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RESEARCH PAPER

MORPHOMETRIC ANALYSIS USING GEO-INFORMATION TECHNIQUES FOR BASTORA BASIN NORTH EAST OF ERBILCITY IRAQI KURDISTAN REGION

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A B S T R A C T:
The current study aims to conduct a detailed morphometric investigation of the Bastora basin in the northeastern section of Erbil, Iraq. The present research attempts to study detail morphometric analysis of Bastora basin in the northeastern To meet the goals of this study, the areas of the basins are 236.4 Km2. Geo-information (Remote sensing and GIS) techniques were utilized to determine and analyze morphometric characteristics in terms of linear, aerial, and relief aspects. Several tools in the ArcGIS 10.8 program were used to prepare and produce maps, analyze and evaluate various parameter features, and enforce specification hydrology tool. An area was covered by a six-order drainage sub-basin with a total of (587) streams and (418.24 km) of stream length. Just the mean bifurcation ratio (3.62). The sixth order sinuosity index value is (1.4). The results were (1.77 km-1 for drainage density and 6.00 for drainage texture. The circulation ratio is and the elongation ratio is (0.31). The extended morphology, low runoff discharge, and high subsurface permeability of the basin imply these characteristics. The river can be thought of as the average stage of balance between erosion and sediment deposition. The hydro-morphometric analysis is a very helpful guide for choosing the location and type of dam.

KEY WORDS: Hydro-morphometry analysis, Basin, Stream, Study area, channel, Ratio, Calculate
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1. INTRODUCTION:

The mean hydro-morphometry can describe as an arithmetically calculated analysis for drainage stream water basins and valleys with the use of main roads and mathematical methods in water basins, definitions, and measures to learn generic possessions for their basins, canals, and vales, with the naturally geomorphology for denudation and deposition sediment with rocks kind, because these properties play an important role in the conclusion, amount, and the relationship between basin shapes estate with basin hydrology. The drainage water systems had an impact on the volume, shape, and development of the basin under investigation.

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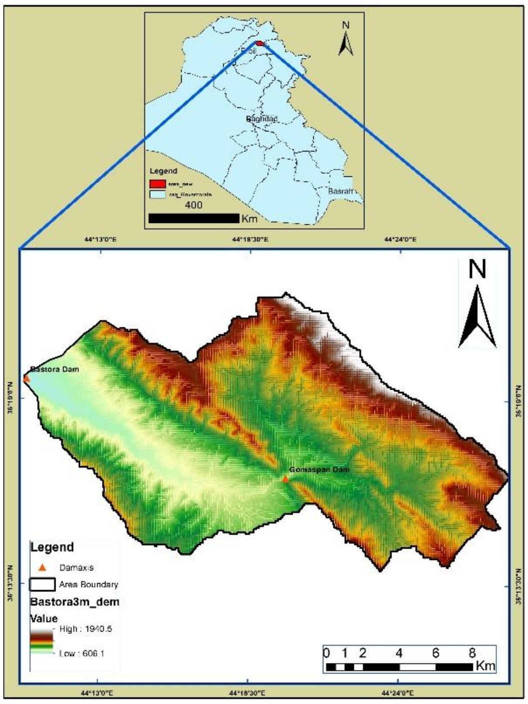
Confirm relationships between runoff characteristics and the geographic and geomorphic properties of drainage basin system have been observed by hydrologists and geomorphologists. Physiographic properties of drainage basins include size, form, and the gradient of drainage site, drainage densities, size, and lengths of contributories. It may be linked to a variety of key hydrologic Phenomena **(Sreedevi et. al, 2009, pp.543-552).** the essential parameter relationships for determining basin morphology, such as elongation, circumference ratio, drainage densities, and drainage textures with form; the essential parameter relationships for determining linear basins, such as river order (quantity, duration), basin duration, and sinuosity indicators; and the major parameter relationships for determining relief basins, such as comfort proportion, relative-relief, and ruggedness number. The morphometric analysis will allow basins to be managed and defined in relation to the physical features of watershed, and it is used in a variety of studies, including environmental studies, soil denudation, water harvesting, and the effect of geology reasons on the causing numerous different river systems, and ground cover ground use planning (Aravinda and Balakrishna, 2013, pp.514-522; Arabameri et al., 2018, pp.1-22 in Fatah et. al, 2020, pp.88-104). According to described **(Charlton 2007)** different trends may be detected and linked to other geographical characteristics within a network and the character of lithology is reflected in the drainage pattern, with dendritic representing weakly rock and parallel representing strong rock. Topography, kind of soil, bedrock type, climatic condition, and plant cover all impact sediment and water intake, outflow, and conveyance in a drainage the basin. In the river, networks generalize, including drainage patterns as a geographical element that aids in the preservation of geographical aspects of the systems **(Zhanga and Guilbert 2013, pp.2319-2342)**. According to the description **(Schumm et al. 2000, vol.276 and Ritter 2006)** where there is a significant gradient to the surface, parallel patterns develop. Following the surface gradient, tributary rivers usually extend out in parallel-like patterns. Dendritic patterns, often known as tree-like patterns, are most common in areas with little geological control **(Charlton 2007).** The dendritic patterns may be seen in horizontal sedimentary or uniformly resistant crystalline pebbles with a mild local gradient. The major Geometric Distinguishing is the sharp angle of tributaries merging **(Zhanga and Guilbert 2013, pp.2319-2342).**

2. Study Area

The total basin study area selected from Bastora basin is 236.4 square kilometer as determined by Global Mapper v 20.0 which is located 20 km north east of Erbil city. The study area is situated between latitudes ($36^{o}19^{'}36$” to $36^{o}15$’17” N) and longitudes ($44^{o}10$’19” to $44^{o}27$’33” E) as show in (Fig. 1). The area is bordered on the north by Pirmam Mountain, on the east by Safin Mountain, and on the west by the Greater Zab River. The Safin Mountain, where the study area's highest



point is situated, has a height of 1940 meters above mean sea level, while the lowest point is 606 meters. The dam is situated close to the major road connecting Erbil's Shaqlawa district and the starting point study area.

