

MORPHOMETRIC ANALYSIS IN GIS FRAMEWORK: A CASE STUDY IN CHAMPABATI WATERSHED

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Abstract - The present study deals with the morphometric analysis and soil loss estimation of CHAMPABATI watershed, Assam. ASTER DEM data has been utilized in Arc-GIS environment for carrying out morphometric analysis to get the various morphometric parameters and their correlation with stream order. Geographical Information System (GIS) has proved to be an efficient tool in delineation of drainage pattern and water resources management and its planning. GIS technique is adopted for the identification and analysis of morphological features and their properties of the CHAMPABATI watershed. The basin morphometric parameters such as linear, aerial and relief aspects of the watershed were determined and computed. It is 5th order drainage basin and drainage pattern mainly in dendritic type. Low bifurcation ratio of the watershed indicates its weak structural control on the drainage. It is observed that the drainage density value is low which indicates the basin is highly permeable subsoil. The circularity ratio value reveals that the basin is elongated and highly permeable homogenous geologic materials.

Key Words: Champabati, Gis, Morphometric, Linear, Areal, Relief

1. INTRODUCTION:

Mathematical analysis and measurement of the configuration of the earth's surface, its shape and dimensions of landforms is called as morphometric analysis. Watershed morphometric characteristics cover important information regarding the catchment area, its formation and development because all geomorphic and hydrologic processes occur within the watershed. Morphometric analysis is the framework within which the Geographer and Geomorphologists examines shapes and forms in space. The bases of morphometric analysis are generally Geometric, Mathematical and Statistical.

Morphology (of river) is a field of science which deals with the change in a river's plan form and cross-sections due to erosion and sedimentation. In the field, dynamics of flow and sediment transport are the principal elements. The morphological studies, therefore, play an important role in planning, designing and maintaining river engineering structures. In recent years, there has been a growing awareness about the need for taking up morphological studies of rivers in the country, especially with particular reference to their unique problems. For a scientific and rational approach to different river problems and proper planning and design of water resource projects, an understanding of the morphology and behaviour of the river is a pre-requisite.

The term 'morphometry' means the measurement and analysis of form characteristics. Morphometric studies in the field of hydrology were first initiated by Horton and Strahler in the 1940s and 1950s. The main purpose of this work was to discover holistic stream properties from the measurement of various stream attributes.

River morphology is of great interest to hydraulic engineers, geologists, geomorphologists, geographers and environmental engineers since many of the complex problems they have to deal with are due to the form of streams created by the erosion, transportation and deposition of sediment carried by them. River characteristics are reasonably understood by the morphometric analysis of that particular river basin.

2. LOCATION AND PHYSIOGRAPHY:

Latitude = N 26° 15' 44.352"

Longitude = E 90° 28' 39.54"

Champabati River flows west to Aai River. It is a combination of three rivers- "Bhur River", "Mora Bhur River", "Lopani" and "Dhol pani" which are flowing out from Bhutan hills. Among them "Bhur River" is biggest. Bhur River is originated from a place called Gurungdando and flows 14 km south east to Bhur Village and entered into Assam near post no.267 and flows south for 2km and takes a small river called "Patiakhola" in its left. Then the river turned into a narrow sandy form and flows 13 km through Manas National Park and arrives at Shantipur. From Shantipur the river flows 4km in south west direction and entered into Bengtal Sanctuary taking Khungrung River at its right in Hantupara. After coming through the sanctuary for 2km, a tributary flows out to south taking the name of Baahbari River. 1Km from that another tributary flows out to south. Then the Bhur River flows another 1 km to reach the Saalbari Bhurpar which is in south of Baahbari forest. After 2.5 km from that, the

river takes two tributary from phoolkumari River in its both sides. From this place the river flows 2 km to meet with the Dholpani river which is west to centre Ranikhata and it finally takes the name of Champabati River. Dholpani is Champabati's one of the most prominent tributary. The Dholpani River is initiated in Bhutan and it flows 9 km south and reach near to Assam and west to Bhur River. Then it flows in Assam Bhutan border and flows 3 km in south west and enters into Assam. Near the border Dholapani takes Arne Khola River in its right. Then the river flows 4km south and takes Tiniabadhi river in its right and turns to south east. The river flows through Chirang sanctuary for 12 km and takes Champabati in its right. Then the river flows for 1km and takes Kalikhola or Potolsonol River in its right and flows south west and flows for 1km and reach Charaguri. Then the Dholpani River turns into a sandy river and flows for 7km and then takes Lopani River in its right.

This Lopani River is also a big river. Lopani flows west to Dholpani. Kharpani river enters into Assam and flows south east for 1km and takes kofole khola river to its left and forms Lopani River. Then the river flows through Chirang forest for 9 km and takes a tributary from Jhora Beel to its right and flows for 12 km before it meets the Dholpani river. Dholpani and Lopani combined themselves to take the name of Champabati River. It flows to south east for 3 km and join Bhur River to its right in Centre ranikhata and then it flows as Champabati River. After flowing for 2km in south from centre Ranikhata a tributary is emerged and takes the name of Demdema River and flows to west for 2km and again join Champabati. Then the Champabati flows for another 2km and takes Raampati River to its left. Then the river flows for 3km south and takes Morabhur River to its left.

In Saalbari Champabati divides into two parts after crossing 31(c) National Highway. The main part flows to south east and the other part flows in the south west in Tarang River's path. The main Champabati river flows south and takes a zig zag path and after flowing for 5km it takes Sukti river in its left in Tirimari. From Tirimari the river flows for 3km in south east and takes Shakati River in its left. From that the river flows for 1.5 km and takes kakormari Dokong River in its left and flows another 1 km before it crossed railway line 2km from Basugaon Railway station. Then the river flows for 10 km in south east direction in zigzag path and then follows a straight path before reaching Tilakgaon. Here it takes Duramari river in its left.

