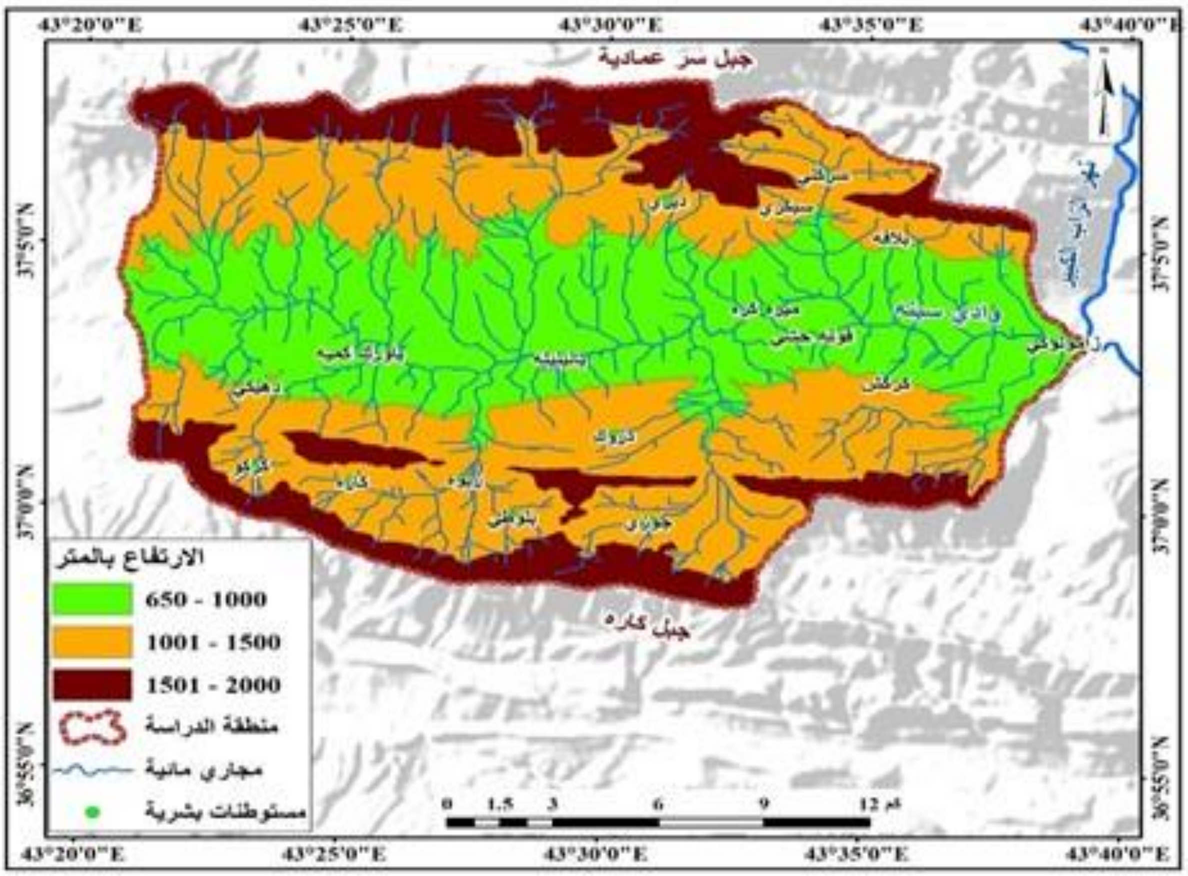


Table No. (2) Areas of Equal Height Categories

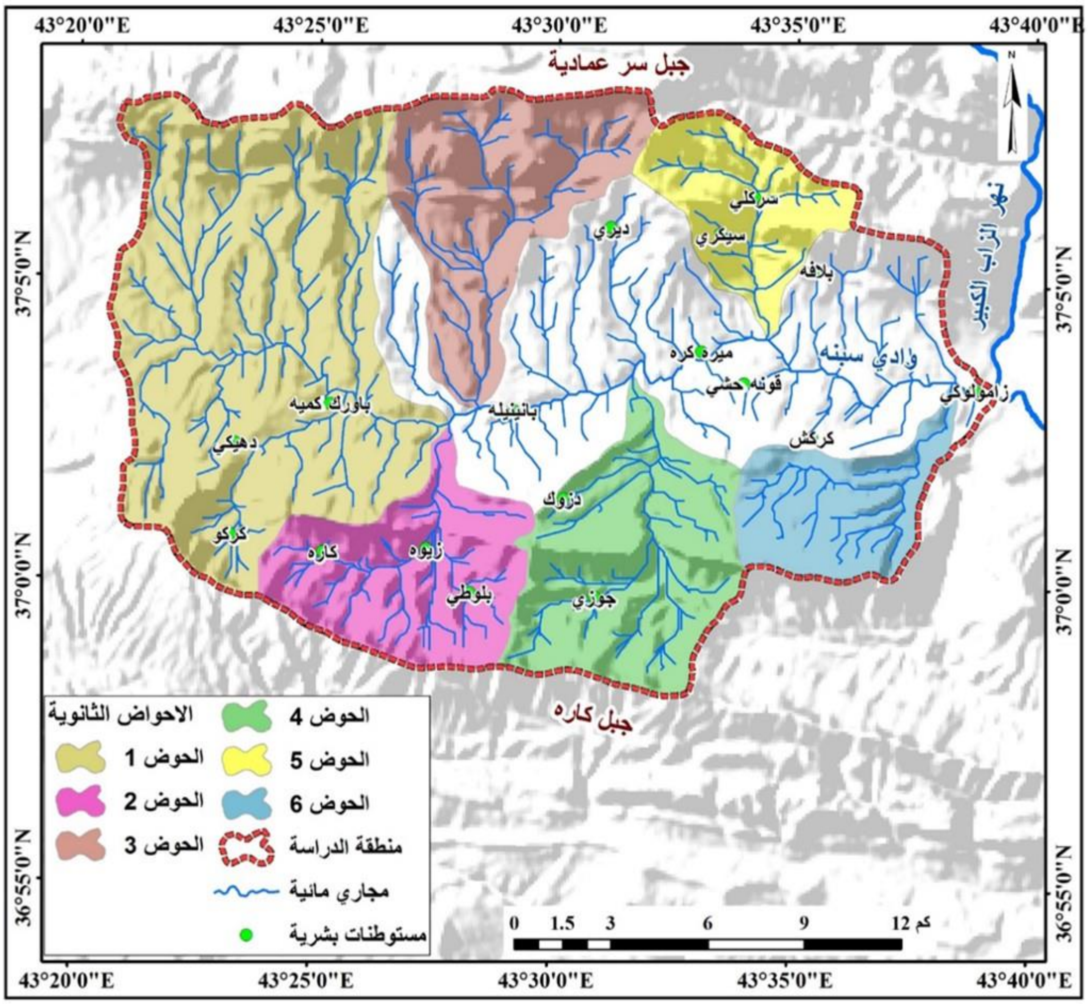
Heights/ Meter	Area/ KM^2
650-1000	143.29
1001-1500	167.01
1501-2000	72.66
Total	382.96

Source: based on map (3)

Morphometric Characteristics:

Morphometric quantitative studies are one of the most important trends in the study of spatially different water basins according to climatic and geological conditions and land movements, in addition to the time factor. By studying it, it is possible to avoid the risks resulting from torrential rains and floods, and even control them and benefit from them. These are some mathematical applications. Sbna Basin consists of several basins (1,2,3,4,5,6). See map No. (3) and we will utilize some morphometric coefficients.

Map (4): The secondary basins of the study area



First, Cadastral Characteristics:

1- The area of the basins

The area of the Sabna Basin is 382.98 km2, which is one of the medium-sized basins. The area of the selected basins within the study area is (279.08) km2, which represents (72.8%) of the area of the total study area. The area of basin No. (1) (109.30) km2 and Basin No. (2) (35.84) km2, Basin No. (3) (42.73) km2, Basin No. (4) (44.87) km2, and Basin No. (5) (23.48) km2 (6) (22.86) km2.

2- **Width**: The study of the width of the basins is important in the morphometric variables, and it is extracted by the following equation:

Average Width = (Basin Area/ km2)/ (Basin Length/ km)

Average Width of Sabnah Basin = 382.98/ 39.43 = 9.71 km

The width of the Sbna Basin valley is (9.71) km, and thus it is considered one of the wadis of medium width and low risk for this coefficient.

3- Basin Length

The measurement of the length of the basins is one of the important basic variables used in the study of the shape and characteristics of the basin. The lengths of the basins vary according to the degree of slope and the severity of the terrain. 39.43 km, while the ideal length is estimated (28.38) km, while the secondary basins may constitute some of them a source of danger due to their short lengths, low drainage time, and little evaporation and leakage.

