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Morphometric Analysis of a Drainage Basin: A Study of Ghatganga River, Bajhang District, Nepal

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Abstract

This study attempts to study the morphometric characteristics of Ghatganga basin by using Geographical information system (GIS). This analysis has shown that the relation of stream order (U) and stream number (Nu)which gives negative linear pattern that order increases with a decreasing number of stream segment of a particular order. Different morphometric parameters such as stream length (Lu), bifurcation ratio (Rb), drainage density (D), stream frequency (Fs), texture ratio (T), elongation ratio (Re), circularity ratio (Rc), form factor ratio (Rf), relief ratio (Rh) and river profile have revealed the basin has dendritic pattern of drainage, indicating high relief and steep ground slope with less elongated young and mature landforms in which geological structures don't have a dominant influence on basin.

Keywords: Morphometric analysis, GIS, drainage pattern, landform, stream order

Introduction

Geomorphometry is the measurement and mathematical analysis of the earth's surface and its dimensions of the landforms (Clarke, 1996). Morphometric analysis of a river basin provides a quantitative description of the drainage system, which is an important aspect of the basins (Strahler, 1964). Drainage basin is three-dimensional extent of land where surface water from precipitation; rain, snow, sleet, hail and frost, converges to a single point or join another water body, such as a river, lake, reservoir, estuary, wetland, sea, or ocean before exiting the basin through the process of surface runoff, through flow, and groundwater flow. Storage to basin system comprises of interception by vegetation, surface storage, transpiration, evaporation, soil moisture and groundwater. Primarily, the physical, meteorological, and human characteristics control the drainage basin. Various important hydrologic phenomena can be correlated with the physiographic characteristics of drainage basins such as size, shape, slope of drainage area, drainage density, size and length of the tributaries etc. (Rastogi & Sharma, 1976). Whereas elevation and slope, rock types, soil types, drainage density, rainfall type and intensity, antecedent conditions, rates of evapotranspiration, urbanization, deforestation, afforestation, water extraction are some other factors control the basin. There are three important aspects used for analyzing the drainage basin characteristics. These are linear aspects, areal aspects, and relief aspects, which include stream order, stream length, bifurcation ratio, basin area and length, perimeter, drainage density, stream frequency, elongation ratio, circularity ratio, texture ratio and form factor ratio (Shreve, 1966). The paper aims to describe the drainage characteristics of the eastern part of Saipal rural municipality of Bajhang district. One of the purposes of this study is; to predict the quantity of overland flow, their extent and intensity to conserve nutrients and organic matter in the soil for the preservation of vegetation found in the basin.

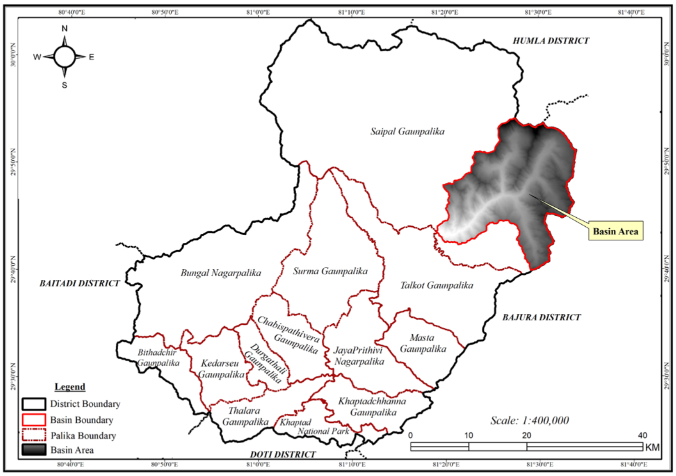

Figure 1. Location of study area

Methods and Materials

Study area

The Ghatganga drainage basin covers 348.79 km². It is situated in the eastern part of Saipal rural municipality of Bajhang district. Its geographic extent is 29° 39' 53.97" south to 29° 54' 5.22" north and 81° 18' 54.52" west to 81° 33' 51.81" east (Figure 1).

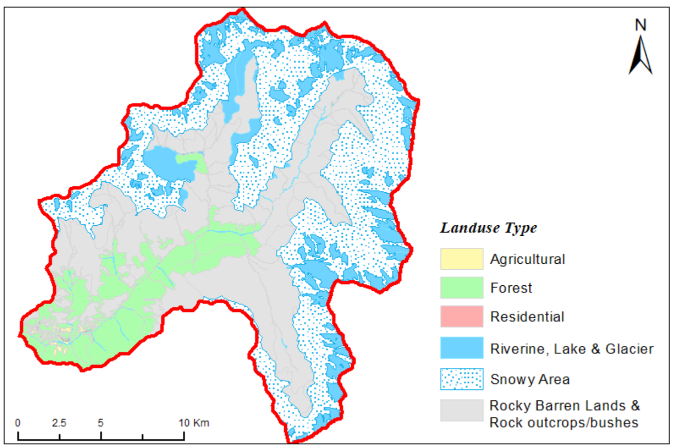

Figure 2. Land use of study area

The Ghatganga river is one of the important tributaries of Seti river. As basin located in the mountainous region; the rise of altitude up to alpine zone has created variation in temperature from high to low. The study area is bounded on the north by Saipal Himal range which has a major role in the drainage basin system (Figure 2).