Then near Bidyapur it takes Kujia River in its left. Then west to Lathuri Tila the river flows for 2.5 km and reach Naaldoba. Here the river again divided itself into 2 parts. The main part flows south east and near bamuni Tila it flows for 5km and takes Ghoga River to its left. Then eventually the two parts meet again and flows for another 1 km before crossing 31st National Highway. From here it flows for 3km and opposite to Jalikura it takes Tunia River in its left. Then the river flows to south west. Then it flows for 3km and takes Garojhara in its right. Then it flows for 2km and it reach Chapar town. From Chapar the river flows for 1km and joins Brahmaputra.

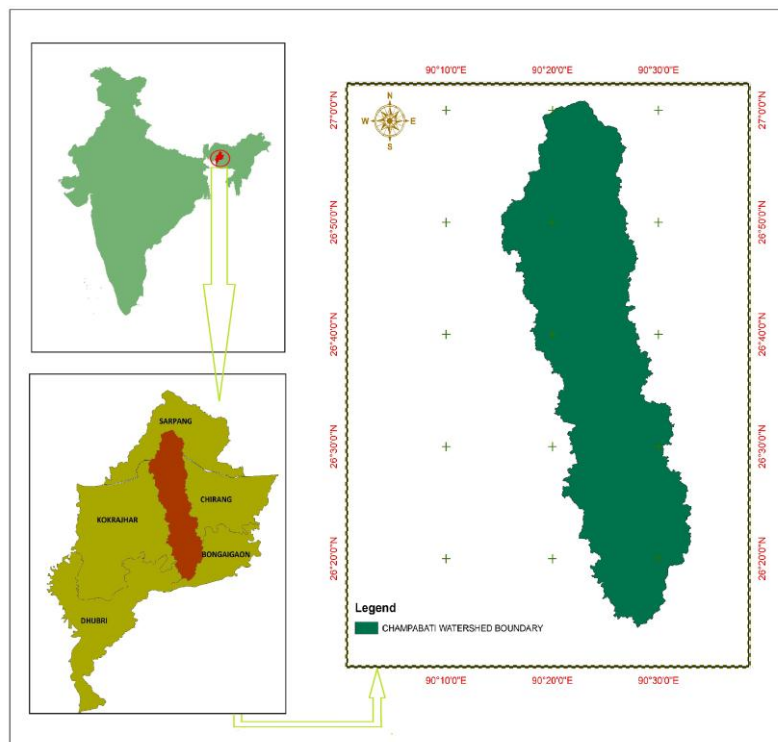
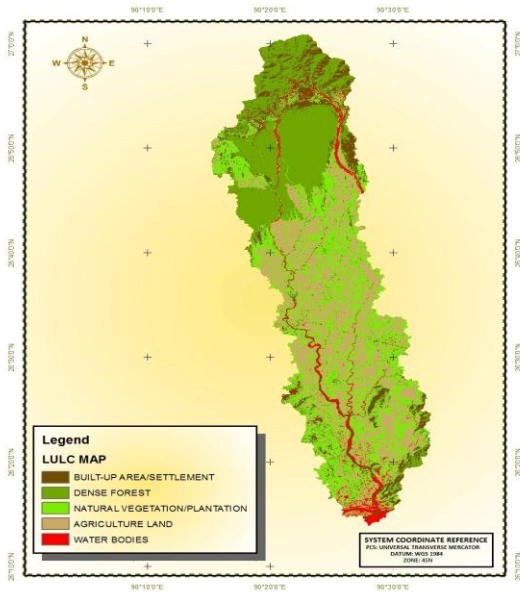


Fig 1: Location map of the study area

2.1 LAND USE/LAND COVER OF STUDY AREA:

Table -1: APPROXIMATE AREA UNDER EACH LAND USE TYPE



SL NO	LAND USE TYPE	AREA (KM ²)	AREA (%)
1	BUILT-UP AREA/SETTLEMENT	130.595	10.392
2	DENSE FOREST	288.599	22.965
3	NATURAL VEGETATION/PLANTATION	413.096	32.872
4	AGRICULTURE LAND	374.959	29.836
5	WATER BODIES	49.444	3.935

Fig 2: Land use land cover map

3. MORPHOMETRIC PARAMETER ESTIMATION:

3.1 Linear Aspects:

The drainage network transport water and the sediments of a basin through a single outlet, which is marked as the maximum order of the basin and conventionally the highest order stream available in the basin considered as the order of the basin. The size of rivers and basins varies greatly with the order of the basin. Ordering of streams is the first stage of basin analysis.

3.1.1 STREAM ORDER (S₀) :

There are four different system of ordering streams that are available (Gravelius, 1914; Horton, 1945;. Strahler’s system, which is a slightly modified of Hortons system, Strahler, 1952; Schideggar, 1970) has been followed because of its simplicity, where 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. When two channel of different order join then the higher order is maintained. The trunk stream is the stream segment of highest order. The CHAMPABATI watershed is designated as fifth order watershed having a total number of 250 stream segments of different orders (Fig 5). There are 201 first order streams, 37second order streams, 8 third order streams, 3 fourth order streams, and the highest order stream that is available in this basin is fifth order stream.

