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Watershed Based Morphometric Analysis Using Geospatial Technique: A Case Study From Betul-Chhindwara District Of Middle Satpura Region, Central India

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The Geographical Information System (GIS) has become a useful tool for planning and managing watersheds by defining drainage patterns. The Tapi (WS1), Kanhan (WS2), Pench (WS3), and Tawa (WS4) river basins, which are situated in the Betul - Chhindwara district of Madhya Pradesh are the subject of study here. Strahler (1964) stream order method and GIS techniques have both been employed for the morphometric study. The drainage densities for the WS1, WS2, WS3, WS4 are 0.826, 0.774, 0.831, and 0.803 respectively. There are a total of 1847 streams in WS1, 2768 in WS2, 2381 in WS3, and 1829 in WS4. Thus, the lengths of all the streams over the entire study region have been determined to be WS1: 2322.35722 km, WS2: 3543.17686 km, WS3: 2905.11956 km, and WS4: 2361.78943 km in, with the Kanhan and Pench rivers indicating a dense drainage network. It has been found that the research area, is well drained and has a well-integrated drainage system.

Keywords: Watershed, Morphometry, Stream order, Drainage Pattern, Drainage Density

Highlights:

- Stream frequency and stream order are inversely related.
- In the Betul - Chhindwara region WS2 & WS3 shows the higher value of Rb indicate a strong structural control in the drainage pattern.
- WS1 has 0.566km, WS2 – 0.827km, WS3 – 0.703km, & WS4 – 0.858km relief value and the high relief value of basin indicates the gravity of water flow, low infiltration and high runoff conditions.
- Higher density (0.831) is identified for Pench River watershed whereas low drainage density (0.774) is calculated for Kanhan River watershed of Betul – Chhindwara region
- WS1 and WS2 are moderately elongated and circular but WS3 are more circular and WS4 are moderate circular in shape.

1. INTRODUCTION

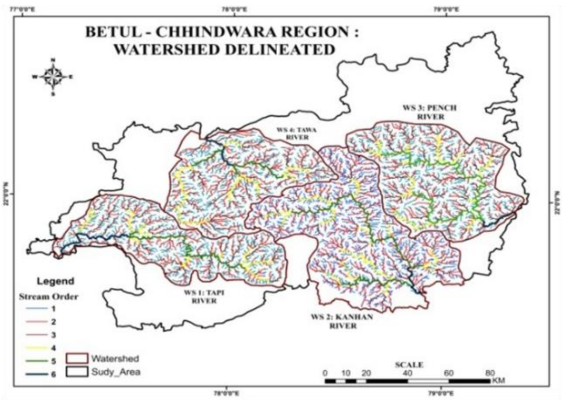
The watershed has become the fundamental organising principle for all hydrological analysis units and the foundation for many hydrological programmes. Every watershed demonstrates distinctive qualities that are so various and variable that no two watersheds are exactly same in nature (Murthy, 2000). Analysis of the drainage basins is one of the crucial requirements for any hydrological inquiry. It offers useful details regarding the quantitative description of the drainage system, which is an essential component of a basin's characterization (A.N. Strahler 1964). The word "morphometry," which introduces quantitative descriptions of landforms, literally means measuring of forms (Horton, R.E 1945). Measurements of linear characteristics, aerial aspects, and channel network gradient are needed for this investigation of the drainage basin (Nautiyal, 1994). The configuration of the earth's surface, as well as the size, shape, and location of its landforms, are all subject to measurement and quantitative analysis (Clarke 1996; Agarwal 1998; Obi Reddy et al. 2002). Using traditional techniques, the drainage features of numerous river basins and subbasins around the world have been examined (J. Krishnamurthy et. al. 1996). Any drainage basin's physiographic properties, such as its size, shape, slope, drainage density, size and length of the contributories, etc., can be used to correlate a variety of hydrological phenomena (Rastogi and Sharma 1976; Mageshet al. 2012a). Drainage basins are the fundamental units for understanding the geometric elements of fluvial landscapes, such as the topology of stream networks and quantitative images of drainage texture, pattern, shape, and relief features (G.P. Obi Reddy et.al. 2004, and Subba Rao, 2009). Traditional techniques like field observation and topographic maps, as well as more sophisticated techniques like remote sensing and extracting features from digital elevation models, can be used to identify drainage networks in a basin (D.R. Maidment 2002).