Glacial lakes near its source and possible avalanche nearby could be a threat of flash flood caused by Glacial Lake Outburst Flood. The heaviest rainfall of 404.85mm is received in July because of monsoon rainfall that occurs from June to August. In the monsoon season, the small rivers and streams are filled with huge volume of water that can create the situation of floods. The lowest mean monthly temperature of Chainpur is observed as 10.9^{o}C in January and the highest mean monthly temperature as 25.4°C in June. The MCT strikes in southeast-northwest direction and separates the high-grade metamorphic rocks of the Higher Himalaya to the north and low-grade metamorphic rocks of the Midland Group of the Lesser Himalaya to the south. The vicinity of landforms around MCT (Main Central Thrust) is considered to be the geologically weak zones bearing various fractures and joints which sometimes gives rise to the opening of hot springs, and factors to the porosity and permeability. The main lithology of the study area is slate. Beside slate, quartzite, marble, phyllite, and limestone with the intrusion of basic igneous rocks are other types of rock found in this area. The age of the rock is ranging from Precambrian to Ordovician period. The metamorphic rocks such as gneiss, slate, marble, schist, quartzite, etc., and rocks with good porosity and permeability such as sandstones, limestone also occurred in the study area (Figure 3). The soil taxonomy has been studied by using USDA (United States Department of Agriculture and the National Cooperative Soil Survey) soil taxonomy (Figure 4).

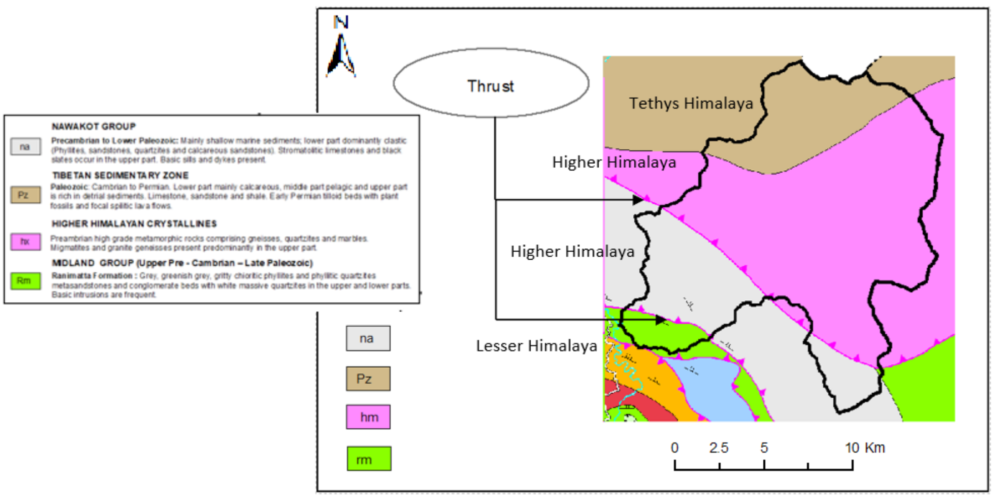

Figure 3. Geology of study area
Source: Department of Mines and Geology

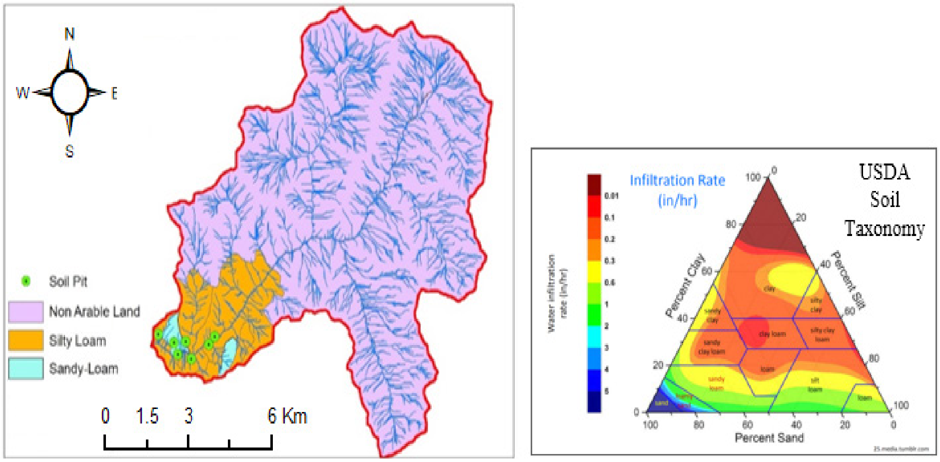

Figure 4. Soil texture
Source: TSLUMD, Survey Department, 2020

Similarly, in this study, required bio-physical information which are extracted from various maps such as land utilization, land capability, land system, topographical map, geological map. Meteorological data are also collected from the Government of Nepal. Land use map has been used to identify type of land cover such as riverine bodies, glacier area, agriculture, forest, residential, barren uncultivable land etc., of the basin area. Lands in the vicinity of river seem to have more farming activities with dense cluster of settlements.