Figure 1: Watershed Study Area Located on the DEM Map

3. Hydro Morphometry Analysis for Bastora Basin

3.1 Linear Morphometry Parameters

The mensuration of linear characteristics of a drainage basin and its river canal (water bath) is required for a systematic characterization of the drainage basin's geometry and its flow channel **(Nanda et.al, 2014, pp.7).** Using (DEM 3m) mapping for border Bastora basin area designing linear morphometry (Fig.2) with different ways for linear morphometric computing and arithmetically equation for each value kind linear morphometry analysis in (Table 1) and detailed each one below:

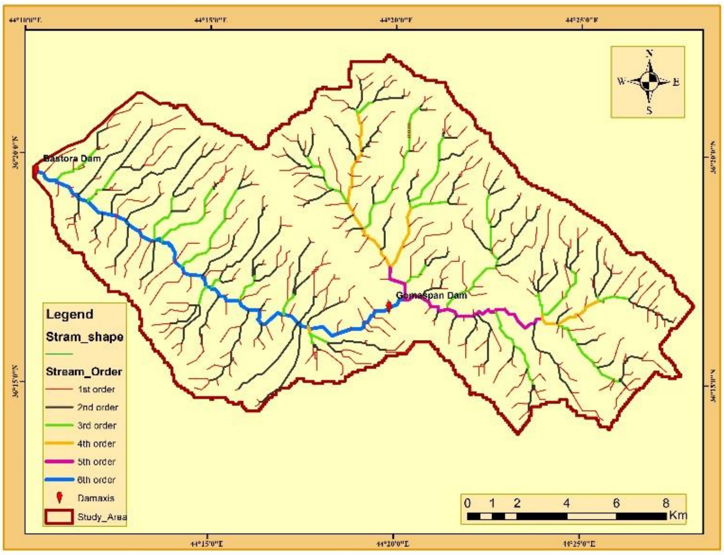


Figure 2: Linear Morphometry map for Bastora Basin

Table1: Main Equation Using to Determine Linear Morphometry Parameters

Morphometric Parameter	Formula	Reference
Stream order (Su)	Using by GIS 10.8 compute program.	Strahler (1964)
Stream number (Nu)	Number of streams in each order.	Horton (1945)
Bifurcation ratio (Rb)	Rb= Nu/Nu+1 Rb= Bifurcation ratio Nu= Number of stream segments order Nu+1= Number of segments of the next higher order	Schumm (1956)
Mean Bifurcation ratio(Rb⁻)	Rb⁻ = ∑Rb/total number of order Rb⁻ = Average of Bifurcation ratio of all order	Strahler (1957)
Stream length (Lu)	Length of the stream(kilometers)	Horton (1945)
Mean Stream length (Lu⁻)	Lu⁻ = Lu / Nu Lu= total stream length of order Nu= total stream number of order	Strahler (1964)
Stream length ratio (Rl)	Rl= Lu/Lu-1 Rl= Stream length ratio Lu= Total stream length order Lu-1= Total stream length of its next lower order	Horton (1945)
Basin length (Lb)	$Lb=1.312\times A^{0.568}$ Lb= Basin length A= Basin area	Gregory and Walling (1973)
Sinuosity index (SI)	SI=AL/EL SI= Sinuosity index AL= Actual length of main stream EL= Expected straight path of the stream	Schumm (1956)

3.1.1 Stream order (Su)

Stream order it involves assigning a hierarchical ranking to existent streams of various ranges and patterns **(Nanda et.al, 2014, pp.7).** The classification of streams in the current study basin was done using the approach suggested by (Strahler and Chow, 1964, pp.39-76). The basin study area produced a six orders drainage sub-basin shown in (Table 2), covering an area of 236.4 km2.

3.1.2 Stream number (Nu):

The whole number of streams in the study basin area shown in (Table 2) is 587, with the first number order of (458) the second order of (96), the third order of (25), the fourth-order of (5), and the fifth and sixth orders of (2) and (1), respectively. In the Bastora river basin, Horton's (1932) law visually depicts the relationship between stream number (Nu) and stream order. Figure 3 depicts a diminishing stream number as stream order increases. This implies that the first order began in the stream segment and subsequently decreased to a single segment high order through the sixth.

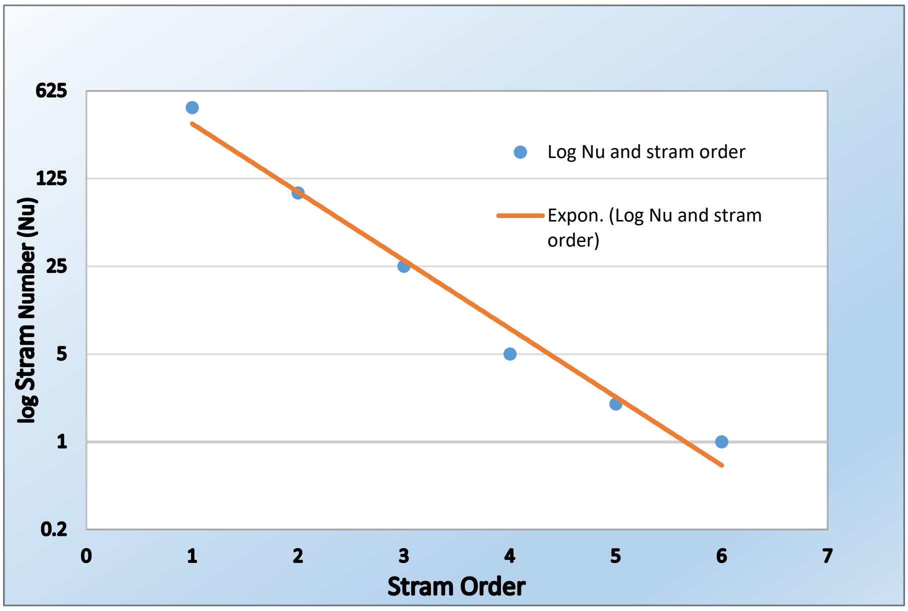


Figure 3: Relationship between stream number on the logarithmic scale and stream order on the normal scale

3.1.3 Bifurcation ratio (Rb)

The bifurcation ratio (It is the proportion of all stream segments in a drainage basin from one stream order to the next higher order.), as defined by (Schumm, 1956, pp.597- 646), is connected to the divaricate pattern of a drainage network. The bifurcation ratio normally ranges from the theoretical minimum of 3 to 5; however, in the study basin area, the overall mean of the bifurcation ratio vary from (2 to 4.77) in (Table 2), indicating that the geologic formations do not affect the drainage pattern (Strahler and Chow, 1964, pp.39-76).