4- Basin Circumference

The basin circumference represents the line dividing the water between the basin, and the neighboring basins, and this coefficient is used to show the extent of the basin's spread and breadth. It was accompanied by an expansion in geomorphological processes and a multiplicity of risks thanks to the increase in operations.

Second: Formal Characteristics: They have implications related to the geomorphological processes and the ways of forming the basin and the geomorphological development of the landforms.

1- Elongation Ratio: It is extracted by the following equation:

$$\frac{\boldsymbol{Area\ KM2 * 1.1282}}{\boldsymbol{Max\ Basin\ Length\ in\ KM}} = \boldsymbol{Elongation\ Ratio}$$

$$\frac{\boldsymbol{\sqrt{382.98} * 1.1282}}{\boldsymbol{39.43}} = \boldsymbol{Sabnah\ Basin\ Elongation}$$

The elongation of sabnah basin = 0.55

We conclude that the shape of the basin is oblique to a rectangle and thus is less dangerous.

2- Basin Form Factor:

The value of the shape modulus of the basin can be extracted from the following equation.

$$\textbf{Basin Form Factor} = \frac{\textbf{Basin Area (km2)}}{\boldsymbol{Basin\ Length\ Square\ (km)}}$$

$$\frac{\boldsymbol{382.98\ km2}}{\boldsymbol{1554.72\ km}} = \boldsymbol{Sabnah\ Basin\ Form\ Factor}$$

Since the coefficient is smaller than (the correct one), then the basin moves away from the square shape and approaches the triangle or oval shape, and its danger increases because the triangle's apex is at the mouth and the base at the sources.

3- Rotation Coefficient:

$$\frac{Basin\ Area\ km2 * 12.57}{(Basin\ Circumference\ km)} = (Area\ Cohesion\ Ratio)\ Basin\ Rotation$$

$$\frac{382.98\ km2 * 12.57}{83.66\ km2} = Sabnah\ Basin\ Rotation\ Coefficient$$

Sabnah Basin Rotation Coefficient = 0.68

Knowing the rate of rotation of the basins is useful for knowing the extent to which the basin is close to or away from the regular circular shape, where the ratios lie between (0 and 1) and the closer the result is to the correct one, it indicates that the basin is close to the circular shape) and the values of the basin rotation ratio are extracted according to the following equation:

This indicates that the Sibnah Basin is close to circular or oval shape, i.e., average roundness, and tectonic factors such as the presence of folds contributed to determining its shape as well, and that its danger is high.

4- Integration Coefficient:

The coefficient of integration refers to the extent to which the shape of the basin is regular, and the dimensions of the basin are homogeneous with its area, and the detection of the underlying phase of the basin. The coefficient is obtained according to the following equation by Dr. Saad Al-Daraji:

$$\frac{Basin\ Perimeters\ in\ km}{\sqrt{Basin\ Area\ in\ km2}} * D = Integration\ Coefficient$$

$$\frac{83.66\ km}{\sqrt{382.98\ km2}} 0.282 = Integration\ Coefficient\ of\ Sabnah\ Basin$$

Integration Coefficient of Sabnah Basin = 1.20

We conclude on the consistency of the perimeter of the basin and its consistency with its area and its progress in the stages of its upstream cycle.

Third, topographical characteristics, which are important in knowing the role and activity of erosion processes and the role of influencing factors such as geological structure and tectonic movements.

1- Relief Ratio: The relief ratio is one of the important and simple measures in knowing the number of transported sediments. The coefficient is extracted from the following equation:

$$\textbf{Terrain degree} = \frac{\textbf{Basin Relief}\ (\mathbf{M})(\boldsymbol{The\ Vertical\ difference\ between\ the\ highest\ and\ the\ lowest\ ratio\ within\ the\ basin})}{\boldsymbol{Basin\ Length\ in\ KM}}$$

The degree of topography of the Sabnah Basin reached 34.23 m/km, thus the transported sediments are few and the risk is weak, while the danger of some secondary basins increases to reach the topography degree to (120) m/km due to the different rock formations.

2- Basin Tissue:

This coefficient is an important criterion for knowing the extent of the terrain and the extent of its intersection, and as an indication of the extent of drainage density in them, and the closer the valleys are to each other and the lines of the drainage network crowded out the numbers of valleys without taking into account their lengths, indicates the severity of their interruption and the extent of the erosion rates in them. According to what was stated in (Strahlar, 1952), the basin tissue is extracted using the following equation:

$$\textbf{Basin Structure}\ \frac{\boldsymbol{Basin\ Valleys\ Number}}{\textbf{Basin Diameter KM}} = \textbf{200 m}$$

Sibnah Basin Structure = 1710km/ 83.66km = 20.43

According to the value of the coefficient, we conclude that the rocks are impermeable to water, the intensity of rain precipitation and the low density of vegetation cover in the basin.

