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Drainage Basin Characteristics of Dhund River Basin, Eastern Rajasthan India, Using Remote Sensing and GIS Techniques

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Abstract

Morphometric analysis is mathematical evaluation and measurement of the earth's shape, surface and its landform's dimension. Morphometric analysis of Dhund river basin in Jaipur district of Rajasthan India has been carried out to evaluate various morphometric parameters following the linear, areal and relief aspects. The drainage basin, which covers a total area of about 1828 km^2 lies in eastern part of the district with maximum and minimum elevation of 603 m and 214 m respectively. Morphotectonic parameters like Hypsometric Integral, Sinuosity index and Asymmetry Factor have also been computed to identify the tectonic characteristics of the drainage basin. Primary and secondary data such as SOI topographic map, Cartosat-1 DEM and other relevant data were utilized. ArcGIS software (Arc Map 10.2) was used for georeferencing of topographic maps, delineation of watershed and preparation of DEM, slope and drainage network. The basin is 6th order drainage basin having dendritic pattern of drainage network. A relatively lower mean value of Bifurcation ratio suggests that the drainage basin is formed by uniformed materials. Drainage basin area has little elongated shape and is less prone to floods. Basin has different erosional stages and levels of tectonic activity, Moderate Meandering and unstable setting.

Keywords

Drainage Basin, Dhund River, Rajasthan, DEM

1. Introduction

Rivers and various fluvial processes induce morphometric changes in drainage basins as these are the most dominant geomorphic systems of earth's surface that play a vital role in the understanding of land processes, soil and its physical properties and erosional features, etc. Drainage patterns form by rivers and fluvial processes demonstrate lithological and structural controls of underlying rocks. River profile and drainage pattern are analyzed for the study and analysis of the morphological characteristics of a drainage basin. Drainage pattern and its distribution depend on various factors like climate, relief, slope, structure and vegetation and can vary from one type to another type of topography [1].

Morphometric analysis, which is one of the characteristics of drainage basin is done by measuring and performing numerical and quantitative evaluation of earth's shape, surface and its landforms dimension [2] [3]. It is an important indicator of hydrogeologic processes and landform structure which also helps to demarcate the drainage system changes that happened due to anthropogenic activities or natural disturbances [1] [3].

The use of Geographical Information System (GIS) techniques and remote sensing is becoming more common in the study and analysis of the morphometric parameters of drainage basins as these are the most effective, convenient and accurate way to perform the analysis [4]-[9].

Morphometric characteristics of a drainage basin consist of quantitative parameters of landscape, derived from its elevation surface or terrain and drainage network within the basin [10]. Quantitative methodologies were first used by Horton in morphometric analysis of drainage basins from topographic maps using manual methods [11]-[17]. Many researchers in different studies, have considered morphometric characteristics of a drainage basins as indicators of structural effect on neo-tectonic activity and drainage development [18] [19] [20] [21].

Morphometric parameters are categorized in three aspects namely linear aspect (stream order, stream count, steam length, mean stream length, stream length ratio, bifurcation ratio, mean bifurcation ratio, basin length), areal aspect (basin area, drainage density, stream frequency, drainage texture, elongated ratio, circulatory ratio, etc.) and relief aspect (basin relief, ruggedness number, relief ratio) which are evaluated to derive general characteristics of a watershed [3].

Morphometric parameters categorized in areal, linear and relief aspects help in numerical evaluation of shape of a landscape and explain the basin characteristics, processes and flood hazard corresponding to the hydrological and climatic processes [1].

The current study makes an attempt to analyze the watershed characteristics of the Dhund river basin in Jaipur district of Eastern Rajasthan, India using DEM and GIS.

2. Study Area

Dhund river basin lies in Jaipur district of East Rajasthan, India and is bounded between 75˚40'E to 76˚10'E longitudes and 26˚30'N to 27˚10'N latitudes that covers a geographical area of about 1828 km^2 (**Figure 1**). The Dhund river flows