3.1.4 Mean Bifurcation ratio (Rb-)

The mean bifurcation ratio in the study basin area is equivalent to the sum of bifurcation ratios of all orders (Table 2), just (3.62). This area's geological variability, increased permeability, and structural control are shown by the lower mean bifurcation ratio.

3.1.5 Stream length (Lu):

Stream length is one of the most important factors in determining flow and basin characteristics in a drainage basin. It's a measure of how stream segments have changed over time. Shorter streams are more common in mountainous locations with steeper slopes, while longer streams are more common in flat areas with gentler slopes (Nanda et.al, 2014, pp.7). Using Geographical Information System (GIS) technology, the number of streams of different kinds in the basin is recorded, and their lengths are measured. The aggregate length of the streams in the studied area is (418.24 km) (Table 2). In the Bastora river basin, Horton's law depicts the link between stream length (Lu) and stream order visually. Figure 4 shows that stream length decreases as stream order increases, with the exception of the 6th high segment order, which has a more significant stream than the lower segment order.

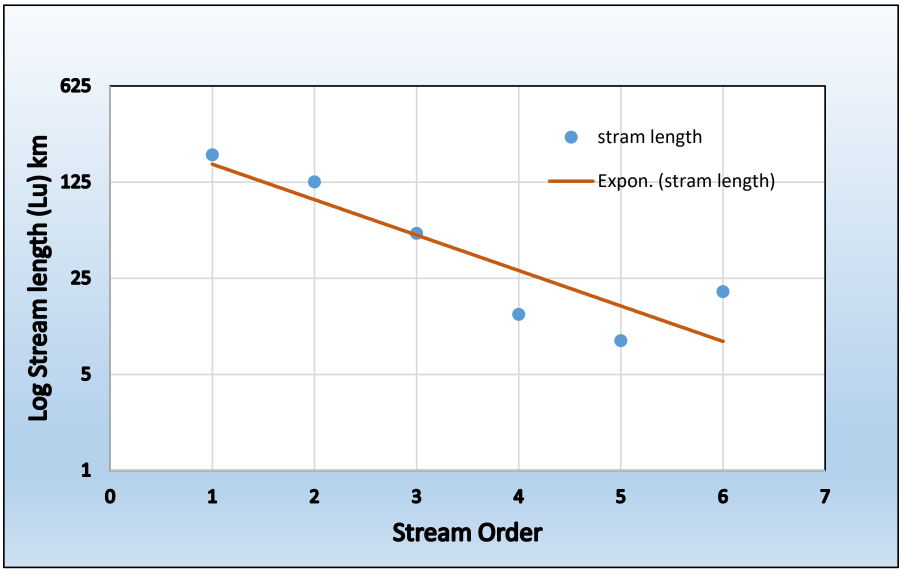


Figure 4: Relationship between stream length on the logarithmic scale and stream order on the normal scale.

3.1.6 Mean Stream length (Lu¯):

It is the mean stream length of a particular order in the Bastora drainage basin studied area is greater than the lower order and lower than the next higher order (Nanda et.al, 2014). In the case of median stream length, the lowest value is first order and the highest value is sixth order, with values of (0.43) and (20.02) respectively as shown in (Table 2). Stream length is a distinguishing attribute of drainage network components and associated basins, according to (Strahler and Chow, 1964, pp.39-76).

3.1.7 Stream length ratio (Rl):

According to (Horton, 1945, pp.275-370) the rule of stream length asserts that mean stream length segment of each of the consecutive order of a basin tend to resemble a direct geometric sequence with stream length rising as the order of streams increases. The variation in stream length ratio value from the first to the final order shown in (Table 2) is related to differences in gradient area and topography in the study area. The length ratio is increasing from lower to higher order, suggesting a matured geomorphic stages stream (Vittala et. al, 2004, pp.351-362).

3.1.8 Basin length (Lb):

The Basin length refers to the geometric mensuration of the shape and size of the drainage watersheds. It is the watershed's greatest length inside the largest circle surrounding the basin's border, which is parallel to the major river length (Rawat et al., 2017, pp.5 in Fatah et. al, 2020, pp.88-104). In the study area, the maximum basin length is equal to (29.25) km, as determined by the calculating method in (Table 2).

3.1.9 Sinuosity index (SI):

(Schumm, 1956, pp.597- 646) is the first to describe the Sinuosity index as a criterion for determining how much a river deviates from its predicted straight route. The meander proportion, also known as the sinuosity index, is the proportion of a river's real length to the linear space between its endpoints. Sinuous rivers have a 1 to 1.5, the meandering rivers differ from the typical pattern because the down-valley route is not perfectly straight. The sinuosity index, on the other hand, may be defined as the deviations from a track defined by the greatest downslope route. (Kalantar et al., 2020), whereas meandering rivers have a ratio of 1.5 to 4 (Adhikari, 2020, pp.127-144). The Sinuosity index value of the sixth order (major stream) in the study area is 1.4. The stream course is sinuous, falling somewhere between the straight line and meandering typology of the basin, as shown in (Fig.5) and (Table 2), with a length of (20) km divided by the straight-line length between the start and end points of (14) km.

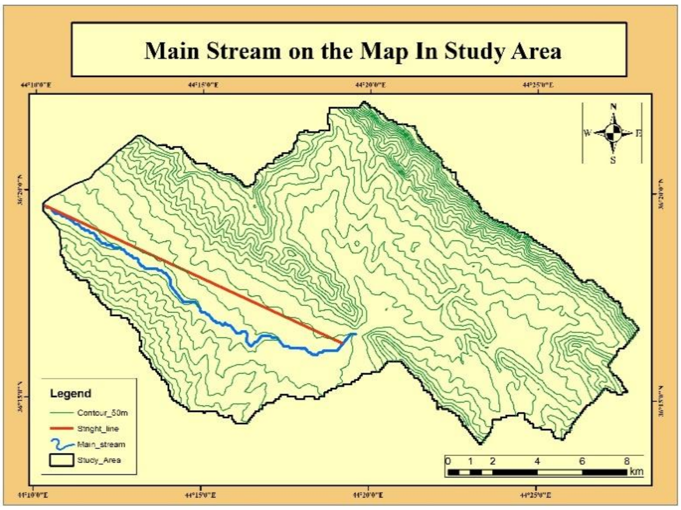


Figure 5: Sinuosity index map for Bastora Rivers that indicate sinuous river.