3.1.2 STREAM LENGTH (L_n):

The total length of the streams in each order is referred as stream length of that order (Horton, 1945). Stream length of an order divided by its stream number gives the mean stream length of that order. The stream length follows Horton’s law of stream length which states that the mean length of streams of each different order in a given drainage basin tends closely to approximate a direct geometric series in which the first term is the mean length of the streams of the first order. As shown in table 2, Total stream length of the basin was 958.20 km, first order is 461.08 km, 226.55 km for second order, 178.95 km for third order , 56.25 km for fourth order and 35.37 for fifth order. The logarithm of stream length of each order as a function of order is plotted and yields a set of points lying generally along a straight line Chart 1.

3.1.3 STREAM LENGTH RATIO (L_{ur}):

Horton (1945) states that the length ratio is the ratio of the mean (L_U) of segments of order (S_0) to mean length of segments of the next lower order (L_{U-1}), which tends to be constant throughout the successive orders of a basin. Stream length ratio varies from 0.85 to 1.20 for the study area.

3.1.4 BIFURCATION RATIO (R_b):

The ratio of number of streams of any given order (N_u) to the number of streams in the next higher order (N_{u+1}) is called bifurcation ratio (Horton, 1932). Bifurcation ratios in general have a range from about 2.0 for flat or rolling areas to 3.0 to 5.0 for mountainous, hilly and highly dissected basins (Horton, 1945). Strahler (1964) found that bifurcation ratio characteristically ranges between 2.0 and 5.0 in watersheds in which the geological structures do not distort the drainage basin. In CHAMPABATI watershed the mean bifurcation ratio was observed to be 3.94. Usually this type of value is common in the areas where geologic structures do not exercise a dominant influence on the drainage pattern

3.1.5 LENGTH OF BASIN (L_b):

Several people defined basin length in different ways, such as Schumm (1956) defined the basin length as the longest dimension of the basin parallel to the principal drainage line. Gregory and Walling (1973) defined the basin length as the longest in the basin in which are end being the mouth. The equation Schumm (1956) used for calculation of stream length that is 75.560 km (Table 3).

3.2 Areal Aspects:

The areal aspect is the two dimensional properties of a basin. It is possible to delineate the area of the basin which contributes water to each stream segment. The watershed can be traced from where the stream has its confluence with the higher order stream along hillcrests to pass upslope of the source and return to the junction.

3.2.1 STREAM FREQUENCY (F_s):

Horton (1945) defined stream frequency as the number of stream segments of all orders per unit area of the basin. High stream frequency is favoured in regions of impermeable subsoil and steep gradients. Higher the stream frequency, faster is the surface run-off and therefore less time for infiltration. The lower value indicates that the basin possess low relief and less number of streams. The existence of less number of streams in a basin indicates matured topography, while the presence of large number of streams indicates that the stream is youthful and still undergoing erosion. The stream frequency for study area is 0.20 per square km.

3.2.2 DRAINAGE DENSITY (D_d):

Drainage density is the average length of streams per unit area within the basin (Horton, 1945). Drainage density may be thought of as an expression of the closeness of the spacing of channels. Low drainage density is favoured in regions of highly resistant or highly permeable subsoil materials, under dense vegetative cover and low relief. High drainage density is favoured in regions of weak or impermeable subsurface materials, scarce vegetation, and mountainous relief. Drainage density is a useful numerical measure of land dissection and run-off potential. Krishnamurthy et al (1996) classified drainage density as very coarse for $D_d < 2$, coarse for $D_d = 2$ to 4, moderate for $D_d = 4$ to 6, fine for $D_d = 6-8$ and very fine for $D_d > 8$ (Jaiswal et al, 2007). The overall drainage density (D_d) of the CHAMPABATI watershed is 0.77 km/sq.km (Table 3)

3.2.3 CONSTANT OF CHANNEL MAINTENANCE (C_m):

Schumm (1956) used the inverse of drainage density or the constant of channel maintenance as a property of landforms. The constant indicates the number of Km of basin surface required to develop and sustain a channel 1 Km long. The constant of channel maintenance indicates the relative size of landform units in a drainage basin and has a specific genetic connotation (Strahler, 1957). Regarding the study area, the average constant of channel maintenance is 1.29. (Table 3)

3.2.4 DRAINAGE INTENSITY (D_i):

Faniran (1968) defines the drainage intensity, as the ratio of the stream frequency to the drainage density. This low value of drainage intensity implies that drainage density and stream frequency have little effect (if any) on the extent to

which the surface has been lowered by agents of denudation. With these low values of drainage density, stream frequency and drainage intensity, surface runoff is not quickly removed from the watershed, making it highly susceptible to flooding, gully erosion and landslides. The study area has low drainage intensity of 0.52.

3.2.5 INFILTRATION NUMBER (IF):

The infiltration number of a watershed is defined as the product of drainage density and stream frequency and given an idea about the infiltration characteristics of the watershed. The higher the infiltration number, the lower will be the infiltration and the higher run-off. It is inversely proportional to the infiltration capacity of the basin. The infiltration number of the CHAMPABATI watershed is 0.31 (Table 3).

3.2.6 LENGTH OF OVERLAND FLOW(L_g):

It is all about the soil infiltration capacity when it's exhausted due to heavy precipitation, the excess water flow towards channel and steep slope. It is important parameters to analyse runoff and flood process. According to Horton (1945), this parameter is in most cases half the average distance between the stream channels and hence it approximately equals to half the reciprocal of drainage density. The shorter the length of overland flow, the quicker the surface runoff from the streams. It is inversely related to the average slope of the basin. The study area has length of overland flow value 0.42 (Table 3)

3.2.7 BASIN AREA (A):

The area of the watershed is another important parameter like the length of the stream drainage. Schumm (1956) established an interesting relation between the total watershed areas and the total stream lengths, which are supported by the contributing areas. The basin area computed using GIS software, which is 1256.695 km².