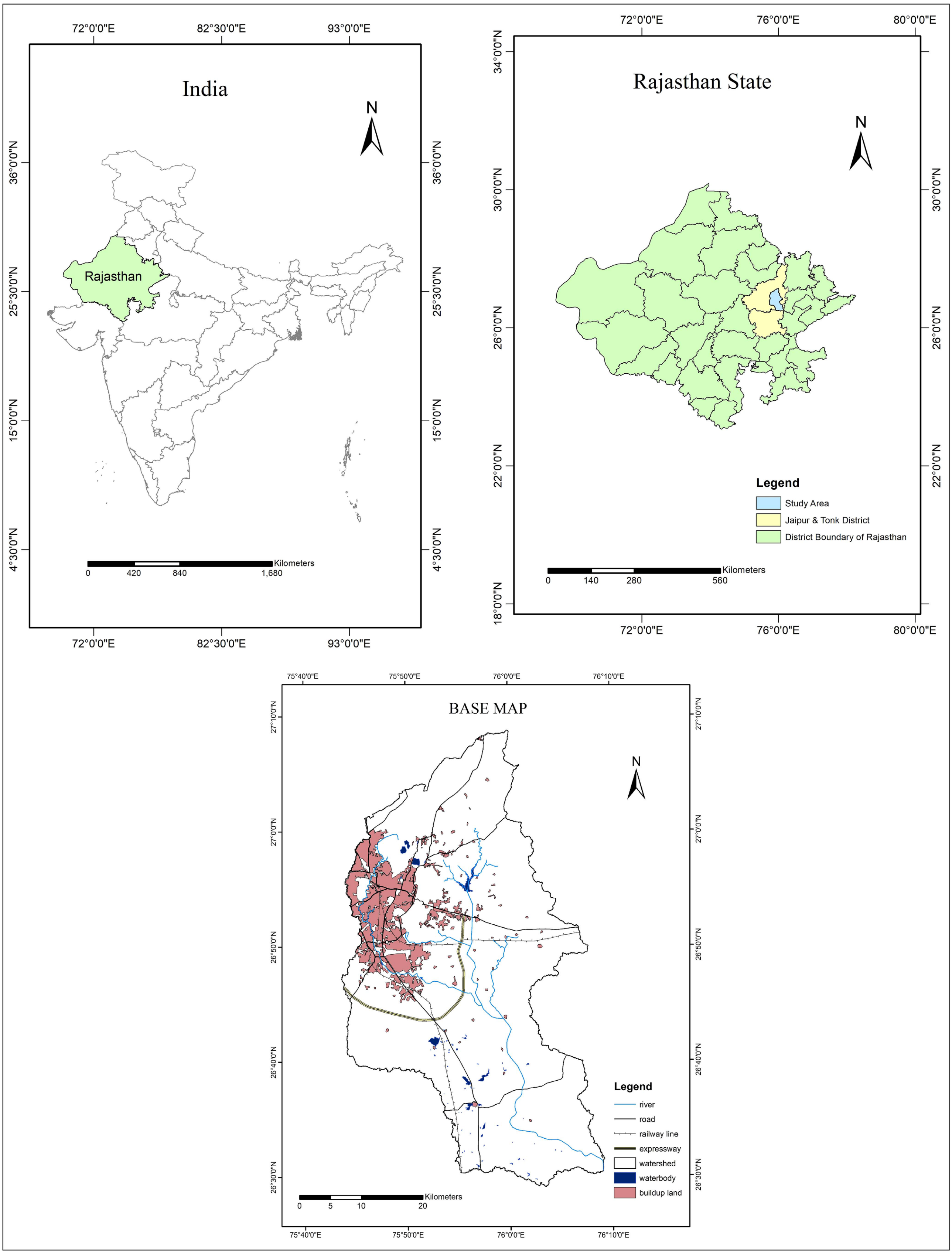

Figure 1. Location map of study area.

in north-south direction with a gentle to moderate slope that ranges 0˚ - 53˚ and has a length of about 98.95 km.

The Dhund river is a seasonal river which flows in semi-desert terrain of district Jaipur. It is the major tributary of Morel river and has subsidiary drainage system which forms a N-S elongated river basin. The main tributaries are Amanishah Nala, Jhalana river and Ratanganga nala. It joins river Morel in south-east of village Mandaliya and attains the status of main tributary of river Morel which itself joins the river Chambal near village Rameshwar in Sawai Madhopur district of Rajasthan.

Channel width of Dhund river is variable as it is narrower in the upstream side but as we move downstream the channel becomes wider.

The study area has a semi-arid climate and receives an average rainfall of 536 mm annually. The vast area of the basin is dependent upon rain for irrigation as it is the perennial source of water. The average annual temperature is 25.1˚C with mean maximum temperature 40˚C in the month of May and June. The basin's lowest and highest elevations are 214 m and 603 m above mean sea level, respectively.

The basin has residual, structural and denudational linear ridges with ravines and alluvial plains. The litho-units exposed in the Dhund river basin belong to Bhilwara supergroup, Aravalli supergroup and Delhi supergroup of Archean age besides quaternary alluvium.

Primary land use of the basin is agriculture, but at places reserve forest and wasteland has also been reported. At places stone quarrying activity is also seen, especially in the southern area of the watershed.