The study area is well drained and have good fertile soil in the vicinity of river whereas the northern side has rocky barren lands, snowy and glacier area with poor vegetation. Soil map has been used to identify soil taxonomy and infiltration capacity of study area. Hydrological and Meteorological data have been used for basin's tendency of drainage capacity. Geological map has been used to identify rock types and their porosity and permeability characteristics. Topographical maps of 1:50,000 scale bearing 40 meters contour interval with 20 meters supplementary and mean sea level spot height has been used to create digital elevation model (DEM) in Modified Universal Transverse Mercator (MUTM) projection system with central meridian at 81^0 E local projection. Arc GIS software, Google earth, DoS portal, Microsoft excel tools have played major roles in hydrological analysis. Delineation of the drainage basin, preparation of imperfections free raster surface (sink), flow direction, flow accumulation, snapping pour points, stream calculated greater than 50 in raster calculator, determining Strahler stream order, raster to vectors and other various linear, areal and relief ratio are analyzed and evaluated in Arc-GIS environment. The morphometric parameters have been determined as per the standard methodology as shown in Table 1.

Table 1. Methods of calculating morphometric parameters

Morphometric Parameters	Formula	References
Linear Aspects		
Stream order (U)	Hierarchical order	Strahler,1952
Stream Length (Lu)	Length of the stream	Horton, 1945
Mean stream length (Lsm)	Lsm=Lu/Nu; Where, Lu=Mean stream length of a given order (km), Nu=Number of stream segment.	Horton, 1945
Stream length ratio (RL)	RL= Lu / Lu-1 Where, Lu= Total stream length of order (u), Lu-1=The total stream length of its next lower order	Horton, 1945
Bifurcation Ratio (Rb)	Rb = Nu / Nu+1 Where, Nu=Number of stream segments, present in the given order, Nu+1= Number of segments of the next higher order	Schumm, 1956
Sinuosity Index (SI)	SI=AL/EL Where, AL= Actual length of stream, EL= Expected straight path of the stream	Schumm, 1956
Areal Aspects		
Drainage density (Dd)	Dd=L/A Where, L=Total length of stream, A= Area of basin.	Horton, 1945
Stream frequency (Fs)	Fs=N/A Where, L=Total number of streams, A=Area of basin	Horton, 1945
Texture ratio (T)	T=N1/P Where, N1=Total number of first order stream, P=Perimeter of basin.	Horton, 1945
Form factor (Rf)	$Rf=A/(Lb)^2$ Where, A=Area of basin, Lb=Basin length	Horton, 1945
Elongation ratio (Re)	$Re=\sqrt{(Au/\pi)}/ Lb$ Where, A=Area of basin, π=3.14, Lb=Basin length	Schumm, 1956
Circulatory ratio (Rc)	$Rc=4\pi A/P^2$Where A= Area of basin, π=3.14, P= Perimeter of basin.	Miller,1953
Length of overland flow (Lg)	Lg=1/2Dd Where, Drainage density	Horton, 1945
Constant channel maintenance(C)	C=1/Dd Where, Dd= Drainage density	Horton, 1945
Relief Aspects		
Basin relief (Bh)	Vertical distance between the lowest and highest points of basin.	Schumm, 1956
Relief Ratio (Rh)	Rh = Bh / Lb Where, Bh=Basin relief, Lb=Basin length	Schumm, 1956
Ruggedness Number (Rn)	Rn=Bh×Dd Where, Bh= Basin relief, Dd=Drainage density	Schumm, 1956
Hypsometric Curve	area and elevation are plotted as functions of total area and total elevation of basin in horizontal axis and vertical axis.	Strahler,1964

Results and discussion

Morphometric analysis of a basin describes characteristics of basin based on quantitative evaluation of different parameters. Parameters are allocated according to their dimensional aspects; linear aspects, areal aspects, and relief aspects. Morphometric parameters such as relief, shape, and length also influence basin discharge patterns strongly through their varying effects on lag time (Gregory and Walling, 1973). The arrangement of streams in a drainage system constitutes the drainage pattern, which in turn reflects mainly structural or lithologic controls of the underlying rocks (Eesterbrooks, 1969). The methods of Horton (1945), Strahler (1952), Schumm (1956) are used for linear aspects studies, for areal aspects study using Horton (1945), Miller (1953) and Schumm (1956) technique, and the technique applies to relief aspects are Schumm (1956). The following calculation and evaluation have shown the descriptions regarding the basin characteristics.