3.2.8 BASIN PERIMETER (P):

Basin perimeter is the outer boundary of the watershed that enclosed its area. It is measured along the divides between watersheds and may be used as an indicator of watershed size and shape. The basin perimeter computed using GIS software, which is 297.155 km.

3.2.9 FORM FACTOR (F_f):

Form factor is the ratio of the basin area (A) to the square of the maximum length of the basin (L) (Horton, 1945). Form factor varies from 0 to 1. Low form factor indicates elongated basin. Low form factor ratio will be for basins of flatter peak flow for longer duration (Biswas, 1999) with less side flow for shorter duration and main flow for longer duration (Reddy, 2002), and vice versa for high ratio. In CHAMPABATI watershed, F_f value is 0.2201 indicating it to be elongated in shape and suggesting flatter peak flow for longer duration.

3.2.10 DRAINAGE TEXTURE (Dt):

Horton (Horton, 1945) defined drainage texture as the total number of stream segments of all order in a basin per perimeter of the basin. Smith (1950) has classified drainage texture into 5 different textures i.e., very coarse (<2), coarse (2 to 4), moderate (4 to 6), fine (6 to 8) and very fine (>8). In present study the watershed has a drainage texture of 0.85 (Table 3)

3.2.11 ELONGATION RATIO (Re):

According to Schumm (1956) the shape of any drainage basin is expressed by the elongation ratio (Re), which is the ratio between the diameter of a circle with the same area as the basin and maximum length of the basin. Similar to the elongation ratio Miller (1953) used a measure which is the ratio of circumference of a circle with same area as the basin to the basin perimeter. The value of elongation ratio generally varies from 0.6 to 0.1 associated with a wide variety of climate and geology (Strahler, 1964). Values close to 1.0 are typical of regions of very low relief, whereas that of 0.6 to 0.8 are associated with high relief and steep ground slope (Dar et al., 2013). These values can be grouped into four categories, viz., circular (>0.9), oval (0.9-0.8), less elongated (0.8-0.7) and elongated (<0.7) (Sentivelan et al., 2012). The Re for the CHAMPABATI watershed is 0.529 which indicates watershed to be elongated in shape with moderate to low relief.

3.2.12 CIRCULARITY RATIO (R_c):

The circularity ratio has been used as an aerial aspect and is expressed as the ratio of basin area (A_u) to the area of a circle (A_c) having the same perimeter as the basin (Miller, 1935). Similar to form factor, value nearer to one means more circular shape (Strahler, 1964). The value of circularity ratio varies from 0 (in line) to 1 (in a circle). It is a significant ratio, which indicates the dendritic stage of a basin. Its low, medium and high values are indicative of the youth, mature and old stages of the life cycle of the tributary basins. Circularity ratio of CHAMPABATI is 0.18 which is below 0.5 and shows strongly elongated basin with semi permeable homogeneous lithology. (Table 3)

3.2.13 COMPACTNESS COEFFICIENT (C_c):

Compactness Coefficient is unity for a perfect circle and increases as the basin length increases. Thus, it is a direct indicator of the elongated nature of the basin. The study area has compactness coefficient value of 2.36.

3.3 Relief Aspect:

Linear and areal features have been considered as the two dimensional aspect lie on a plan. The third dimension introduces the concept of relief. By measuring the vertical fall from the head of each stream segment to the point where it joins the higher order stream and dividing the total by the number of streams of that order, it is possible to obtain the average vertical fall.

3.3.1 RELIEF RATIO (R_h):

Difference in the elevation between the highest point of a watershed and the lowest point on the valley floor is known as the total relief of the river basin. The relief ratio may be defined as the ratio between the total relief of a basin and the longest dimension of the basin parallel to the main drainage line (Schumm, 1956). Normally, it has inverse correlation with drainage area and size of drainage basin. As the basin area decrease, relief ratio increases and vice versa (Joji, 2001). The relief ratio of the CHAMPABATI watershed is 0.028.

3.3.2 RELATIVE RELIEF (R_r):

Relative relief termed as 'amplitude of available relief' or 'local relief' is defined as the difference in height between the highest and the lowest points (height) in a unit area. Melton (1958) suggested to calculate relative relief by dividing the difference of height between the highest and lowest points in the basin (H) with basin perimeter (P), thus relative relief = H/P . Relative relief is calculated on the basis of highest and lowest elevations and the data of relative relief so derived are tabulated and classified into three categories viz. (i) low relative relief = 0m – 100m, (ii) moderately relative relief 100m – 300 m and (iii) high relative relief = above 300m. For present study, it is 0.72.

3.3.3 RUGGEDNESS NUMBER (R_n):

Strahler's (1968) ruggedness number is the product of the basin relief and the drainage density and usefully combines slope steepness with its length. An extreme high value of ruggedness number occurs when both variables are large and slope is steep (Strahler, 1956). The low ruggedness value of watershed implies that area is less prone to soil erosion and have intrinsic structural complexity in association with relief and drainage density. Ruggedness Number of CHAMPABATI watershed is 1.66.

4. DATA ACQUISITION AND RESULTS:

In order to estimate the morphometric parameters of the CHAMPABATI watershed, ASTER (Advanced Space borne Thermal and Reflection Radiometer) DEM (digital elevation model) with resolution 30m x 30m is downloaded from the (<http://www.usgs.gov>) website.