3. Data Sources and Methodology

3.1. Data Sources

The current study has been conducted with the help of following sets of primary and secondary data that includes Survey of India topographic maps, Digital Elevation Model of Cartosat-1 DEM, ArcGIS software, published literature and internet. SOI topographic map no's 45M/16, 45N/9, 45N/10, 45N/13, 45N/14, 54A/4, 54B/1, 54B/2 and 54B/3 on 1:50,000 scale has been downloaded from SOI website (soinakshe.uk.gov.in) and utilized to get relevant information about village/town, drainage network, major roads and railways etc. Cartosat-1 DEM data has been downloaded from NRSC-ISRO website (bhuvan.nrsc.gov.in) having 2.5 m resolution is used for generation of Digital Elevation Model (DEM), preparation of slope map and drainage network of the watershed. ArcGIS software (Arc Map 10.2) is used for geo-referencing of topographic maps, delineation of watershed and preparation of DEM, slope and drainage network.

3.2. Method

DEM is used to delineate watershed boundary and drainage network in ArcGIS (Arc Map 10.2) software by using UTM zone 43N and WGS84 as global datum.

Slope is also prepared by using DEM. Base map was prepared by digitizing features like build-up land, road network, expressway, railway line, waterbodies and river. Elevation map and slope map (Figure 2 & Figure 3) are prepared by using DEM. Drainage network is also prepared by using DEM and it has six orders of which 6th order stream is the highest order found in the watershed. Stream count, stream order, stream length, stream length ratio, mean stream length, bifurcation ratio and mean bifurcation ratio are the parameters that comes under linear aspect of morphometric analysis which are calculated in Arc map following Strahler method of stream order as mentioned in Table 1. Drainage density, length area relation, stream frequency, drainage texture, texture ratio, form factor, circulatory ratio, infiltration number, elongation ratio, basin shape, length of overland flow, drainage intensity, compactness coefficient and constant of channel

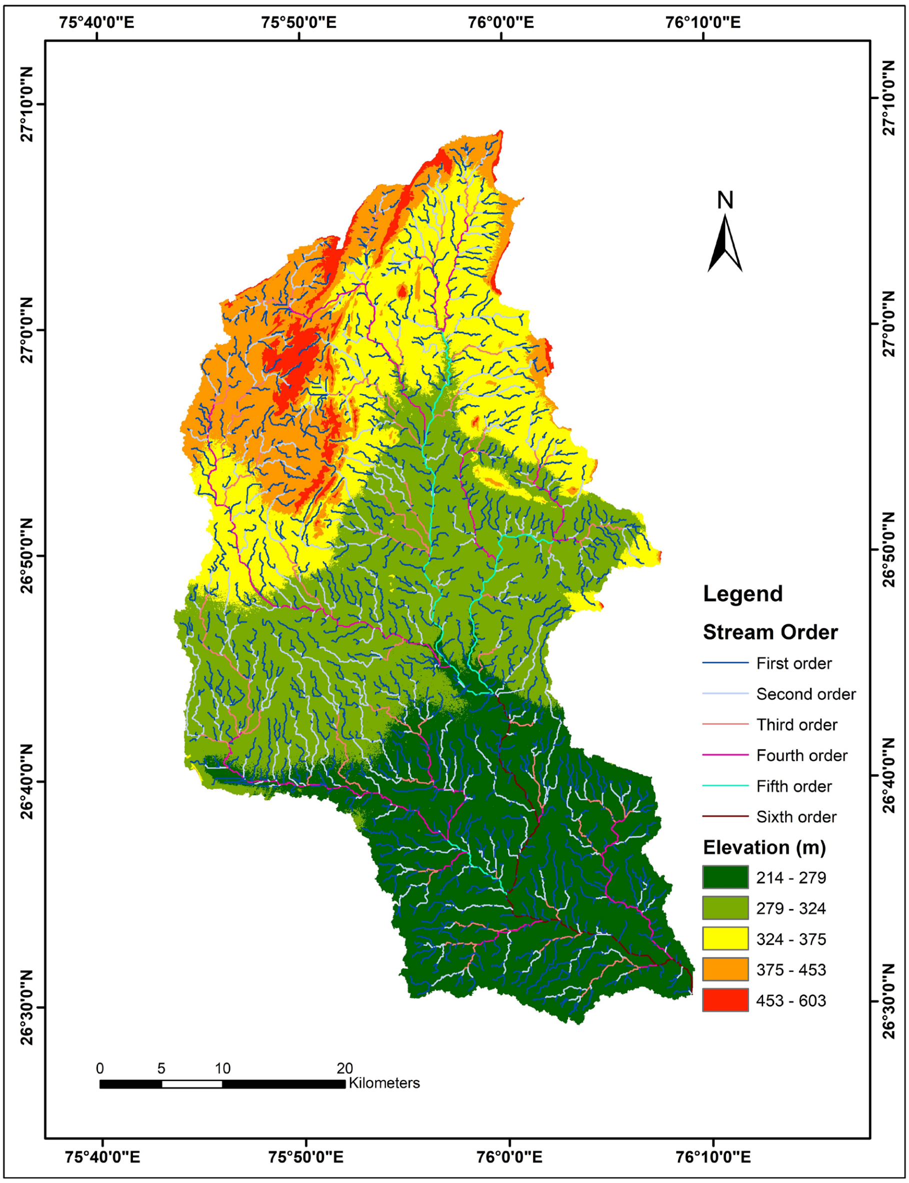

Figure 2. Drainage network superimposed on DEM.