Linear morphometric parameters

Linear aspects give the information about one-dimensional parameter like Stream Order, Stream Number, Bifurcation Ratio, Stream Length, Sinuosity Index. This indicates channel patterns of the drainage network with the topological characteristics of the stream segments and analysis are based on open links of the stream network.

Stream order (U)

It is defined as a measure of the position of a stream in the hierarchy of tributaries (Leopold, Wolman, & Miller, 1964). For the analysis modified Horton's law (Strahler law) has been followed because of its simplicity. The smallest, un-branched fingertip streams are designated as 1st order, the confluence of two 1st order channels give a channels segments of 2nd order, two 2nd order streams join to form a segment of 3rd order and so on. While designating stream order between two channels of different order then the higher-order is maintained. The observation shows that Ghatganga river has up to 7th order tributaries where 1st, 2nd, 3rd, 4th, 5th, 6th and 7th stream are 2277, 566, 123, 38, 6, 2 and 1 respectively in numbers (Figure 5, Table 2).

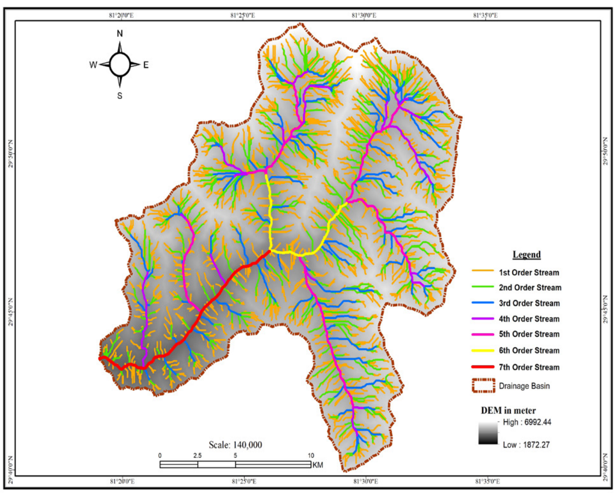

Figure 5. Strahler stream order of Ghatganga River

The total number of stream segments is 3,013. The drainage patterns of stream network indicate dendritic type that develop where the river channel follows the slope of the terrain. According to the Horton, the number of stream segments of successively lower orders in a given basin tend to form a geometric series beginning with the single segment of the highest order and increasing according to the constant ratio. The relation gives a negative linear pattern when plotted in the logarithmic and Arithmetic scale in Y-axis and X-axis respectively (Figure 6).

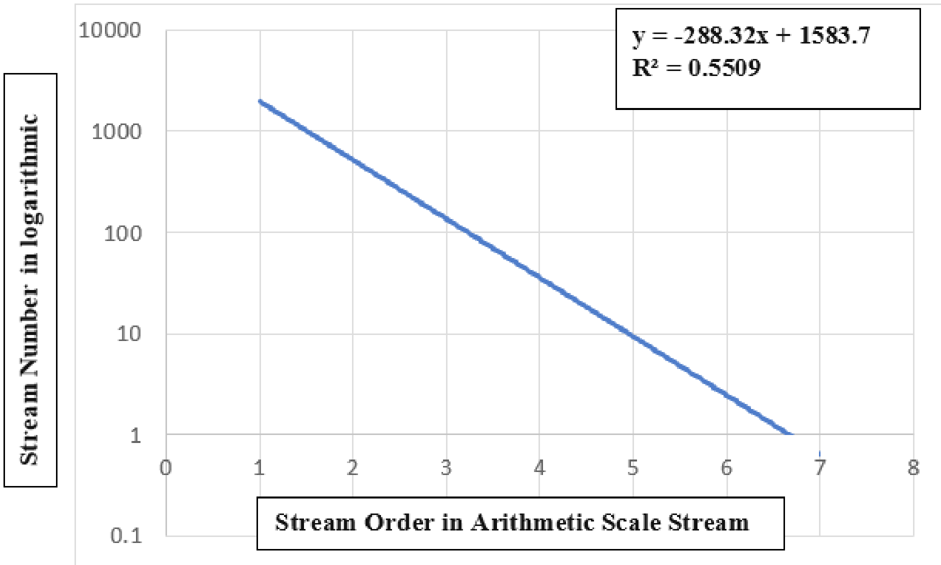

Figure 6. Stream number versus stream order

Stream length (Lu)

Stream length indicates the behavior of surface runoff on the basin which has a significant role in the drainage basin system. The stream with longer lengths is normally indicative of flatter gradient whereas the smaller length is characteristics of areas with larger slopes and finer textures. The total length of stream segments is maximum in first-order stream and decreases as stream order increases. In the study area; unexpectedly 5th and 7th order streams are relatively larger in length than their lower order stream respectively (Table 2). So, sometime, we have to consider the drainage pattern that is the result of structurally controlled joining or faults, fold in the underlying rock. These breaks in the rock are weak or least resistance areas, so the streams tend to flow or cut down along those eroded area.