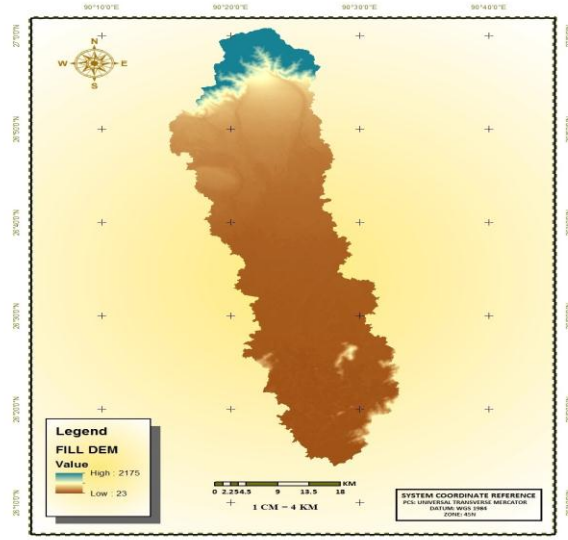


Fig 3: DEM of CHAMPABATI watershed

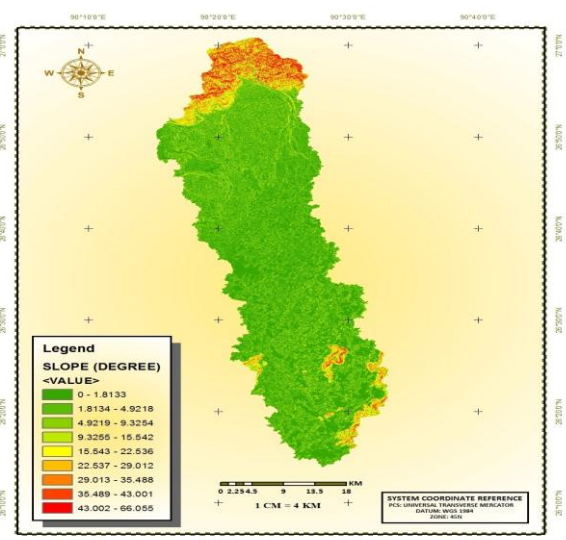


Fig 4: Slope map

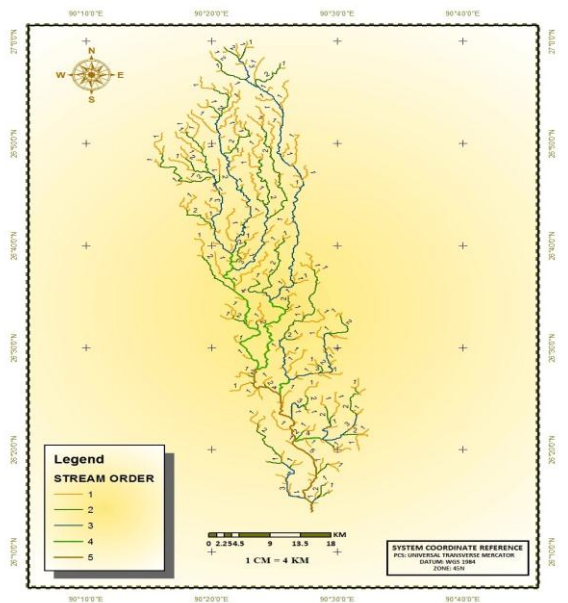


Fig 5: Stream order map

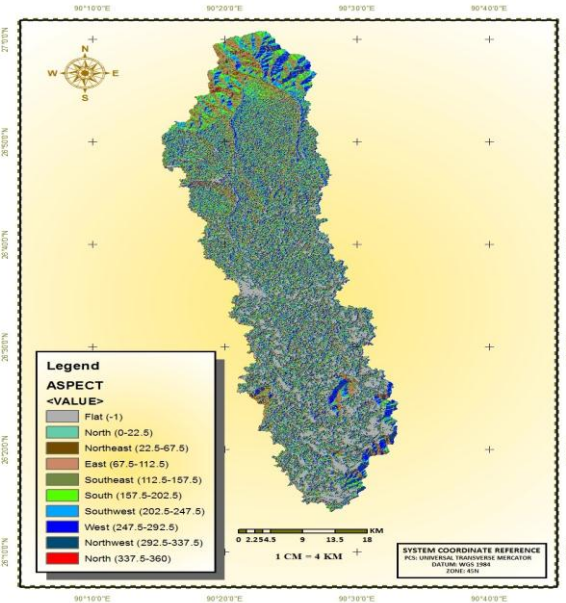


Fig 6: Aspect map

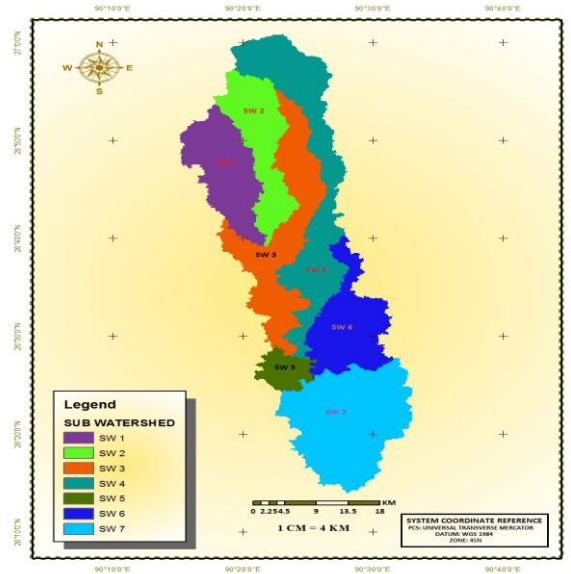


Fig 7: Sub watershed map

Table 2: LINEAR ASPECT OF CHAMPABATI WATERSHED

STREAM ORDER	NUMBER OF STREAM	TOTAL STREAMLENGTH (KM)	MEAN STREAM LENGTH	STREAM LENGTH RATIO	Log (Nu)	Log (Lu)	BIFURICATION RATIO	MEAN BIFURICATION RATIO
1	201	461.08	0.55	-	2.30	2.66	5.43	3.94
2	37	226.55	0.49	0.89	1.57	2.35	4.63	
3	8	178.95	0.53	1.08	0.90	2.25	2.67	
4	3	56.25	0.45	0.85	0.48	1.75	3	
5	1	35.37	0.54	1.20	0	1.54	-	