Table 2: Summary to produce Linear Morphometry Data Parameters for Bastora Basin

Stream Order (u)	Stream Number (Nu)	Stream Length (Lu)(km)	Mean Stream Length (Lu^-)	Stream Length ratio (RI) (km)	Cumulative Mean Stream Length (Km)	Maximum Basin length (Lb) (Km)	Sinuosity index (SI)	Bifurcation Ratio (Rb)	Mean Bifurcation Ratio (Rb^-)
1st	458	197.25	0.43	0.64	0.43	29.25	1.4	4.77	3.62
2nd	96	125.63	1.31	0.42	1.74			3.84	
3rd	25	52.92	2.12	0.26	3.86			5	
4th	5	13.63	2.73	0.64	6.59			2.5	
5th	2	8.79	4.40	2.28	10.99			2	
6th	1	20.02	20.02	…….	31.01			……..	
Total	**587**	**418.24**						**18.11**	

3.2 Areal Morphometry Parameters

In quantitative morphology, the region of a basin (A) and its perimeter (P) are essential characteristics. The basin's size is described as the whole area placed on a horizontal plane that contributes to the sum of all basin orders. The perimeter is the basin border length constructed using GIS software in (Fig.6) to Determine (Area, texture, frequency, and density) of each stream in the examined basin. The size of the storm hydrograph and the amounts and time of occurrence of peak and mean runoff are immediately affected by the size of the basin. The time of concentration is defined as the time from the hydraulically furthermost point to watershed outlet. It is one of the most important parameters to be able to predict the response of a watershed to a given rain event and plays a key role in rainfall-runoff simulation (Salimi et al., 2017 pp.123-132.). And time of occurance of the peak hydrograph the arrival of stream flow from up-watershed, occurring with rainfall at the mouth, causes a hydrograph to rapidly rise to peak value. With the storm passing off the watershed rapidly, the hydroraph recedes fairly rapidly (Singh, 1997pp.1649-1669). It's intriguing that the size of an area has the Opposite effect on the greatest flood discharge per unit location **(Chorley et al., 1957, pp.138-141 in Nanda et.al, 2014, pp.7).** To determine basin morphology for the Bastora basin, a digital elevation model (DEM) in 3 meters was utilized, along with numerous GIS tools. The results are reported in the table below (Table 3).

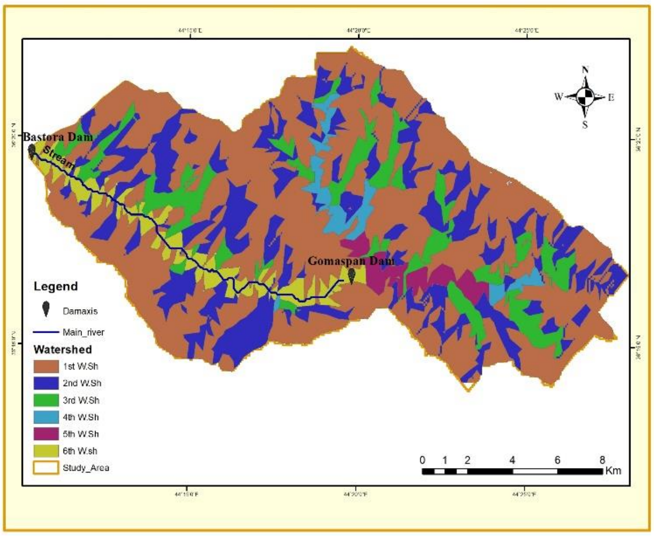


Figure 6: Areal Watersheds for Bastora Basin

Table 3: Main Equation Using to Determine Areal Morphometry Parameters

Morphometric Parameter	Formula	Reference
Basin Area (A)	A=Area from which water drains to a common stream and boundary determined by (GIS) program.	Strahler (1969)
Basin Perimeter (P)	P=Outer boundary of drainage basin determined by (GIS) program.	Schumm (1956)
Basin Width(Wb)	Wb=A/Lb Wb= Basin Width A= Area of the Basin Lb= Maximum length of the basin	Ibrahim (2019)
Stream Frequency (Sf)	Sf=∑Nu/A Sf=Stream Frequency ∑Nu=Sum all stream number of the basin A= Area of the Basin	Horton (1945)
Drainage Density (Dd)	Dd=∑Lu/A Dd=Drainage Density ∑Lu=Sum length all stream order of the basin A= Area of the Basin	Horton (1945)
Drainage Texture (Dt)	Dt=∑Nu/P Dt= Drainage Texture ∑Nu= Sum all stream number of the basin P= Perimeter of the basin	Horton (1945)
Elongation Ratio (Re)	Re=1.128√A/Lb Re= Elongation Ratio A= Area of the Basin Lb=Maximum length of the basin	Schumm (1956)
Circularity Ratio (Rc)	$Rc=4\pi A/P^2$ Rc= Circularity Ratio A= Area of the Basin P= Perimeter of the basin	Miller (1953)
Form Factor (Ff)	$Ff=A/Lb^2$ Ff= Form Factor A= Area of the Basin Lb^2= Maximum length of the basin	Horton (1945)
Constant of Channel Maintenance (C)	C=1/Dd C= Constant of Channel Maintenance Dd= Drainage Density	Schumm (1956)
Length of Overland Flow (Lg)	Lg=1/2Dd Lg= Length of Overland Flow Dd= Drainage Density	Horton (1945)

3.2.1 Basin Area (A)

A drainage area is a collection place from which water is channeled to a stream. The ridge dividing water flowing in opposing directions defines the area's boundaries **(Nanda et.al, 2014, pp.7).** The basin area was calculated using a GIS tool to be (236.4) km2.