Table 2. Stream length measurement

Stream Order	Stream Number	Total Length (Km)	Mean Stream Length (Km)	Cumulative Mean Stream Length
1st	2277	842.36	0.37	0.37
2nd	566	320.91	0.57	0.94
3rd	123	133.1	1.08	2.02
4th	38	35.49	0.93	2.95
5th	6	38.98	6.50	9.45
6th	2	11.74	5.87	15.32
7th	1	14.72	14.72	30.04

Stream length ratio (RL)

The stream length ratio can be defined as the ratio of the mean stream length of a given order to the mean stream length of the next lower order and having an important relationship with the surface flow and discharge and erosion stage of the basin (Horton, 1945). The calculation is shown below:

RL 21= 0.57/0.37= 1.54

RL 32= 1.08/0.57= 1.89

RL 43= 0.93/1.08= 0.86

RL 54= 6.50/0.93= 6.99

RL 65= 5.87/6.50= 0.90

RL 76= 14.72/5.87= 2.51

It is noticed that the RL between successive stream orders of the basin varies due to the differences in slope and topographic conditions.

Mean stream length ratio (Lsm)

The mean stream length is a characteristic property related to the drainage network and its associated surfaces (Strahler, 1964). The mean stream length has been calculated by dividing the mean stream length of given order by the number of stream segment. The mean stream length ratio of study area is 2.45; i.e., Lsm= (1.54+1.89+0.86+6.99+0.90 +2.51)/6= 2.45.

Figure 7 shows the relation between stream order and mean stream length is positive. Line increases geometrically while plotted in arithmetic scale in X-axis and logarithmic scale in Y-axis.

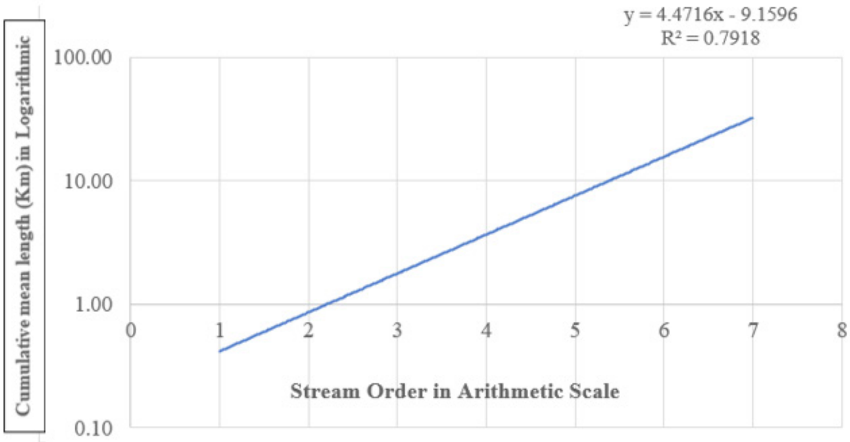

Figure 7. Stream order versus cumulative mean length of streams

Bifurcation ratio (R_b)

Bifurcation ratio is related to the branching pattern of a drainage network. It is defined as the ratio between the total numbers of stream segments of one order to that of the next higher-order in a drainage basin (Schumm, 1956). Strahler (1957) demonstrated that the bifurcation ratio shows a small range of variation for different regions or different environmental conditions, except where the geology dominates. It is observed that Rb is not the same from one order to its next order. The mean Rb of the entire basin is 3.87. According to Kale and Gupta (2001), the bifurcation ratio ranging between 3 and 5 indicate the natural drainage system within a homogenous rock. The lower value of bifurcation ratio are characteristics of the watershed which have flat or rolling watersheds while the higher values of bifurcation ratio indicate strong structural control on the drainage pattern and have well-dissected drainage basins). The higher bifurcation ratio leads to less chances of risk of flooding (Eze & Efiong, 2010).

The calculation is given below;
Rb 12= 2277/566 = 4.02
Rb 23= 566/123 = 4.60
Rb 34= 123/38 = 3.24
Rb 45= 38/6 = 6.33
Rb 56= 6/2 = 3
Rb 67= 2/1 = 2
Mean Bifurcation ratio= (4.02+4.60+3.24+6.33+3+2)/6= 3.87

The result shows the natural drainage system within a homogenous rock having dendritic pattern of drainage.

Sinuosity index (SI)

Schumm (1956) explains it as a factor to define a river deviation from the expected straight path. The meander ratio or sinuosity index is the ratio of actual length along a meandering river to the straight distance between the end points. In the study area, SI of the 7th order stream is calculated which is known as the trunk stream segment that has the highest order. For a straight river course this ratio is equal to unity. A ratio varying from 1 to 1.5 defines the river course as sinuous and from 1.5 to 4 as meandering. The SI value of the 7th order is 1.14 in the study area. So, the course of a stream is sinuous which is in-between straight and meandering typology of basin as shown in Figure 8.