2. STUDY AREA

Four watersheds are delineated (Fig 1) through the GIS process in the Betul – Chhindwara region and the following are mentioned below:

2.1 Watershed 1 (WS 1: Tapi River Basin in Betul – Chhindwara region)

The Tapti River, also spelled as Tapi, is a river in central India that rises in the Gawilgarh Hills of the central Deccan plateau in south-central Madhya Pradesh state. Its basin measures 107.046 km in length and 2811.41 sq km in area (Fig. 2). It flows westward between two spurs of the Satpura Range, across the Jalgaon plateau region in Maharashtra state, and through the plain of Surat in Gujarat state to the Gulf of Khambhat (an inlet of the Arabian Sea). The major Satpura Range separates the Tapti from the longer Narmada River, which flows nearly parallel to it to the north.



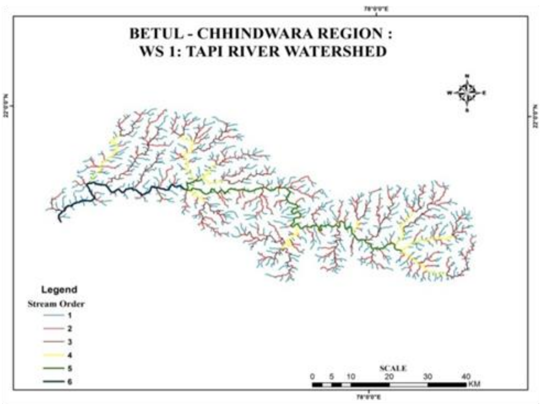


Fig. 1: Delineation of watershed in study area

Fig. 2: Tapi River Watershed

2.2 Watershed 2 (WS 2: Kanhan River Basin in Betul – Chhindwara region)

Wainganga's longest tributary, the Kanhan, has a length of 275 km, a basin length of 90.450 km, and a basin area of 4573.1 km2 in the Betul-Chhindwara region (Fig. 3). In the northwest corner of Chhindwara District, it begins to rise in the southern spurs of the Satpura Range. The first settlement it meets as it flows south from its starting point is Damua. Jam River connects it, and for a short distance, it acts as a natural border with Maharashtra, the neighbouring state.

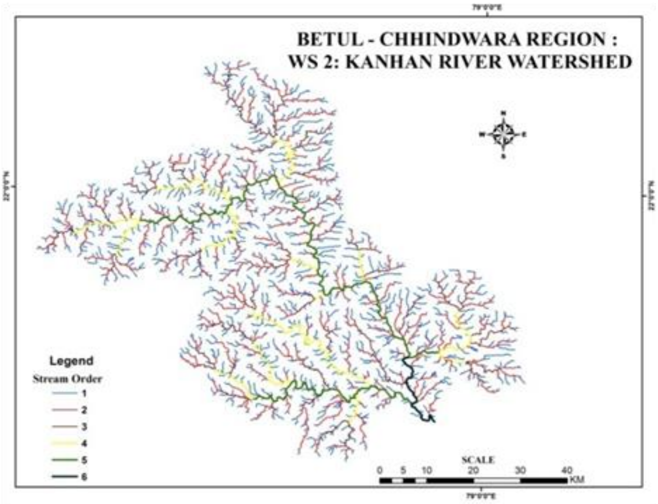


Fig. 3: Kanhan River watershed

2.3 Watershed 3 (WS 3: Pench River Basin in Betul – Chhindwara region)

An Indian tributary of the Kanhan River is the Pench River basin, which is seen in figure 4. It rises in the Madhya Pradesh district of Chhindwara and flows through the Tiger Project of India's reserve of Pench National Park. Only the Chhindwara district contains 3494.33 km2 of the 4466.540675 km2 that make up the pench river basin (Fig. 4). The reserve is located in the Indian state of Madhya Pradesh, in the districts of Seoni and Chhindwara, to the south of the Satpura Hill Ranges.