Table 3: MORPHOMETRIC ANALYSIS OF CHAMPABATI WATERSHED

SL NO	MORPHOMETRIC PARAMETER	FORMULA	RESULT	REFERENCE
LINEAR ASPECTS				
1	Stream Order (S_o)	Hierarchical Rank (GIS)	5	Strahler (1964)
2	Stream Number (N_u)	$N_u = N_1 + N_2 + \dots + N_n$ (GIS)	250	Horton (1945)
3	Stream Length (L_u) Km	$L_u = L_1 + L_2 + \dots + L_n$ (GIS)	958.20	Horton (1945)
AREAL ASPECTS				
4	Watershed Length (L_b) Km	$1.312 \times A^{.568}$	75.560	Schumm(1956)
5	Mean Basin Width (W_b) Km	$W_b = \frac{A}{L_b}$	16.631	Horton (1932)
6	Basin Area (A) Km^2	GIS Software Analysis	1256.695	Schumm(1956)
7	Basin Perimeter (P) Km	GIS Software Analysis	297.155	Schumm(1956)
8	Relative Perimeter (P_r)	$P_r = \frac{A}{P}$	4.229	Schumm(1956)
9	Length Area Relation (LAR)	$LAR = 1.4 \times A^{-6}$	101.32	Hack (1957)
10	Form Factor Ratio (F_f)	$F_f = \frac{A}{L_b^2}$	0.2201	Horton (1932)
11	Shape Factor Ratio (R_s)	$R_s = \frac{L_b^2}{A}$	4.543	Horton (1956)
12	Elongation Ratio (R_e)	$R_e = \frac{2\sqrt{A}}{L_b}$	0.529	Schumm(1956)
14	Circularity Ratio (R_c)	$R_c = \frac{12.57A}{P^2}$	0.18	Miller (1953)
15	Drainage Texture (D_t)	$D_t = \frac{N_u}{P}$	0.85	Horton (1945)
16	Compactness Coefficient(C_c)	$C_c = \frac{0.2821 \times P}{A^{.5}}$	2.36	Gravelius(1914)
17	Stream Frequency (F_s)	$F_s = \frac{N_u}{A}$	0.20	Horton (1932)
18	Drainage Density (D_d) Km	$D_d = \frac{L_u}{A}$	0.77	Horton (1932)
19	Constant of Channel Maintenance (Km^2 / Km)	$C_m = \frac{1}{D_d}$	1.29	Schumm(1956)
20	Drainage Intensity (D_i)	$D_i = \frac{F_s}{D_d}$	0.52	Faniran (1968)
21	Infiltration Number (If)	$If = F_s \times D_d$	0.31	Faniran (1968)
22	Overland Flow Length (L_g)	$L_g = \frac{A}{2 \times L_u}$	0.42	Horton (1945)
RELIEF ASPECTS				
23	Maximum Elevation (Z) m	GIS Analysis /DEM	2175	-

24	Minimum Elevation (z) m	GIS Analysis /DEM	23	-
25	Total Basin Relief (H) m	$H = Z - z$	2152	Strahler (1952)
26	Relief Ratio (R_h)	$R_h = H / L_b$	0.028	Schumm(1956)
27	Relative Relief Ratio (R_r)	$R_r = H \times 100 / P$	0.72	Melton (1957)
28	Gradient Ratio (R_g)	$R_g = \frac{(Z - z)}{L_b}$	0.028	Sreedevi(2004)
29	Ruggedness Number (R_n)	$R_n = D_d \times H$	1.66	Strahler (1958)

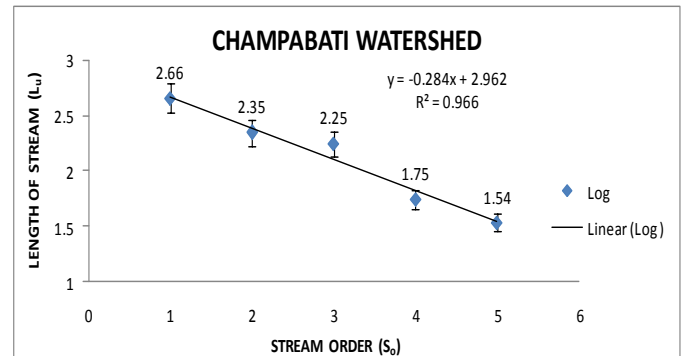
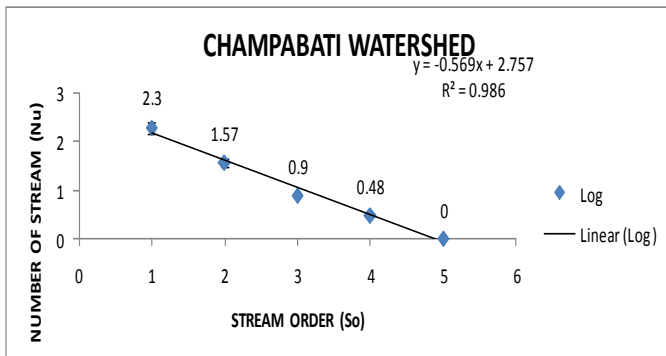


Chart- 1: Plot of regression of logarithm of (N_u) VS (S_o)

Chart -2: Plot of linear regression of logarithm of (L_u) Vs (S_o)