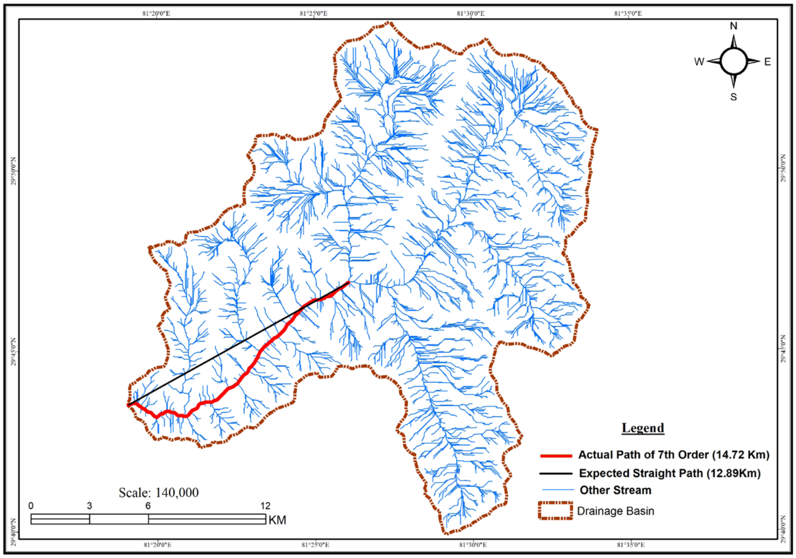

Figure 8. Sinuosity index

Areal morphometric parameters

Areal aspects deal with two-dimensional parameters like basin shape and area, drainage density, drainage texture, stream frequency, elongation ratio, circularity ratio, and form factor. The area of the basin is defined as the total area flowing to a given outlet, or pour point upon a horizontal plane contributing to cumulate of all orders of a basin which are delineated by ridgelines which are called water divides. Perimeter is the length of the outline of a basin that can be plot and calculate in the GIS software. The area and parameters of the basin are found to be 348.79 km² and 113.96 km respectively.

Drainage density (Dd)

It is the ratio of total channel segment length cumulated for all orders within a basin to the basin area. It is expressed in terms of Km/Km^2. The drainage density is an expression of the closeness of spacing of channels (Horton, 1932). Dd is suggested that the low drainage density indicates the basin is a highly permeable subsoil and thick vegetative cover (Nag & Chakraborty, 2003). High drainage density is the result of weak or impermeable subsurface material, sparse vegetation, and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture. Drainage texture is a measure of relative channel spacing in a fluvial-dissected terrain, which is influenced by climate, rainfall, vegetation, lithology, soil type, infiltration capacity, and stage of development (Smith, 1950). In the study area, Dd is 4.01 km/km^2 which indicates, moderate drainage texture and steeply to very steeply sloping mountainous terrain with variation in vegetation coverage. Smith has classified drainage texture into five different textures.

Stream frequency (Fs)

The stream frequency (Fs) of a basin may be defined as the total number of stream segments within the basin per unit area (Horton, 1945). Stream frequency exhibits a positive correlation with drainage density in the watershed indicating an increment in stream population with respect to increase in drainage density. Climatic character, vegetation coverage, rock and soil types, rainfall intensity, infiltration capacity, relief, run-off intensity, permeability terrain, slope has played vital role in controlling the drainage frequency and density. The Fs for the basin is 8.6. Greater the drainage density and stream frequency in a basin, the runoff is faster, and therefore, flooding is more likely in basins with a high drainage and stream frequency (Kale & Gupta, 2001).

Texture ratio (T)

Texture ratio is an important factor in the drainage morphometric analysis which is depending on the underlying lithology, infiltration capacity, and relief aspect of the terrain (Schumm, 1956). The texture ratio is expressed as the ratio between the first-order streams and the perimeter of the basin. The texture ratio in the study area is 19.98 km^{-1}.

Form factor (Rf)

Form factor (Rf) is defined as the dimensionless ratio of the basin area to the square of the basin length. This factor indicates the flow intensity of a basin of a defined area (Horton, 1932). The value of form factor would always be less than 0.754 (the value indicating to a perfectly circular watershed). The smaller the value of the form factor, the more elongated will be the basin whereas the higher values corresponding to the circular basin. Basins with high form factors experience larger peak flows of shorter duration, whereas elongated watersheds with low form factors experience flatter peak flows of longer duration. The Rf value for the study area is 0.46, which is more towards the circular shape of the basin rather than elongated.