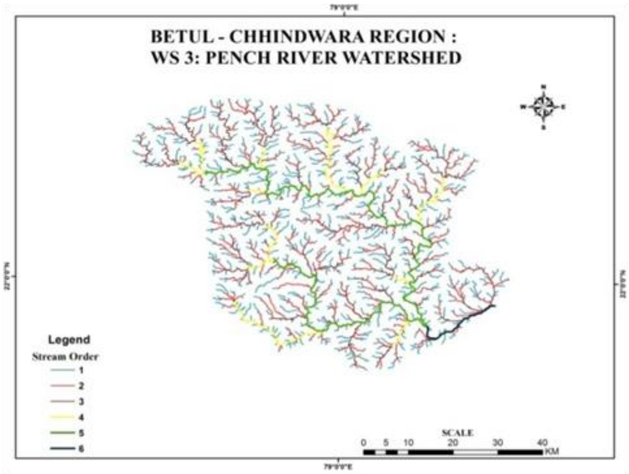


Fig. 4: Pench River watershed

2.4 Watershed 4 (WS 4: Tawa River Basin in Betul – Chhindwara region)

The Tawa is the longest tributary of the Narmada, with a length of 172 km, 65.018 km of which are found in the Betul-Chhindwara region (fig. 5). It originates in Betul's Satpura Range and flows north and west before joining the Narmada at the Hoshangabad District village of BandraBhan.

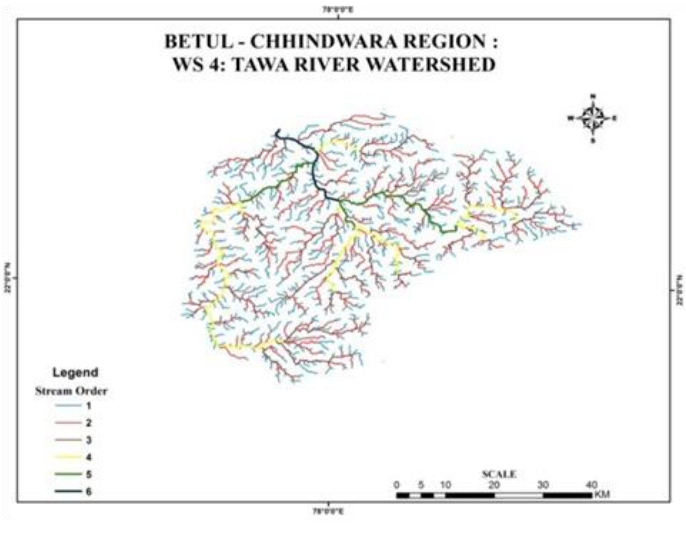


Fig. 5: Tawa River Watershed

3. Methodology

In comparison to the manual outline system of seepage organisers, the computerised depiction approach of seepage system and stream asking from ASTER DEM is now a more beneficial, efficient, and precise route. The procedure adjusted for the examination is to first extraction of waterway bowl and after that to extricate the seepage arrange. From the http://earthexplorer.usgs.gov website, the first ASTER DEM (30m spatial resolution) images were obtained; at that point, the downloaded ASTER DEM images were effectively mosaicked. The Betul-Chhindwara waterway bowl zone was removed and the stream bowl limit was depicted using a mosaicked image using the Arc hydro tool in the ARC GIS 10.4 software. In addition, numerous efforts have been made to outline the seepage system of the Betul-Chhindwara stream bowl using the Arc hydro device (Fig. 6). Additionally, the Betul-chhindwara stream bowl's inclination map, perspective map, and triangular sporadic system guide were obtained from the ASTER DEM using the Spatial Analyst tool in Curve GIS 10.4. The scientific recipes listed in Table 1 were used to evaluate the morphometric parameters stream request, stream number, bifurcation proportion, stream length, stream length proportion, length of flood land, bowl region, bowl border, bowl length, length of overland stream, waste thickness, seepage recurrence, waste surface, invasion number, structure factor proportion, lengthening proportion, circularity proportion, bowl help, alleviation proportion, and analytical parameters. Figure 6 shows the many steps taken during the process of extracting waste system and stream arrangements using various ARC GIS tools.