3- Relative Relief:

It indicates the extent of the relationship between the circumference of the basin and the degree of resistance of rocks to erosion processes, and it is measured by the following equation:

Relative Relief = Basin Relief m/ Basin Diameter m = 200 m

The value of the coefficient result is weak and indicates the strong resistance of rocks to erosion processes.

Fourth, the characteristics of the drainage network of water basins: (Network Drainage)

The study of the drainage network is important in analyzing the effects on water resources and understanding geomorphological processes, which are a reflection of climate factors, topography, rock composition, soil and vegetation cover.

1- Longitudinal drainage density: It indicates the extent to which the basin surface is exposed to cutting and erosion processes and reflects the influence of various factors on it. It is calculated by the following equation:

Longitudinal drainage density = The sum of the lengths of the waterways in the basin in KM/ Basin Area/KM^2

Longitudinal drainage density of Sibnah Basin = 1710/382.92 = 4.46

2- Coefficient of Inflection:

It is the ratio between the ideal length of the riverbed and the real length, and the real length is always greater than the ideal length, and what is meant by the real length (is the distance that the river travels from the source to the estuary). On the maps, and the deflection coefficient is extracted from the following equation.

Deflection coefficient = true length of the river / ideal length of the river

Sibnah Basin Coefficient of Inflection = 39.43/28.38 = 1.38

The value indicates that the pelvis is not straight and is punctuated by bends and torsion, especially in areas with a slight slope. It leads to the absorption of the momentum of the water flow and the increase in the carrying capacity of the stream, and the water losses increase by evaporation, so the risks are weak.

3- Stream Flow Rate

It is a coefficient that expresses the area needed to supply water to the wadi network in the river basin, and the increase in the value of the coefficient indicates the capacity of the basin area at the expense of the lengths of the sewers.

Stream Flow Rate = Basin Area in KM^2/ The sum of the lengths of drainage networks in the basin

Stream Flow Rate = 382.97 km^2 / 1710 km = 0.22

Table No. (3) The value of morphometric coefficients for the main basin and secondary basins

Variable	Sibnah main basin	Basin No. 1	Basin No. 2	Basin No. 3	Basin No. 4	Basin No. 5	Basin No. 6	
Area/KM2	382.97	109.30	35.84	42.73	44.87	23.48	22.86	areal properties
Length/KM	39.43	18.03	10.09	12.79	10.96	8.89	11.19	
Width/KM	9.71	6.06	3.55	3.34	4.09	2.64	2.04	
Basin Diameter/KM	83.66	49.20	27.67	31.43	29.69	21.90	22.66	
elongation coefficient	0.55	0.65	0.66	0.57	0.67	0.61	0.48	formal characteristics
Basin shape parameter	0.24	0.33	0.35	0.26	0.37	0.29	0.18	
rotation coefficient	0.68	0.61	0.58	0.54	0.63	0.61	0.55	
buckling factor	1.01	0.74	0.71	0.96	0.66	0.84	1.36	
Length to width ratio	4.06	2.27	2.84	3.82	2.67	3.36	5.48	
Integration coefficient	1.20	1،32	1.30	1.35	1.25	1.27	1.31	
Terrain degree m/km	34.23	60	110	90	110	120	190	terrain features
Basin tissue sleeve	20.43	13.35	4.51	8.59	8.82	7.12	6.12	

Relative terrain%	2.39	1.21	3.97	2.86	3.70	5.47	8.38	
longitudinal discharge density	4.46	2.91	2.96	2.70	2.96	2.91	3	Drainage network characteristics
inflection coefficient	1.38	1.29	1.27	1.16	1.11	1.22	1.32	
Stream survival rate	0.22	0.34	0.33	0.36	0.33	0.34	0.33	
topographic tissue rate	20.43	13.35	8.13	8.59	8.82	7.12	6.17	
Numerical Discharge Density	4.46	6.01	6.27	6.31	5.83	6.64	6.12	
Total lengths of sewers	1122.85	318.67	106.46	115.76	132.3	68.49	68.74	
Hypsometric parameter	23.69	24.7	27.1	22.9	35.8	27.7	37.6	

Source: From the researcher's work based on mathematical equations

The risk assessment process is carried out by granting each parameter of the morphometric transactions a degree or value, according to what we see as its relation to the geomorphological risks that result from the morphometric value, and that these degrees consist of three levels (first level) with low risk, taking one degree (second level) average. The risk has two degrees (and the third and last level) is of high risk and takes three degrees. Then each morphometric coefficient takes its value from the degrees according to the total and is divided into three categories or levels. The study area, for example, was relied on (20) morphometric coefficients, which are related to geomorphological risks and accordingly be the sum of these points for the morphometric coefficients is (60) degrees and is divided into three categories, each category takes (20) see Table No. (38).