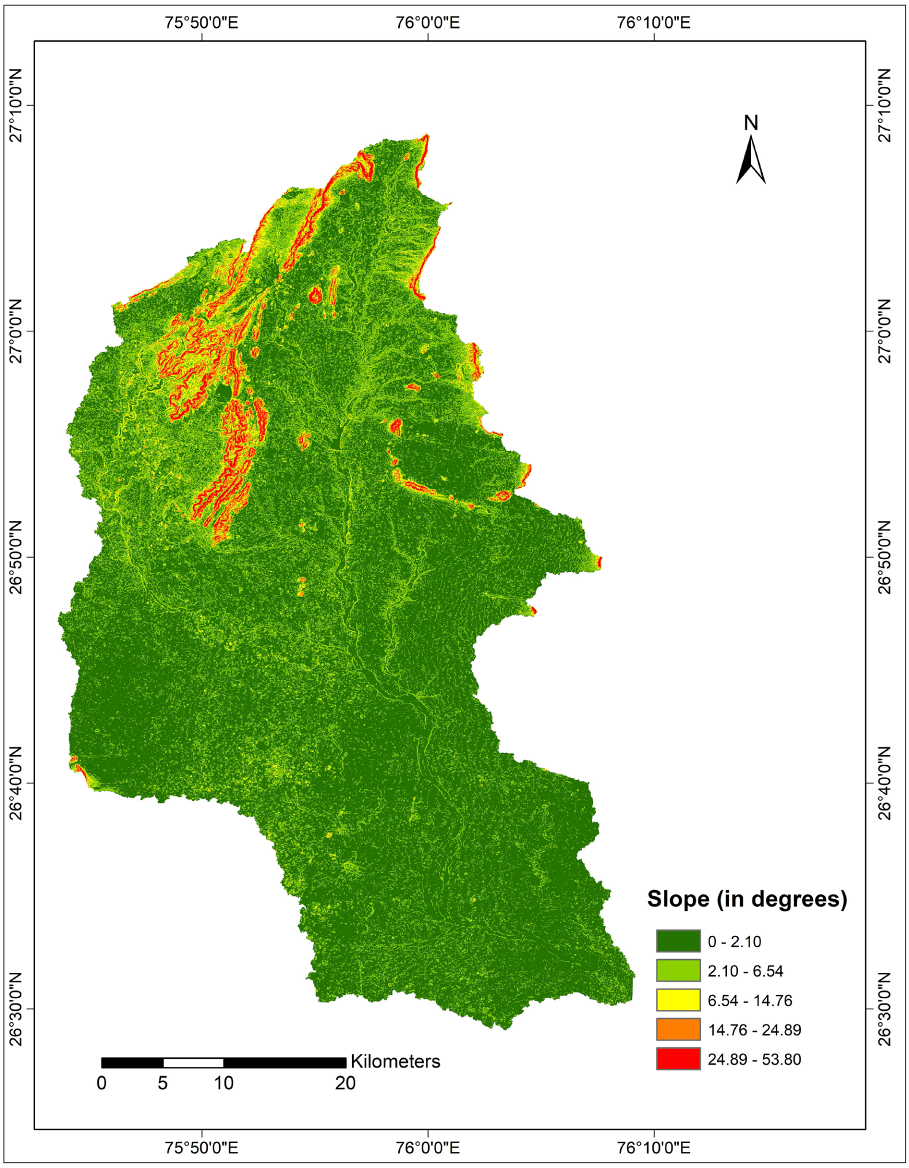

Figure 3. Slope map of study area.

Table 1. Linear aspect of Dhund river basin.

Stream Order(u)	Stream number/ Count (Nu)	Stream Length (Lu) (in km)	Mean Stream Length (Lsm)	Stream Length Ratio RL = Lu_i/Lu_{i-1}	Bifurcation Ratio Rb = Nu_i/Nu_{i+1}
1	1215	1349.83	1.11	0.23	4.43
2	274	312.51	1.14	0.19	4.49
3	61	60.18	0.99	0.18	4.36
4	14	10.80	0.77	0.19	4.67
5	3	2.10	0.70	0.06	3
6	1	0.12	0.12		
Total	1568	1735.54			Mean Bifurcation Ratio (Rbm) = 4.19

maintenance are the parameters that are classified as aerial aspects while relief aspect has three parameters namely basin relief, ruggedness number and relief ratio that are calculated using conventional procedure and formulae as mentioned in Table 2 and Table 3 respectively.