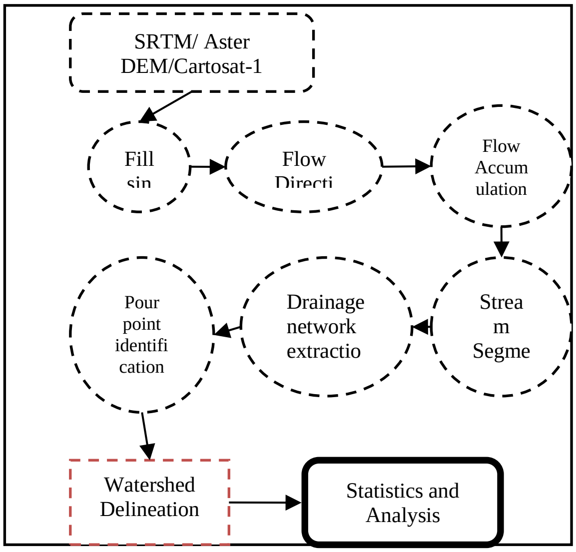


Fig. 6: Flowchart for the delineation of watershed in study area

Table 1: Morphometric Parameters and their formulas

S. No.	Morphometric Parameter	Symbols/Formulas	References
1	Stream order (U)	Hierarchical rank	Strahler (1964)
2	Mean stream length (Lsm)	Lsm =Lu/Nu Lu=Stream length of order 'U' Nu=Total number of stream segments of order 'U'	Strahler (1964)
3	Stream length ratio (RL)	RL = Lu/(Lu-1) Where Lu=Total stream length of order 'U', Lu-1=Stream length of next lower order.	Horton (1945)
4	Bifurcation ratio (Rb)	Rb=Nu/(Nu+1) where, Nu=Total number of stream segment of order'u'; Nu+1=Number of segment of next higher order	Schumm (1956)
5	Mean bifurcation ratio (Rbm)	Rbm = average of bifurcation ratios of all order	Strahler (1957)
6	Basin Relief (Bh)	Vertical distance between the lowest and highest points of watershed	Hadley and Schumm (1961)
7	Relief ratio (Rr)	Rr=R/L Where, R=basin relief L = Basin length	Schumm (1963)
8	Drainage density (Dd) (in km.)	Dd=Lu/A where, Lu=Total length of streams; A=Area of watershed	Horton, 1945
9	Stream frequency (Fs)	Fs=Nu/A where, Nu =Total number of streams; A=Area of watershed	Horton (1945)
10	Texture ratio (T)	T=Nu/p	Horton, 1945

		where,Nu1=Total number of first order streams; P=Perimeter of watershed	
11	Form factor (Rf)	Rf=A/(Lb^2) Where, A = area of the basin, km2; and Lb = length of the basin, km.	Harton (1932)
12	Circularity Ratio (Rc)	Rf = 2√πA/P Where, A = area of the basin, km2; P= basin perimeter, km2; and Pc= perimeter of the circle having equal area as that of the drainage basin, km.	Miller (1953)
13	Elongation ratio (Re)	Re = 2√A⁄π/Lb where, A=Area of watershed, π=3.14, Lb=Basin length	Schumn (1956)
14	Length of Overland Flow (Lof)	Lof = 1/2Dd Where, Lof= Length of Overland Flow Dd= Drainage Density	Horton (1945)

4. Result & Discussion

The total area of study area for morphometric analysis is 21897.1 sq. km in which some major watershed areas are delineated. Aster DEM is used to prepare slope and aspect maps.