Elongation ratio (Re)

Elongation ratio (Re) is defined as the ratio of the diameter of a circle of the same area as the drainage basin and the maximum length of the basin (Schumm, 1956). The maximum length of the basin is plotted in GIS as shown in Figure 9. Schumm's ratio shows values between 0.6 and 1.0 over a wide variety of climatic and geologic types. The varying index of elongation ratio can be classified as; circular (0.9-0.10), oval (0.8-0.9), less elongated (0.7-0.8), elongated (0.5-0.7), and more elongated (< 0.5). A circular basin is more efficient in the discharge of runoff than an elongated basin (Singh and Singh, 1997). The value ranges from 0.6 to 0.8 for regions of high relief and the values close to 1.0 have very low relief with circular shape (Magesh et al., 2013). The Re of the study area is 0.77 that indicates less elongated, steep to steepy slope and high relief.

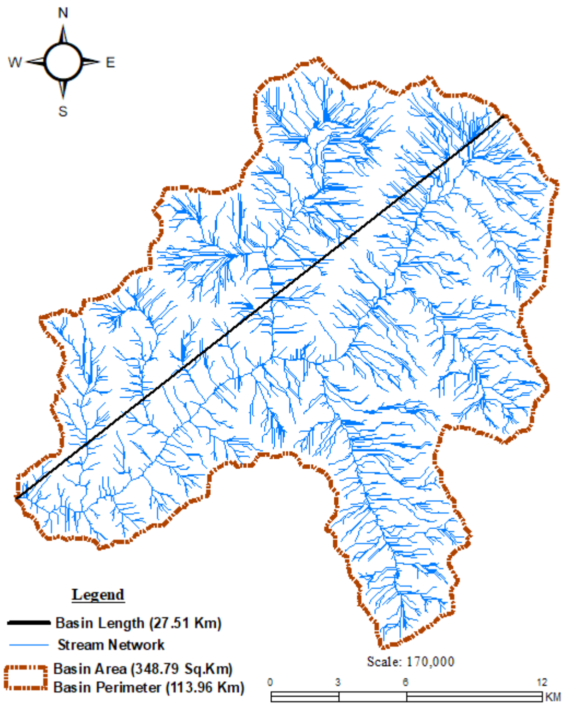

Figure 9. Basin's geometry

Circulatory ratio (Rc)

Circulatory Ratio is defined as the ratio of the area of a basin to the area of the circle having the same circumference as the perimeter of the basin (Miller, 1953). The value of the ratio is equal to unity when the basin shape is a perfect circle and is range 0.4–0.5 when the basin shape is strongly elongated and highly permeable homogeneous geologic materials. Rc is influenced by the frequency of stream, slope, relief geologic structure, climate and land use/landcover of the basin. The Rc value of the basin is 0.34 indicating elongated shape, low discharge of runoff, and high permeability of the subsoil conditions. Rc is a dimensionless number. Its low, medium, and high values are indicative of the youth, mature, and old stages of the life cycle of the tributary basins (Rafiq et al., 2013).

Length of overland flow (Lg)

The Length of Overland Flow (Lg) is defined as the length of water over the ground before it gets concentrated into mainstream which affect hydrologic and physiographic development of the drainage basin (Horton, 1945). Lg is significantly affected by infiltration (exfiltration) and percolation through the soil, both varying in time and space (Schmid, 1997). The high Lg value indicates that the rainwater had to travel a relatively longer distance before getting concentrated into stream channels (Chitra et al., 2011). The value for the length of overland flow in this study is 0.12 km which shows lower distance runoff in the study area.

Constant channel maintenance(C)

Schumm (1956) has used the inverse of the drainage density having the dimension of length as a property termed constant of channel maintenance. This constant, in units of square feet per foot, has the dimension of length and therefore increases in magnitude as the scale of the land-form unit increases. Channel maintenance of the basin is 0.25. It means that on an average 0.25 sq. ft surface is needed in the basin for the creation of one linear foot of the stream channel.

Relief morphometric parameters

Relief Aspects deals with three-dimensional parameters like Relief, Relief Ratio, Ruggedness Number, Slope, River profile, Gradient Ratio and Hypsometric Curve.

Basin relief (Bh)

The basin relief (Bh) is defined as the difference in elevation between the highest and the lowest points on the valley floor of a basin. Relief is measured by subtracting the elevation of the mouth of the basin from the highest point within the basin. It is an important factor in understanding the denudational characteristics of the basin and plays a significant role in landform development, drainage development, surface and sub-surface water flow, permeability, and erosional properties of the terrain. In the study, Bh is obtained as 5120.17m. So, the high relief value of basin indicates the gravity of water flow, low infiltration, and high runoff conditions (Magesh, Jitheshlal, & Chandrasekar, 2013).