Table No. (4) Classification of the hazard values associated with morphometric characteristics

Number of variables	Severity levels	Severity	Variables X	Effect Y	Severity rating X, y	Risk
20 متغير	(3-2-1)	20	20-0	1	Low risk	Potential Risk
		40	40-21	2	Medium risk	May happen
		60	60-41	3	High risk	High Risk

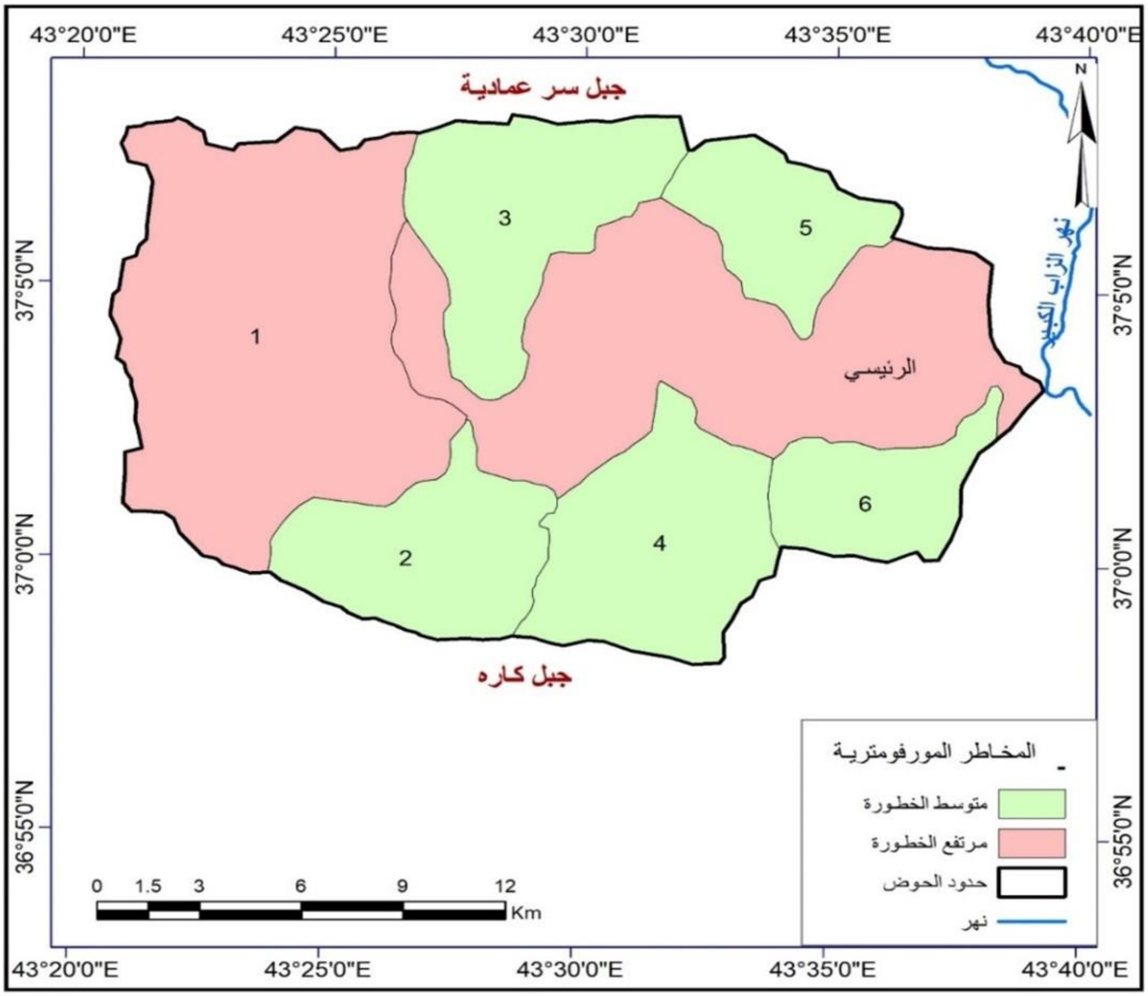
Source: From the researcher's work by accrediting the morphometric parameters included in the assessment (20) parameters