3.2.2 Basin Perimeter (P)

The basin perimeters (also named basin boundary) defined is measured along the divides between basins and may be utilized as an indication of basin size and form according to (**Schumm, 1956,** pp. 597- 646**)** (**Nanda et. al, 2014, pp.7**). The length of the stream basin's perimeter is known as the perimeter **(Rawat et. al, 2017, pp.5 in Fatah et. al, 2020, pp.88-104).** The Bastora River's basin perimeter is (97.73) kilometers (Table 5).

3.2.3 Basin Width (Wb)

In the basin, there is a proportionate link between average width and denudation **(Al-Assadi, 2015, pp.274-253 in Ibrahim, 2019, pp.59-69).** The variation in average width is caused by variations in denudation rate, which is influenced by rock kinds and gradients. The research area's basin width is (8.08) km (Table 5).

3.2.4 Stream Frequency (Sf)

The total amount of stream segment within a basin per unity of area (**Horton, 1945, pp.** 275-370) was the first to characterize the stream frequency (Fs) of a basin. Stream frequency in the basin has a positive relationship with drainage density, suggesting a rise in stream populations as drainage density rises. The climate, the types of plants and rocks and soil, the amount of rain, how well it soaks in, how fast it runs off, how permeable the ground is, and how steep the slope are all important factors in how often and how much water runs off **(Adhikari, 2020, pp.127-144).** High values of the stream frequency show that the surface and subsurface rocks are resistant, that the lithology is not permeable, that the relief is high, and that there are few plants. Low values of the stream frequency show that the surface and subsurface rocks are not resistant, that the lithology is permeable, and that the relief is lesser **(Kumar, 2013, pp.1-6).** Stream frequency is lower in the basin study area (Table 5), indicated good permeability and little resistance.

3.2.5 Drainage Density (Dd)

According to Horton, (1945) it is the proportion of the basin's surface area to the sum of all canal segment lengths for all orders. The closeness of channel spacing is expressed by drainage density. According to defined **Nag & Chakraborty, (2003)** show in (Table 5) the basin has a highly permeable subsoil, the drainage density is low in the study area, while the impermeable underlying material and hilly topography are the causes of the high drainage density.

3.2.6 Drainage Texture (Dt)

The drainage texture was first introduced by **Chorley et al. in 1957, pp.138-141**; it is regarded as one of the most significant geomorphological concepts since it reveals the ratio spacing of the drainage lines. And those utilized to compare permeable and impermeable substances **(Horton, 1945,** pp.275-370 **in Ali and Khan, 2013).** According to described **(Smith, 1950, pp.655-668 in Rawat et. al, 2017, pp.10)** the drainage texture has been put into five groups; Show in (Table 4). The drainage texture is calculated by separator the aggregate number of streams in all orders by the basin's circumference **(Horton, 1932, pp.350-361 in Ali and Khan, 2013 in Fatah et.al, 2020, pp.88-104).** This is shown in (Table 5), which shows the (temperate group) drainage texture.

Table 4: Drainage Texture Classification

Amount of Drainage Texture	Group Classification
Lower than 2	very Coarse
2 - 4	Coarse
4-6	temperate
6-8	fine
More than 8	very fine

3.2.7 Elongation Ratio (Re)

Elongation Ratio is a highly important indicator in basin shape analyses since it assistance to determine the hydrological features of a drainage basin **(Nanda et.al, 2014, pp.7).** According to **(Singh and Singh, 1997, pp.31-43 in Adhikari, 2020, pp.127-144),** Circular (0.9-0.10), oval (0.8-0.9), less elongated (0.7- 0.8), elongated (0.5-0.7), and longer (0.5) are the tectonic classifications for the variable index of elongation ratio. A circular basin discharges runoff more efficiently than an elongate basin **(Singh and Singh, 1997, pp.31-43)**. In the study area, the result elongation ratio was (0.59), showing elongated basin relative relief of the topography and elongated drainage basin morphology.

3.2.8 Circularity Ratio (Rc)

It is the ratio between the basin's surface area and the location of a Circle with the same perimeter as the basin's perimeter **(Miller, 1953 in Vittala et. al, 2004, pp.351-362).** Stream length, stream frequency, geological formations, land use, land cover, temperature, topography, and basin gradient are all elements that influence the circularity ratio of basins **(Ali and Khan, 2013).** The circularity ratio is a number with no dimensions. The Bastora basin's circularity ratio is (0.31), a low number that indicates an elongate form, little runoff discharge, and high subsoil permeability.

3.2.9 Form Factor (Ff)

This factor represents the flow intensities of a basin in a specific region. **Horton's, 1945, pp.275-370** The basin may be categorized into two shapes based on the form factor value; the low value of the form factor, more elongate the basin, and the high value, it's circular basin. When the form factors are high, large peak flows of short duration period occur. **(Adhikari, 2020, pp.127-144).** The basin's form factor was low throughout the study area (Table 5), indicating that the basin was extended with a flat peak and long-duration flow (flat hydrograph occurred in the elongated basin shape low discharge and water remains for a long time in the basin).

3.2.10 Constant of Channel Maintenance (C)

It's the amount of basin area required to create and maintain a unit length of stream canal **(Schumm, 1956, pp. in Kumar, 2013).** Permeability, rock fragments, relief, vegetation, and rainfall duration are all factors that influence the aspect Constant of canal Maintenance **(Kumar, 2013).** The basin has highly permeable, low surface runoff, high plant cover, and medium gradient in the study location, with a factor value of (0.56) km and a drainage density value of (1.77) km-1.

3.2.11 Length of Overland Flow (Lg)

According to the presented **(Schmid, 1997, pp.530-535)** the Infiltration and percolation are through the soil, both variable in time and location, have a substantial impact on the duration of overland flow. The higher overland flow length value implies that precipitation had to move a longer space afore being condensed in stream canals **(Chitra et al., 2011, pp.311 in Adhikari, 2020, pp.127-144).** The value of length of overland flow in the Bastora basin is 0.28 km Show in (Table 5), which is a low value that indicates reduced spread runoff in the study area and equals half of the canal maintenance constant value.