Relief ratio (Rh)

Relief ratio is defined as the ratio between the total relief of a basin i.e., elevation difference of lowest and highest points of a basin, and the longest dimension of the basin parallel to the principal drainage line (Schumm, 1956). It is a dimensionless ratio. The high values of Rh indicate steep slope and high relief and vice-versa. Run-off is generally faster in steeper basins, producing more peaked basin discharges and greater erosive power (Palaka & Sankar, 2016). The value of Rh in the basin is 0.19 indicating high relief and high slope. The result is also visually interpreted and calculated by using Google earth and a topographical map of 1:50,000.

Ruggedness number (Rn)

Rn is the product of maximum basin relief (Bh) and drainage density (Dd), where both parameters are in the same unit. It is a measure of surface unevenness (Selvan, Ahmad, & Rashid, 2011). An extremely high value of ruggedness number occurs when both variables are large and the slope is steep (Strahler, 1956). The value of ruggedness number in the present basin is 20.5 which has a steep slope and suggests more prone to soil erosion.

Hypsometric curve

A hypsometric curve is a graphical representation showing on the abscissa the basin areas situated above various altitudes. If necessary, the basin areas can be given as %ages of the total. The hypsometric curve has also been termed the drainage-basin relief graph (Zävoianu, 1985). It reveals a degree of dissection and stage of erosion. The more mature the river the hypsometric curve is more concave. From the curve, we can know which part of the river basin is more or less eroded or denuded in comparison to other parts. The hypsometric curve below is almost 'S' shaped with concave upward shaped for higher elevation points, whereas convex upward for the lower elevation points. The curve indicates landform with elevation between 1872.27m to 5000m has equilibrium mature stage and above 5000m has an in-equilibrium young stage. This marks the presence of mature and youthful landforms as shown in Figure 10 which is based on the model proposed by Ritter and his company in 2002. (Martinez, Ramírez, Steinich, & Tuxpan, 2017).

Table 3. Morphometric Results of basin

S.N.	Parameter	Calculated Value
1	Basin Area	348.79 Km^2
2	Perimeter	113.96 Km
3	Basin order	7th
4	Basin Length (Lb)	27.51 Km
5	Mean Bifurcation ratio (Rb)	3.87
6	Stream frequency (Fs)	8.6 Km^{-2}
7	Drainage density (Dd)	4.01 km/km^2
8	Basin relief (Bh)	5120.17 m
9	Relief ratio (Rh)	0.19
10	Texture ratio(T)	19.98 km^{-1}
11	Ruggedness number (Rn)	20.5
12	Form Factor (Rf)	0.46
13	Circulatory ratio (Rc)	0.34
14	Elongation Ratio (Re)	0.77
15	Length of overland flow (Lg)	0.12 km
16	Constant channel maintenance (C)	0.25 Km
17	Sinuosity Index of 7th order (SI)	1.14

Source: Calculation by author based on parameters shown on Table 1.

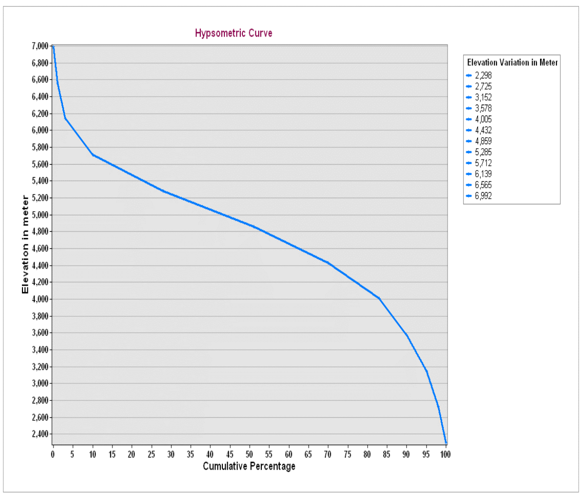

Figure 10. Hypsometric curve of Ghatganaga river basin

Conclusion

The measurement of linear, areal and relief aspects based on DEM generated from contour and spot height are really useful to identify physical and meteorological characteristics of the particular basin area. In this study, it is observed that the value indicated by bifurcation ratio, elongation ratio, drainage density, stream frequency, length of overland, relief ratio and hypsometric curve; the basin with 7th order stream has steep to very steep sloping mountainous terrain. Variation in vegetation coverage, rock and soil types highlights the ecological importance of the basin area which comprises of several plant and animal species and their relation with physical surroundings. Drainage pattern depends on the topography and geology of the land. The pattern of the drainage is dendritic in the study area. Many contributing streams joined together into the tributaries of the main river at acute angle and pattern mainly develop where the river channel follows the slope of the terrain. Basin with 'S' shaped curve indicates landform with varying stage that of both equilibrium mature stage and in-equilibrium young stage. The length of overland flow denotes high infiltration and percolation characteristics of soil. Drainage basin has less elongated shape experiencing peak flows of shorter duration with lower distance runoff. So, GIS has proved to be an effective and efficient tool for computation and analysis of various morphometric parameters of the basin.

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