Table No. (5) Dangers of Basins

ت	dock characteristics	Sibnah main basin	Basin No. 1	Basin No. 2	Basin No. 3	Basin No. 4	Basin No. 5	Basin No. 6
1	Basin space	3	3	2	2	2	1	1
2	Basin length	1	1	3	2	3	3	2
3	Basin width	3	3	2	2	2	1	1
4	Basin circumference	3	2	1	2	1	1	1
5	elongation ratio	3	2	2	3	2	2	3
6	Basin shape parameter	3	2	2	3	2	3	3
7	buckling factor	1	2	2	2	3	2	1
8	Length to width ratio	1	1	1	2	1	2	3
9	terrain degree	1	2	3	2	3	3	2
10	Relative terrain	2	1	2	1	2	2	3
11	Basin tissue	1	3	2	2	2	2	2
12	lipisometric lab	1	1	1	1	1	1	1
13	Total number of sewers	3	2	1	1	1	1	1
14	bifurcation ratio	3	3	3	3	3	3	2
15	Density of longitudinal drainage	1	1	1	1	1	1	1
16	scalar exchange density	3	3	3	3	3	3	3
17	inflection coefficient	2	2	2	2	2	2	2
18	Stream survival rate	3	3	3	3	3	3	3
19	Basin tissue rate	3	2	2	2	2	1	1
20	sewer lengths	3	2	1	1	1	1	1
	Total	44	41	39	40	40	38	37

Source: From the researcher's work based on mathematical equations

Map No. (4) Morphometric Hazards of Sibnah Basin



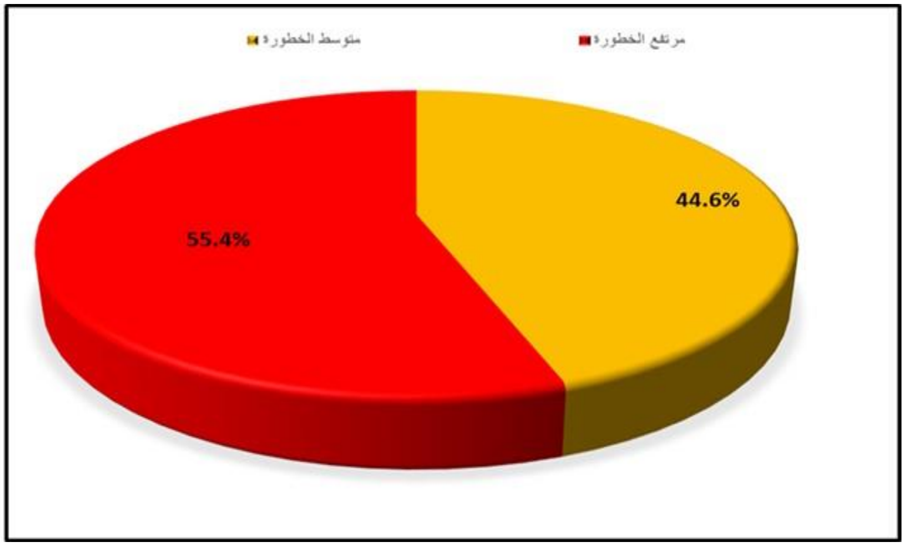
Source: From the researcher's work based on Arc Map Software Version 10.8

Table (6) Categories of Morphometric Hazards

Category	Area/KM2	%
Medium Risk	171	44.6
High Risk	212	55.4
Total	383	100.0

Source: From the researcher's work based on map No. (4)

Figure (1) Ratio of Morphometric Risks within Sibnah Basin



Conclusions

1- The highest elevation in the Sabnah Basin is (2100) m above sea level, and the lowest is (650) m

2- The impact of the basin hydrologically and morphometrically by heavy precipitation

3- Reaching the values of morphometric transactions and building a comprehensive database for the basin

4- The basin includes a high level of danger, and therefore dams must be built to harvest water

5- The study found two levels of risk (medium and high risk).

6- The study revealed that the natural characteristics of the basin have an impact on the risks

Recommendations:

1− We recommend the concerned authorities to take advantage of the study and make it a database for forecasting risks

2− Construction of dams along the length of the basin in order to reduce the velocity of water and the amount of flow.

3− Keeping urban construction away from high-risk areas.

4− Educating the population about the dangers to preserve their lives and property

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