Table 5: Summary to produce Areal Morphometry Data Parameters for Bastora Basin

Areal Morphometric Parameter	Value of the Bastora Basin	Unite
Basin Area (A)	236.4	Km^2
Basin Perimeter (P)	97.73	km
Basin Width(Wb)	8.08	km
Stream Frequency (Sf)	2.48	$No./km^2$
Drainage Density (Dd)	1.77	Km^{-1}
Drainage Texture (Dt)	6.00	No./km
Elongation Ratio (Re)	0.59	……
Circularity Ratio (Rc)	0.31	……
Form Factor (Ff)	0.28	……
Constant of Channel Maintenance (C)	0.56	km
Length of Overland Flow (Lg)	0.28	km

3.3 Relief Morphometric Parameters

According to (Strahler 1968, pp.898-911), relief measurements are a good indicator of its probable energy Due to the drainage system's elevation. Basin relief, relative relief, relief ratio, and roughness number are among the relief factors taken into account for the current research (Sakthivel et. al, 2019, pp.1-18). The primary techniques for calculating the morphometric relief parameter are shown in Table 6:

Table 6: Main Equation Using to Determine Relief Morphometry Parameters

Morphometric Parameter	Formula	Reference
Basin Relief (Bh)	Bh=H-h Bh= Basin Relief H=It is maximum elevation in basin h= It is minimum elevation in basin	Schumm (1956)
Relief Ratio (Rr)	Rr= Bh/Lb Rr= Relief Ratio Bh=It is relief of the basin Lb=Maximum basin length	Schumm (1956)
Relative Relief (Rf)	Rf=Bh/P Rf= Relative Relief Bh= It is relief of the basin P=Perimeter of the basin	Huggett and Cheesman (2002)
Ruggedness Number (Rn)	Rn=Bh×Dd Rn= Ruggedness Number Bh= It is relief of the basin Dd=It is drainage density	Strahler (1956)

3.3.1 Basin Relief (Bh)

It has a key influence in the landforms, drainage systems, the surface run off and base flow, permeability, and the erosional features of the terrain. It is crucial to understand the erosion advantage of the basin (Adhikari, 2020, pp.127-144). The variation in rising between the highest and lowest region close to the dam placement in the basin study area equals (1334) m above sea level in (Table 7), which was calculated using a DEM with a resolution of 3 meters and the Global Mapper 20.0 with GIS 10.8 application. While the South and Southwest sides of the research area have low relief values, the North and Northeast side of the basin has high and steep relief values, indicating gravity-driven water flow, little infiltration, and high runoff conditions.

3.3.2 Relief Ratio (Rr)

According to firstly defined (Schumm, 1956, pp.597-646) the relief ratio is the difference in height between the maximum and minimum points of a basin divided by the maximum length aspect of the basin that runs along the main drainage line. It is a dimensionless ratio (Adhikari, 2020 pp.127-144). The channel gradient and relief are directly related by the relief ratio (Khare et. al, 2014, pp.1650-1662). In the study area, the relief ratio has the lowest value of (0.05).

3.3.3 Relative Relief (Rf)

In the same climatic circumstances, there is an inverse relationship between relative relief, rock resistance, and denudation variables (Al-Assadi, 2015, pp.274-253 in Ibrahim, 2019, pp.59-69). The proportion of the basin relief to the basin perimeter can be thought of as the relative relief (Ibrahim, 2019, pp.59-69) .In the study area, the low value of relative relief equals (0.01) and has no units.

3.3.4 Ruggedness Number (Rn)

Greatest basin relief multiplied with drainage density, both of which are measured in the same unity, results in the ruggedness number. It is a measurement of surface irregularity (Selvan et. al, 2011, pp.22-27 in Adhikari, 2020, pp.127-144). Based on the mount of the ruggedness number, there are five main kinds of morphology: below 0.1 is subdued, 0.1 to 0.4 is subtle, 0.4 to 0.7 is temperate, 0.7 to 1.0 is acute, and more than 1.0 is severe morphology, which contains bad-lands topography (Farhan et al., 2015, pp.456 in Ibrahim 2019, pp.59-69) . Show in (Table 7) the basin study area has the kind of morphology that comprises Bad Lands terrain, and the ruggedness number there is (2.36).

Table 7: Summary to produce Relief Morphometry Data Parameters for Bastora Basin

Basin Relief (Bh) (m)	Relief Ratio (Rr)	Relative Relief (Rf)	Ruggedness Number (Rn)
1334	0.05	0.01	2.36

4. Other Factor Effected Morphometry of the Basin Produces By Tectonic Activity

4.1 Hypsometric Analysis

These are crucial elements in describing the watershed conditions because they relate to the equilibrium between tectonic activity and denudation. Hypsometric integral and hypsometric curve are two of its components (Ibrahim, 2019, pp.59-69).

4.1.1 Hypsometric Curve

A hypsometric curve, which plots prorate area (a/A) versus prorate height (h/H), effectively depicts the percentage of land area that is present at different altitudes. (**Strahler, 1952, pp.1117-1142**) has divided into three categories. Young, mature, and old phases of the hypsometric curve- which correspond to the stages of Basin dissection depend on the curve's shape and form. Young stage is associated with a convex-shaped curve, the mature stage is associated with S-shaped bend, and older stage is associated with a concave-shaped bend. The mature basins' S-shaped curve is shown in (Fig. 8). The river can be characterized as the mean equilibrium stage between sediment deposition and erosion.