Table 4: SUBWATERSHED WISE AREAL PARAMETERS

SL NO	SUB WATERSHD	NUMBER OF STREAMS					STREAM LENGTH IN (KM)				
		1 ST	2 ND	3 RD	4 TH	5 TH	1 ST	2 ND	3 RD	4 TH	5 TH
1	SW1	27	4	1	-	-	68.62	36.86	17.98	-	-
2	SW2	26	3	1	-	-	70.00	18.88	33.06	-	-
3	SW3	26	6	2	1	-	92.47	56.90	16.45	28.80	-
4	SW4	42	6	1	1	-	76.63	42.38	59.22	19.17	-
5	SW5	4	3	2	-	1	14.20	2.31	0.13	-	8.21
6	SW6	28	5	1	1	-	52.27	28.13	24.18	3.96	-
7	SW7	48	10	4	2	1	86.94	41.12	28.07	4.20	27.06

Table 5: MORPHOMETRIC PARAMETERS OF SUBWATERSHEDS

SUB WATERSHED	AREA	PERIMETER	ELEVATION (m)		BASIN LENGTH (KM)	TOTAL RELIEF (m)	NUMBER OF STREAMS	TOTAL STREAM LENGTH
			MAX	MIN				
SW1	150.03	107.75	979	76	22.594	903	32	123.46
SW2	145.69	129.63	1789	76	22.220	1713	30	121.94
SW3	220.25	237.16	500	43	28.100	457	35	194.62
SW4	266.80	255.07	2175	43	31.333	2132	50	197.40
SW5	41.078	54.180	380	36	10.825	344	10	24.85
SW6	151.53	136.72	486	36	22.722	450	35	108.54
SW7	279.96	124.78	500	23	32.202	477	65	187.39

Table 6: ANALYZED MORPHOMETRIC PARAMETERS OF SUB WATERSHEDS

SUB WATERSHED	LINEAR PARAMETERS					SHAPE PARAMETERS				
	R_b	D_d	F_s	L_g	R_t	R_c	F_f	R_s	R_e	C_c
SW1	5.375	0.83	0.22	0.61	0.30	0.17	0.294	3.402	0.611	2.481
SW2	5.83	0.84	0.21	0.60	0.24	0.11	0.295	3.388	0.613	3.029
SW3	3.12	0.89	0.16	0.57	0.15	0.05	0.278	3.585	0.596	4.508
SW4	4.67	0.74	0.19	0.68	0.19	0.052	0.271	3.679	0.588	4.405
SW5	1.62	0.61	0.25	0.83	0.18	0.18	0.35	2.852	0.668	2.384
SW6	3.87	0.72	0.24	0.70	0.26	0.11	0.294	3.407	0.611	3.133
SW7	2.825	0.67	0.24	0.75	0.53	0.23	0.269	3.703	0.586	2.103

4.1 RELATION BETWEEN BASIN AREA AND BASIN LENGTH:

In general the basin area and the basin length both are proportional and they shows almost +ve relation. This reflects that basin area is maximum when the basin length has a high value.(Chart 3)

4.2 RELATION BETWEEN DIFFERENT SHAPE PARAMETERS:

Mutual relationship of shape parameters can be evaluated from the plot as shown in (Chart 4). It is found that for a given drainage basin that the elongation ratio, circularity ratio and form factor show a relationship of decrease in values the order viz., elongation ratio > form factor > circularity ratio. The three measures thus are conformable and suitable for defining basin shape.

4.3 RELATION BETWEEN BASIN AREA AND STREAM LENGTH:

In order to find the relation between basin area and the total stream length for respective sub basins a regression line is constructed using a double log graph. It is observed that the drainage area bears a power function relationship with stream length.(Chart 5)

4.4 RELATION BETWEEN DRAINAGE DENSITY AND STREAM FREQUENCY:

To evaluate the relationship between drainage density and stream frequency, a graph plot of drainage density vs. stream frequency is prepared. The regression line indicates the existence of direct relationship between the two parameters (Chart 6).

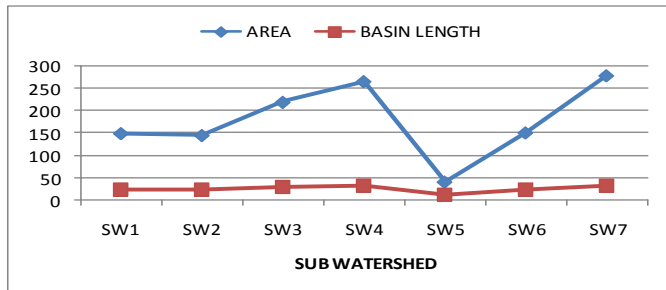


Chart-3: Plot of relationship between (A) and (L_b)

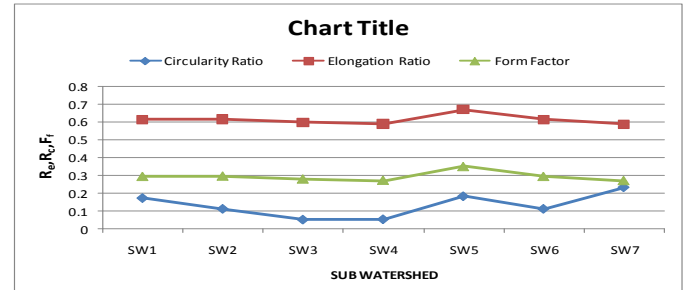


Chart-4: Graphical representations of shape parameters

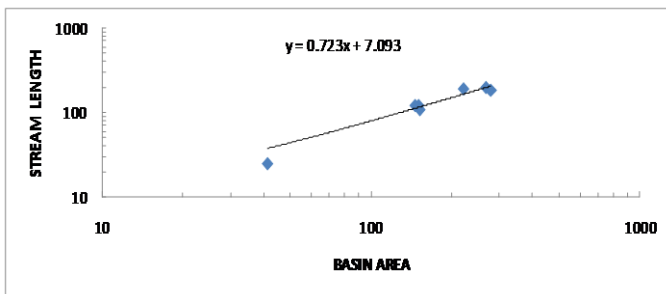


Chart- 5: Log-Log plot of (A) vs. (L_u)