4. Results and Discussions

4.1. Morphometric Analysis

Basic parameters:

Area, perimeter and basin length are the basic parameters of a watershed.

Area:

Table 2. Aerial aspect of Dhund river basin.

Basic Parameter	Unit	Formula	Result
Basin Area (A)	km^2	-	1828
Basin Perimeter (P)	km	-	375.89
Basin Length (Lb)	km	-	68.44
Aerial Parameter			
Drainage Density (Dd)	km/km^2	$\Sigma Lu/A$	0.95
Length Area Relation (Lar)		$1.4 * A^{0.6}$	126.86
Form Factor Ratio (Rf)		$A/(Lb)^2$	0.39
Basin Shape (Bs)		$(Lb)^2/A$	2.56
Elongation Ratio (Re)		$\left(2\sqrt{A/\pi}\right)/Lb$	0.7
Texture Ratio		Nu_1/P	3.23
Circulatory Ratio (Rc)		$4\pi A/P^2$	0.16
Drainage Texture		$\Sigma Nu/P$	4.17
Compactness Coefficient		$P/2\sqrt{\pi A}$	2.48
Stream Frequency (Fs)		$\Sigma Nu/A$	0.86
Infiltration Number (If)		$Dd * Fs$	0.82
Length of overland Flow (Lg)	km^2	$1/(2 * Dd)$	0.53
Drainage Intensity (Di)		Fs/Dd	0.91
Constant of Channel Maintenance (C)	km^2/km	$1/Dd$	1.05

Table 3. Relief aspect of Dhund river basin.

Parameter (unit in m)	Formula	Result
Maximum Elevation (H)	-	603
Minimum Elevation(h)	-	214
Basin Relief (R)	H-h	389
Relief Ratio (Rh)	R/Lb	5.68
Ruggedness Number (Rn)	Dd * R/1000	0.37

Drainage basin area is defined as area of any land where rainfall collects and empties into a single or common outlet like river. Area of Dhund river basin as calculated is 1828 km^2.

Perimeter:

The drainage basin perimeter is considered as the horizontal projection of the basin's water divide. Water divide is the line linking the points of greatest height between two drainage basins and separating their surface runoffs. It delimits the entire catchment area which is drained by the whole of a river network. The calculated perimeter of the basin is 375.89 km.

Basin length:

The length of watershed is measured along the distance of main river channel starting from a point in water-divide opposite to the flow of main river channel where the first order tributaries originate and join at point in water-divide where the main river meets its major tributary. ArcGIS measurement tool is used to calculate the basin length (Lb) [22]. Basin length of the watershed is 68.44 km.

Linear, aerial and relief parameters:

The study of Dhund river basin has been carried out under three major aspects:

- **Linear Aspect**—Morphometric parameters computed are Stream Order (u), Stream Count (Nu), Total Stream Length (Lu), Stream Length Ratio (RL), Mean stream length (Lsm), Bifurcation Ratio (Rb) and Mean bifurcation ratio (Rbm) using standard mathematical equations given in **Table 1**.
- **Aerial Aspect**—Morphometric parameters computed are Drainage Density (Dd), Length Area Relation (Lar), Texture Ratio, Form Factor Ratio, Drainage Texture, Elongation Ratio, Circulatory Ratio (Rc), Compactness Coefficient, Stream Frequency (Fs), Infiltration Number (If), Length of overland Flow (Lg), Drainage Intensity (Di) and Constant of Channel Maintenance (C) using standard mathematical equations provided in **Table 2**.
- **Relief Aspect**—Morphometric parameters computed are Basin Relief (R), Ruggedness Number (Rn) and Relief Ratio (Rh) using common mathematical equations provided in **Table 3**.

Details about the individual morphometric parameter are given below.

4.1.1. Linear Aspect

1) Stream Order (u)—"Stream order" is the parameter which is used to describe the hierarchy of the streams, a positive whole number which indicates the branching level of any river. The ordering of streams in a drainage basin could be done in many ways using a top-down or bottom-up approach. Horton (1945) originally developed the notion of stream orders [23]. The basin has 6 orders of streams and 6^{th} order is the highest order (**Figure 2**).

2) Stream Number (Nu)—Stream number is defined as count of stream channels in a certain order. As the stream order rises, stream frequency gets decreased. Stream number also has a close direct proportional relationship with channel dimensions and size of the drainage basin. A higher value of stream number suggests lower permeability and infiltration [24].