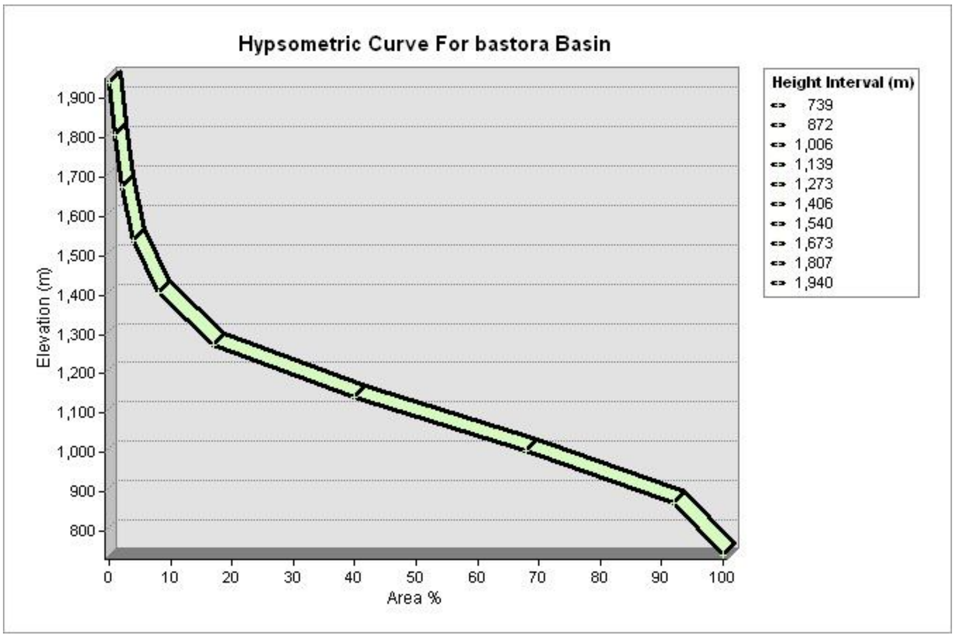


Figure 7: Hypsometric Curve for Bastora Rivers That Indicate Mature Stage

4.1.2 Hypsometric Integral (HI):

The HI value offers details on the tectonic, climatic, and lithological conditions as well as the basin's stage of erosion. According to Strahler's classification from, there are three main types: old stage (HI 0.35), maturity stage (HI 0.35 – 0.60), and youthful stage (HI 0.60) (Ibrahim, 2019, pp.59-69). The main methods calculate (HI) (Wood and Snell, 1960) by equation;

HI= (Hmean – Hmin) / (Hmax – Hmin)

Where

H mean = Mean elevation.

H min = Minimum elevation.

H max = Maximum elevation.

(Ibrahim, 2019). Equation Hypsometric Integral calculations in the examined basin produced is (0.5) m, which is categorized as mature stage.

4.2 Slope Area:

Two main parts of the slop basin in the Bastora basin were calculated using DEM 3m; the north and northeast basins, which are located on the southwest limb of the Safin anticline and thus represent the high folded zone; and the south and southeast basins, which are mostly low-slope areas and thus represent the low folded zone, show in (Fig. 8).

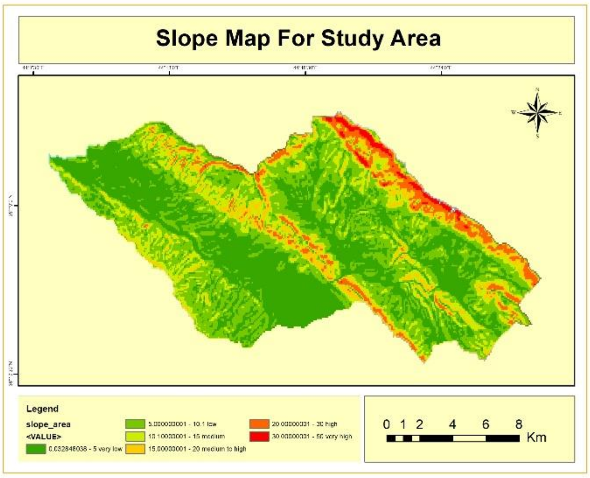


Figure 8: Slope Map Area for Bastora Basin.

4.3 Valley Floor Width and Valley high ratio (Vf)

Deep V-shaped vale (Vf <1) are connected by active, down-cutting streams. This is a sign of active uplift, while U-shaped valleys (Vf > 1) show that the basis level of erosion has been reached mostly because of relative crustal quietness (Keller and Pinter, 2002, pp.362; Keller, 1986, pp.136-147 in Mahmood and Gloaguen, 2012, pp.407-428). In study basin area taken three profiles in different location (Dam axis, Upstream and Downstream) by (Global Mapper V20.0) compute program, dimension upstream profile the dam axis is (4.4) km, downstream profile dimension with the dam axis is (2) km and the third profile on the dam axis calculated by equation (El Hamdouni et al., 2008):

$$Vf = 2Vfw / (EId - Esc) + (Erd - Esc)$$

Where Vf = Valley floor width and valley high ratio

Vfw = is the width of the valley floor

EId and Erd = Are elevations of the left and right valley

Esc = is the elevation of the valley floor.

The results of Bastora basin in three location profiles are less than one (0.2, 0.5, and 0.3, respectively), which means the valley is in the V-shape. According to (Fig. 9) the V-shaped valleys are caused by high levels of stream erosion, and the rocks in the study area are soft and porous with few stones. In the gradient area, the V-shaped valleys got bigger as the speed of the stream went up, and other structures in the area, such as hills, also helped (Anticline and Syncline).

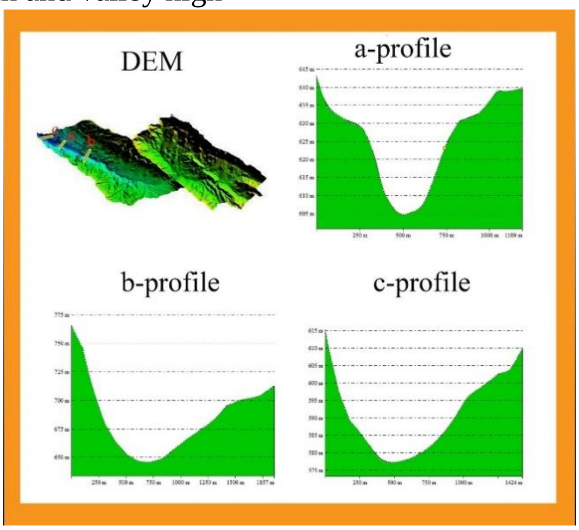


Figure 9: Three section profile locate by DEM Map a-profile section Bastora River on dam axis, b-profile section up stream on Bstora basin and c-profile section on downstream located on River.

4.4 River Profile:

Tectonic, lithological, and climatic may cause a deviation from this steady river pattern (Hack, 1973, pp. 421-429 in Mahmood and Gloaguen, 2012, pp.407-428). The river profile is made up of the relationship between distance and elevation. There are three main types of profile shapes that describe a river: concave, straight, and convex. Concave means the river is older and has low erosion, and is depositing sediment. Straight means the river is in a phase of balance between degradation and deposit. Convex means the river is younger and has high degradation. In the study area, the form of the relationship between elevation and distance at different points was used to create a profile as shown in (Fig. 10).