4.1 Stream order

In the present study, ranking of streams has been carried out based on the method proposed by Strahler (1964). A strategy that is frequently used to classify streams in a river basin is stream ordering. A measure of a stream's location within the tributary system is known as stream ordering (Leopold et al. 1964). In the study area, stream orders are categorised up to sixth orders. In all watersheds, i.e., first-order streams show the highest stream order, followed by second-order streams. WS1, WS2, & WS4 but, as indicated in Table 2, the fourth order in WS3 is lower than the fifth order. As a result, it is shown that stream frequency decreases as stream order increases.

4.2 Stream number (Nu)

Strahler order is designed for the morphology of a catchment and forms the basis of important hydrographical indicators of its structure, such as bifurcation ratio, drainage density and frequency. After assigning stream orders, the segments of each order are counted to get the number of segments of the given order (u). In the study area, the total streams segments present in WS1 is 1847, WS2 is 2768, WS3 is 2381 & WS4 is 1829 of which first order streams having 928 in WS1, 1388 in WS2, 1193 in WS3, & 1829 in WS4 segments. The second, third, fourth, fifth and sixth order stream segments values are mentioned in Table 2.

4.3 Stream Length

According to Horton (1945), stream length is the sum of the lengths of the stream segments in each successive order in the basin, with the first term being the average length of the first order. It is the measurement of the drainage extent and bedrock hydrological parameters. In a basin area with good drainage, only small numbers of relatively longer streams emerge when bedrock has a porous quality (Kulkarni, 2015, Sethupathiet al. 2011). Table 2 displays the length of the sub-watershed, or streams, in stream order i.e. WS 1, WS 2, WS 3, and WS 4 Although the stream length is clearly higher in first-order streams and declines as the stream order increases, the fourth order of WS3 is showing short stream length than the fifth order segment.

4.4 Stream Length Mean (Lsm)

Stream length Mean reveals the size of component of drainage network and its contributing surface (Strahler, 1964). It’s directly proportional to the size and topography of drainage basin (Kulkarni, 2015). Strahler (1964), indicated that the Stream Length Mean is a characteristic property related to the size of drainage network and its associated surfaces. Stream Length Mean values for the WS1, WS2, WS3, & WS4 in Betul – Chhindwara district range from 1.001 to 1.344, 0.999 to 1.393, 0.821 to 1.303 & 0.978 to 1.445 with a mean Lsm value of 1.155km, 1.195km, 1.118 km, & 1.186km.

4.5 Stream length ratio (RL)

Horton’s law of stream length states that mean stream length segment of each of the consecutive of a basin tends to approximate a direct geometric series with stream increasing towards higher order of stream. The stream length ratio has important relevance with surface flow and discharge and erosion stage of the basic (Horton, R.E, 1945 and Obi Reddy et, al. 2002). The stream length ratio (RL) of Betul – Chhindwara district watershed i.e. WS1, WS2, WS3, & WS4 showed an increasing trend. The RL values are also presented in Table 2.

4.6 Bifurcation ratio (Rb)

Bifurcation ratio is the ratio of the number streams of an order to the number streams of next higher order (Horton, 1945, Strahler, 1964). According to Strahler (1964), the values of bifurcation ratio (Table 2) characteristically range between 3.0 and 5.0 for drainage basin in which the geological structures do not disturb the drainage pattern. Rb shows a small range of variation for different areas or for different environments except those where the powerful geological control dominates. In the Betul - Chhindwara region WS2 & WS3 shows the higher value of Rb indicate a strong structural control in the drainage pattern. The Rb for the WS1, WS2, WS3, & WS4 varies from 1.279 to 2.355, 1.491 to 6.304, 0.891 to 6.140 & 1.642 to 2.517.

Table-2: Order, number and bifurcation ratio of streams in different watersheds.