- Total identified stream count—1568
- Out of the above total streams, 1215 streams were in 1st order, 274 streams were in 2nd order, 61 streams were in 3rd order, 14 streams were in 4th order, 3 streams were in 5th order and 1 stream was in 6th order.

3) Stream Length (Lu)—Stream Length is an important morphometric parameter used in quantification of the hydrological attributes of bedrock and the drainage extent and exhibits the characteristic size of components of a drainage network. **Table 1** contains the order wise stream length data and given below are the details:

- Total Stream Length—1735.54 km
- Total Stream Length for 1st order: 1349.83 km, 2nd order: 312.51 km, 3rd order: 60.18 km, 4th order: 10.80 km, 5th order: 2.10 km and 6th order: 0.12 km.

4) Mean Stream Length (Lsm)—Mean stream length (Lsm) exhibits the characteristic size of components of a drainage network and its contributing surfaces [25]. Mean Stream Length is calculated as the ratio of total stream length and the number of streams in any particular order [26]. **Table 1** contains the order wise mean stream length data. Mean stream length for 1st order: 1.11, 2nd order: 1.14, 3rd order: 0.99, 4th order: 0.77, 5th order: 0.70 and 6th order: 0.12.

5) Stream Length Ratio (RL)—Stream Length Ratio is calculated by dividing total stream length of an order (Lu_i) to the total stream length of next lower order (Lu_{i-1}). It is an important morphometric parameter as various studies suggest a direct geometrical corelation between the average stream length of an order and that of the corresponding order [27]. Stream Length Ratio in Dhund river basin (captured in **Table 1**) varies between 0.06 - 0.23. Stream length ratio for 1st order: 0.23, 2nd order: 0.19, 3rd order: 0.18, 4th order: 0.19 and 5th order: 0.06.

6) Bifurcation Ratio (Rb)—Bifurcation Ratio is a dimensionless morphometric parameter in linear aspect which can be used to analyse the structural control in the geological environment which is computed as the ratio of number of streams in any two consecutive stream orders. Low bifurcation ratio value indicates that the geological structures and formations are not affecting the drainage pattern, whereas the high value of bifurcation ratio shows the drainage pattern is influenced by the geologic structures [28]. Calculated Rb values are captured in **Table 1** which varies between 3 - 4.67 and mean value of Rb is 4.19.

4.1.2. Areal Aspect

1) Drainage Density (Dd)—Drainage density (Dd) was introduced by Horton (1964) as an identifier to describe the closeness of spacing of channels [29] and is calculated as the ratio of total stream length in a given basin to the total basin area [25]. A relatively lower value of Drainage density is more likely to occur in the regions of highly permeable subsoil material with low relief and vegetative cover and a higher value of drainage density is noted in the regions of impermeable sub-surface materials with less vegetation and mountainous relief [30]. The study area has a drainage density of **0.95** shown in **Table 2** which is relatively low value and indicates the basin area is highly permeable subsoil material with low relief and vegetative cover.

2) Length Area Relation (Lar)—For Length Area Relation is calculated using the formulae given by Hack (1957), Lar = 1.4 * $A^{0.6}$ where A is the area of the basin [31]. Length Area Relation for the study area is **126.86** (**Table 2**).

3) Form Factor Ratio (Rf)—Form factor of any basin is calculated as the ratio of the basin area (A) to the square of basin length (Lb) [32] where Lb is maximum basin length which is measured as the distance between the mouth and the farthest point of the basin. Basins having high value of form factor get higher peak flows for lesser duration whereas basins having lower value of form factor are more elongated and get lower peak flows for longer duration. The Rf value for the study area was calculated as **0.39** (**Table 2**).

4) Elongation Ratio (Re)—Schumm (1965) defined Elongation Ratio (Re) of a drainage basin as the ratio of diameter of a circle having same area as the basin to the maximum length of basin. Value of Elongation Ratio of a basin lies in the range of 0.6 to 1 [33]. Elongation Ratio index signifies the watershed slope as circular for a value ranging between 0.9 - 0.10, oval for a value ranging between 0.8 - 0.9, less elongated for a value ranging between 0.7 - 0.8, elongated for a value ranging between 0.5 - 0.7 and more elongated for a value < 0.5 [34]. Elongation Ratio calculated for the present study area is **0.7** (**Table 2**), which indicates that the basin is less elongated.

5) Texture Ratio (Dt)—Texture ratio is of a drainage basin is calculated by dividing the first order stream counts to the perimeter of the basin [34]. For the present study area, the drainage texture ratio is calculated as **3.23** (**Table 2**) which would be categorized as moderated and confined in nature.