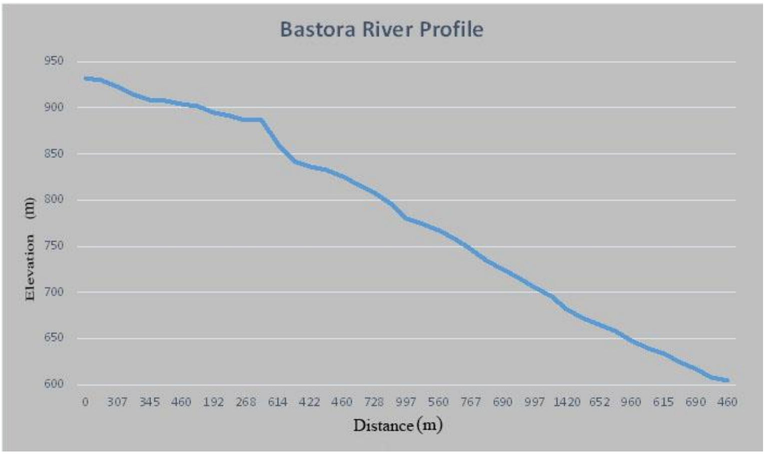


Figure 10: Bastora rivers profile that is drawing straight line by normal scale.

4.5 Drainage the Basin Asymmetry Factor (AF)

The asymmetry factor (AF), as stated in (Hare and Gardner, 1985, pp.75-104), is a method for determining if tectonic tilting exists at the size of a drainage basin. The technique may be used across a vast region. AF is defined by,

AF=100(Ar/At)

Where Ar = Area of the basin to right,

At= Total area of the drainage basin.

In the study of the Bastora Basin, it was found to be an asymmetrical valley. This is because the right side basin area of the basin divided by the total area basin gave a high value of (AF=63), which means that the basin was affected by tectonic, lithological, and structural factors. The Af may be more or lower than 50 because to one or a combination of several factors, such as active tectonics, litho- structural control, differentiation denudation, such as the stream gradually eroding the bedding plain (El Hamdouni et al. 2008, pp.150-173; Mahmood and Gloaguen 2012,pp.407-428 in Ali et. al, 2021, pp.1-15).

5- Land Use and Land Cover Map:

The concentration of land use and land cover mapping has often been on how people utilize the land. The ideas of land use and cover have been more confused over the last several years, which causes problems with studies and inferences taken from land classification. By articulating our understanding of land use and land cover, we may investigate this ambiguity (Fisher et al., 2005 p.98). The northeastern part of the study area basin is mostly built up and urbanized, while the southwestern parts are predominately crops area and are covered by river sediment and alluvial deposits. In general boundary study area is Range land cover Show in (fig.11).

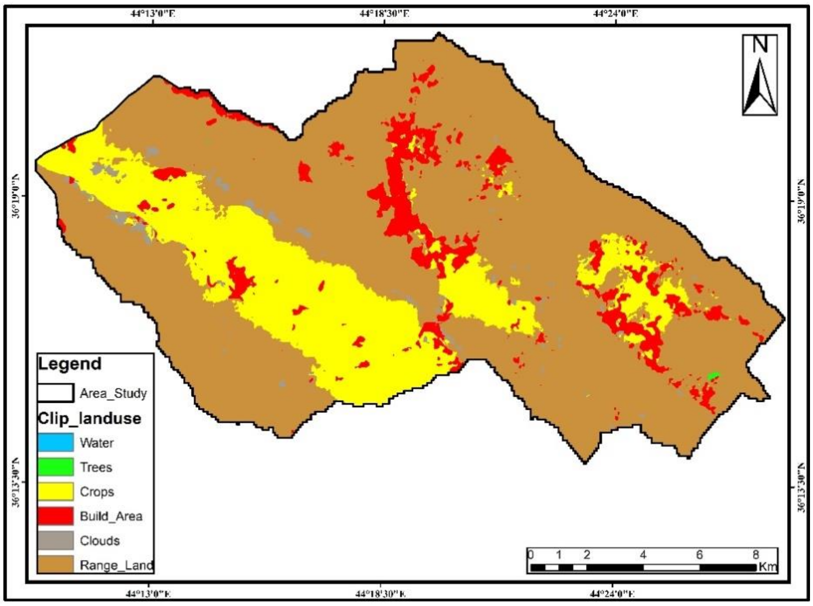


Figure 11: Land Use and Land Cover Map for Study Area

6. Conclusions

1- Hydro-Morphometry it is most important for identified and analysis basin for river runoff or valley for surface water, because can be produced shape and size basin with deposition and denudation sediment. Hydro morphometry analysis can be applied by main hydrology tool in (GIS) software with available data.

2- Most common dendritic and parallel type of drainage pattern for Bastora Basin, dendritic drainage pattern type common in soft rock sediment while the parallel type for hard rock sediment deposited.

3- Study catchment area of Bastora basin about 236.4 km^2 and basin perimeter is 97.73 km.

4- Product six-orders for the study area and total number orders resulted 587, covered 236.4 km^2 first order equal 458, second 96 , third 26, fourth 5, fifth and sixth order equal 2 and 1 respectively numbers.

5- Total stream length or water bath for Basin area is 418.24 km.

6- Stream order it is opposite relation with both stream number and stream length, that is season slope of the location.

7- Bastora River it is meandering river type and mature stage that is indicted equilibrium between deposition and erosion sedimentary rock.

8- Drainage density for the basin depend on land use and land cover, permeability sedimentary rivers and degree of slope in area and amount.

9- The shape and morphology Bastora basin is elongated drainage basin.

10- The degree slope catchment area can be divided in two parts; first area in North-East side is steeper slope and the second area in South-west side is gentle.

11- The dam axis location according to draw three profiles on the river trace that indicated V-shape valley; that is high erosion.

12- The ruggedness number in study area resulted 2.36 that is indicate type of morphology it is bad-lands terrain.

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