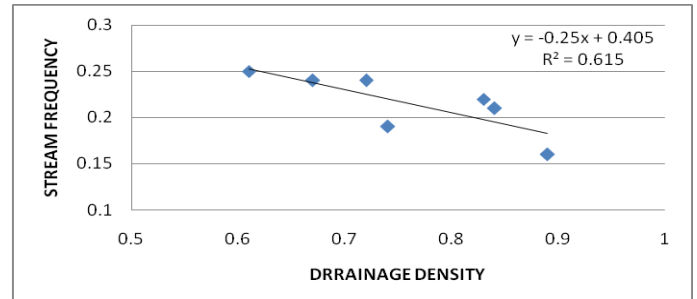


Chart-6: Plot of relation between (D_d) and (F_s)

4.5 RELATION BETWEEN STREAM ORDER AND NUMBER OF STREAM:

Graphical presentation (Chart 7) of the total stream length against the stream order can also be prepared in a semi-log plot as suggested by Strahler (1957).

4.6 RELATION BETWEEN STREAM ORDER VS THE STREAM LENGTH:

Graphical representation (Chart 8) of the total stream length against stream order was also prepared in a semi-log plot as suggested by Strahler (1957).

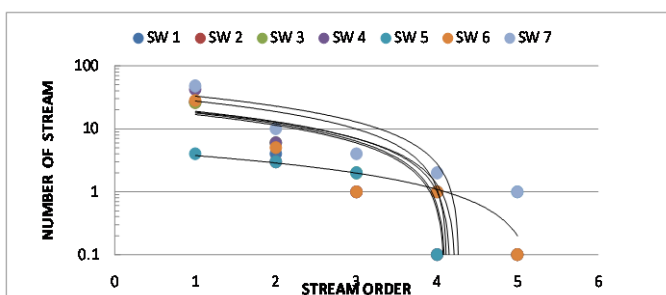


Chart-7: Plot of (S_o) Vs (N_u) for all sub watersheds

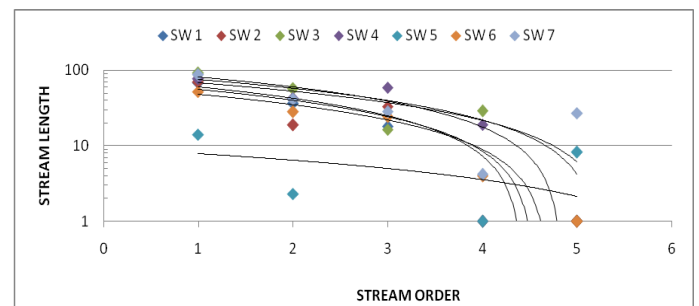


Chart-8: Plot of (S_o) Vs (L_u) for all sub watersheds

Table 7: Regression equations for (S₀) Vs (N₀)

X AXIS	Y AXIS	S-W	LINEAR REGRESSION EQUATION
STREAM ORDER	NUMBER OF STREAM	SW1	$y = -13x + 36.66$ $R^2 = 0.835$
		SW2	$y = -12.5x + 35$ $R^2 = 0.809$
		SW3	$y = -7.9x + 28.5$ $R^2 = 0.759$
		SW4	$y = -12.8x + 44.5$ $R^2 = 0.696$
		SW5	$y = -0.9x + 4.7$ $R^2 = 0.81$
		SW6	$y = -6x + 25$ $R^2 = 0.636$
		SW7	$y = -10.2x + 43.6$ $R^2 = 0.658$

Table 8: Regression equations for (S₀) Vs (L₀)

X AXIS	Y AXIS	S-W	LINEAR REGRESSION EQUATION
STREAM ORDER	LENGTH OF STREAM	SW1	$y = -25.32x + 91.79$ $R^2 = 0.978$
		SW2	$y = -18.47x + 77.58$ $R^2 = 0.489$
		SW3	$y = -23.14x + 106.5$ $R^2 = 0.783$
		SW4	$y = -15.55x + 88.23$ $R^2 = 0.671$
		SW5	$y = -1.429x + 9.257$ $R^2 = 0.135$
		SW6	$y = -11.22x + 57.03$ $R^2 = 0.860$
		SW7	$y = -15.66x + 84.48$ $R^2 = 0.652$

5. CONCLUSIONS

The morphometric analysis has been carried out through measurement of linear, areal and relief aspects of basins. On the basis of the drainage orders, the CHAMPABATI watershed has been classified as 5th order basin. The few parameter values are considered here those are as an elongation ratio was 0.529 which defines that the watershed is elongated, circularity ratio was observed to be 0.18 it is also a evidence as elongated watershed and again from factor also observed 0.2201, this also indicate that it is elongated in shape and suggesting flatter peak flow for longer duration. Bifurcation ratio observed 3.94 it indicates that there appears to be no strong geological control in the development of the drainage. Drainage network of the basin exhibits as mainly dendritic type which indicates the homogeneity in texture and lack of structural control. Ruggedness number reveals that the watershed is highly eroded surface and gentle slope. So the evaluated and analysed morphometric parameters such as area, length, stream pattern, flow direction, and perimeters all these are reflect the shape and topography of the given watershed.

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