6) Circulatory Ratio (Rc)—Circularity Ratio is an important dimensionless morphometric parameter which is calculated by dividing the basin area by the area of a circle which has circumference equal to the basin perimeter [35]. Length and frequency of streams, geological formations, land use/land cover, climate and basin slope are the factors affecting Circularity Ratio [36]. The computed circulatory ratio for the study area is **0.16** (**Table 2**)

7) Drainage Texture (Rt)—Ratio of sum of stream counts to the drainage basin parameter is known as the Drainage texture of a drainage basin [36] and its value is influenced by various natural aspects like rock and soil type infiltration capacity, climate, vegetation density and type, stage of development and relief. Low drainage density results into coarse drainage texture while high drainage density leverages fine drainage texture which is depends on infiltration capacity of bed rock or mantle rock or [37]. Rt value lesser than 4.0 signifies the texture as coarse, Rt value in the range of 4.0 - 10.0 signifies the texture as intermediate, Rt value in the range of 10.0 - 15.0 signifies the texture as fine and Rt value beyond 15.0 signifies the texture as ultra-fine [38]. The Rt value of the

Dhund river basin is **4.17** (**Table 2**), which suggests the texture of drainage basin has intermediate.

8) Compactness Coefficient—Compactness coefficient is defined as the ratio of the perimeter of a drainage basin to the circumference of an area having the same as the drainage basin. A circular basin has a compactness coefficient Cc value as 1 whereas a compactness coefficient value > 1 signifies that basin shape deviates from the circular nature [39]. The compactness coefficient (Cc) is dependent on the slope of watershed and independent of its size [36]. Calculated value of Compactness Coefficient (Cc) of Dhund river basin is **2.48** (**Table 2**).

9) Stream Frequency (Fs)—The stream frequency (Sf) is calculated by dividing the total number of stream segments to the total basin area (Horton 1932) [36]. Runoff pattern and other hydrological parameters of the basin are controlled and influenced by Stream frequency. The calculated value of Stream Frequency for Dhund river basin is **0.86** (**Table 2**) which directly relates to the Drainage density of the study area which is **0.95** as per the calculation.

10) Infiltration Number (If)—The infiltration number is defined as the product of stream frequency and drainage density. Infiltration number is used to define and quantify watershed infiltration potential and has inversely proportional relationship [40]. Infiltration Number for Dhund river basin is calculated as **0.82** (**Table 2**) which is a lower number indicates higher infiltration.

11) Length of overland Flow (Lg)—It is the length of water above the ground before it gets concentrated into definite stream channels which is roughly equivalent to half of the reciprocal of basin drainage density [41]. Calculated value of Lg for the study area is **0.53** (**Table 2**) which indicates gentle slopes and long flow path.

12) Drainage Intensity (Di)—Drainage intensity is calculated by dividing the stream frequency by basin drainage density [34]. Calculated value for Drainage intensity is **0.91** (**Table 2**) for Dhund river basin.

13) Constant of Channel Maintenance (C) –Schumm (1956) defined Constant of channel maintenance for a basin as reciprocal of its drainage density which is a parameter having dimension of length [42]. Calculated value of Constant of Channel Maintenance is **1.05** (**Table 2**) which signifies that, to create 1 linear km of the stream channel, it needs an average **1.05** km^2 of surface area.

4.1.3. Relief Aspect

1) Basin Relief (R)—The basin relief (R) of a basin is defined as the elevation difference between the highest and lowest locations on its valley floor. Basin Relief is calculated by subtracting the elevation of the lowest point of the basin from the highest point within the basin [43]. The Basin relief calculated for the study area is **389 m** (**Table 3**) which is a lower value and indicates high gravity of water flow.

2) Relief Ratio (Rh)—Relief ratio is defined as a dimensionless parameter which is calculated by dividing the total relief of a basin by the longest dimension of the basin parallel to the principal drainage line (Schumm, 1956) [44]. Relief ratio of watershed is directly proportional to the slope and relief, watershed with steep slope and high relief has relatively high value of Relief Ratio whereas the watershed with lower slope and basement rocks has lower value of Relief Ratio [45]. Calculated value of Relief ratio for the study area is **5.68** (**Table 3**)

3) Ruggedness Number (Rn)—Ruggedness Number is defined as the product of drainage density and basin relief and is closely related to the drainage density of the basin [45]. Dhund river basin has ruggedness number as **0.37** (**Table 3**).

4.2. Morphotectonic Parameters

1) Hypsometric Integral (HI)—The ratio of the area under the curve to the area of the full square created by covering it is known as the hypsometric integral, which is determined from the hypsometric curve. It is calculated from the percentage hypsometric curve by calculating the area under the curve and is represented in percentage units [46] as shown in **Figure 4** for the current study area. Hypsometric Integral signifies the distribution of elevation of any drainage basin area.

$$HI = (\text{Mean Elevation} - \text{Minimum Elevation})/(\text{Maximum Elevation} - \text{Minimum Elevation}).$$

Theoretical range of HI values varies between 0 - 1. A low value of HI signifies the area as old and more eroded which eventually infers the evenly dissected drainage basins whereas the high values signify high topography relative to mean [47]. For the current study area, Hypsometric Integral values lies between 0.24 - 0.84 with an average value of **0.49** (**Table 4**) which indicates mature eroded area.

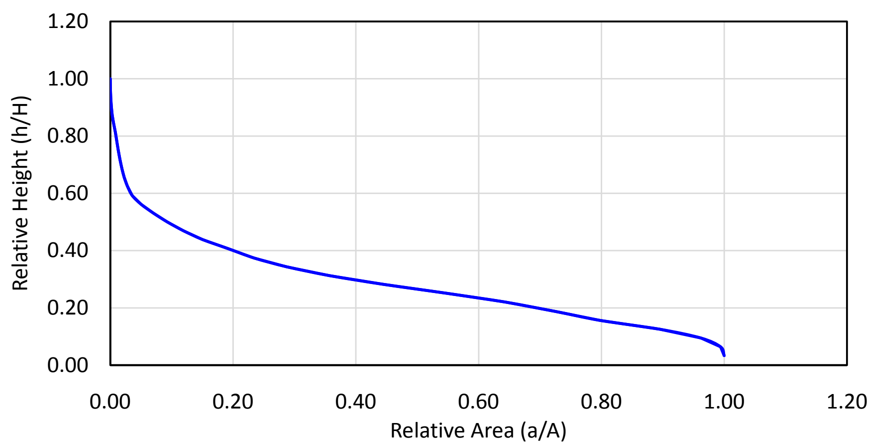

Figure 4. Graph of hypsometric integral.

Table 4. Morphotectonic parameters of Dhund river basin.

Morphot ectonic Parameter	Unit	Formula	Result
Hypsometric Integral (HI)	-	HI = (Mean Elevation − Minimum Elevation)/ (Maximum Elevation − Minimum Elevation)	Range = 0.24 - 0.84 Average = 0.49
Sinuosity Index (SI)	-	SI = (Length of Stream Channel)/(Length of Straight – Line Distance)	1.37
Asymmetry Factor (Af)	-	100 * (Ar/At)	67.29

2) Sinuosity Index (SI): The sinuosity index of river (SI) is calculated as the ratio of the channel (length of river between two points) to the length of meander axis (straight distance between those two points) [48].

SI = (Length of Stream Channel)/(Length of Straight-Line Distance)

SI is a dimensionless parameter, and its value can be categorized into 4 buckets as classified below [49]:

SI Range	Category
SI < 1.05	Straight
1.05 < SI < 1.3	Sinuous
1.3 < SI < 1.5	Moderate Meandering
SI > 1.5	Meandering Form

During the analysis the calculated values are as below:

Length of Stream Channel = 98.95;

Length of Straight-Line Distance = 71.62;

SI = **1.37** (**Table 4**) which indicates Moderate Meandering.

3) Asymmetry Factor (AF): Asymmetry factor (AF) specifies asymmetricity of a drainage basin. It detects tectonic tilting at drainage basin or any larger scale area [50].

AF can be calculated by below formula:

$$Af = 100 * (Ar/At)$$

Ar = Area of the basin to the right of the trunk stream;

At = Total drainage basin area.

Calculated value for Asymmetry Factor of the study area is **67.29** (**Table 4**).

As an asymmetric factor close to 50 denotes stable setting and uniform lithology, less than 50 signifies that the channel is shifted towards the downstream right to the drainage basin and greater than 50 indicates that the channel is shifted towards the downstream left [51]. Calculated value for the study area basin indicates an unstable setting and the channel is shifted towards the downstream left to the drainage basin.

5. Conclusion

Morphometric analysis of the basin was done by using ArcGIS and it is observed that this tool helps in making the drainage pattern analysis easier and more accurate than any other method. The basin has 6 orders of streams, and the stream ordering depicts dendritic pattern of drainage network. A lower mean value of bifurcation ratio indicates that the drainage basin is formed by uniformed materials. The low drainage density indicates that the basin area has highly permeable sub-soil material with low relief and vegetative cover. The calculated value of Stream Frequency shows a high correlation with drainage density (Dd). Elongation ratio indicates that the area has little elongated shape hence less prone to floods. Relief study of the area suggests that the basin has a relatively lower relief value which indicates the river basin has high gravity of water flow and low ruggedness number shows that the soil erosion is less likely to occur. The study on morphotectonic indices of the drainage basin suggests erosional stage and level of tectonic activity of basin are not uniform and differ from each other. Sinuosity Index value indicates moderate meandering whereas value of Asymmetry Factor is indicative of unstable setting.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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