Watershed No.	**Stream Order**	**No. Of Streams**	**Stream Length (km)**	**Mean stream length (Lsm)**	**Stream length ratio (RL)**	**Bifurcation Ratio**
WS 1 (Tapi river watershed)	I	928	1220.337	1.315	0.434	-------
	II	394	529.7494	1.344	0.555	2.355
	III	262	294.127	1.122	0.423	1.503
	IV	119	124.3471	1.044	0.825	2.201
	V	93	102.7044	1.104	0.497	1.279
	VI	51	51.09232	1.001	------	1.823
Total		**1847**	**2322.35722**	**6.93**		**9.161**
WS 2 (Kanhan	I	1388	1800.384	1.297	0.506	-------

river watershed)	II	654	911.2639	1.393	0.444	2.122
	III	334	405.0682	1.212	0.552	1.958
	IV	224	223.967	0.999	0.797	1.491
	V	145	178.556	1.231	0.128	1.544
	VI	23	23.93776	1.040	-------	6.304
Total		**2768**	**3543.17686**	**7.172**		**13.419**
WS 3 (Pench River watershed)	I	1193	1470.4	1.232	0.469	------
	II	530	690.9463	1.303	0.556	2.251
	III	317	384.6661	1.213	0.394	1.671
	IV	148	151.6045	1.024	1.222	2.142
	V	166	185.3209	1.116	0.119	0.891
	VI	27	22.18176	0.821	------	6.140
Total		**2381**	**2905.11956**	**6.709**		**13.095**
WS 4 (Tawa River watershed)	I	919	1158.118	1.260	0.530	-------
	II	425	614.2639	1.445	0.568	2.162
	III	248	349.3618	1.408	0.441	1.713
	IV	151	154.1214	1.020	0.392	1.642
	V	60	60.47798	1.007	0.420	2.517

	VI	26	25.44635	0.978	-------	2.307
Total		**1829**	**2361.78943**	**7.118**		**10.341**

4.7 Mean Bifurcation ratio (Rbm)

The mean bifurcation ratio (Rbm) ranges between 3.0 and 5.0 for a basin when the influence of geological structures on the drainage network is negligible (Verstappen 1983). The analysis showed that the Rb is not same for all orders. Geological and litho-logical development of the drainage basin may be the reason for these variations. Low Rb value indicates poor structural disturbance and the drainage patterns have not been distorted whereas the high Rb value indicates high structural complexity and low permeability of the terrain. This shows that the geologic structures within the drainage area do not distort the drainage pattern. It also indicates that the area has mature topography due to the result of the process of drainage integration. The Rbm of WS1, WS2, WS3, & WS4 is 1.832km, 2.683 km, 2.619km, & 2.068km.

4.8 Basin Area

The area of entire study area is 21897.1sq.km in which, WS1 is about 2811.41 km2 WS2 is 4573.1 km2, WS3 is 3494.33 km2, & WS4 is 2938.6 km2. The maximum basin area is covered by the WS2 which is sub-watershed of Kanhan River. If a basin size is small it is likely that rainwater will reach the main channel more rapidly than in a larger basin, where the water has much further to travel (Waugh, 1996).

4.9 Basin length (Lb)

Length in a straight line from the mouth of a stream to the farthest point on the drainage divides of its basin. The length (L) is the longest length of the basin from the headwaters to the point of confluence, (Gregory and Walling, 1973). The basin length determines the shape of the basin. High basin length indicates elongated basin. The length of the basin of sub-watershed in study area i.e. WS1, WS2, WS3 and WS4 is 107.046 km, 90.450 km, 87.837 km, & 65.018 km. In this WS1 which is sub-watershed of Tapi river has a maximum basin length.

4.10 Basin Relief (R)

An index (R) of the relief characteristics of a drainage basin, It is expressed as Rh = H/L, where H is the difference in height between the highest and lowest points in the basin and L is the horizontal distance along the longest dimension of the basin parallel to the main stream line. The ratio can be positively correlated with the rate of sediment loss from a basin. From the morphometric study, it should be noted that the maximum relief value of Betul – Chhindwara district is 1.258 km in which the present different watershed area Shown in Fig. 7 i.e. WS1 has 0.566km, WS2 – 0.827km, WS3 – 0.703km, & WS4 – 0.858km relief value and the high relief value of basin indicates the gravity of water flow, low infiltration and high runoff conditions.

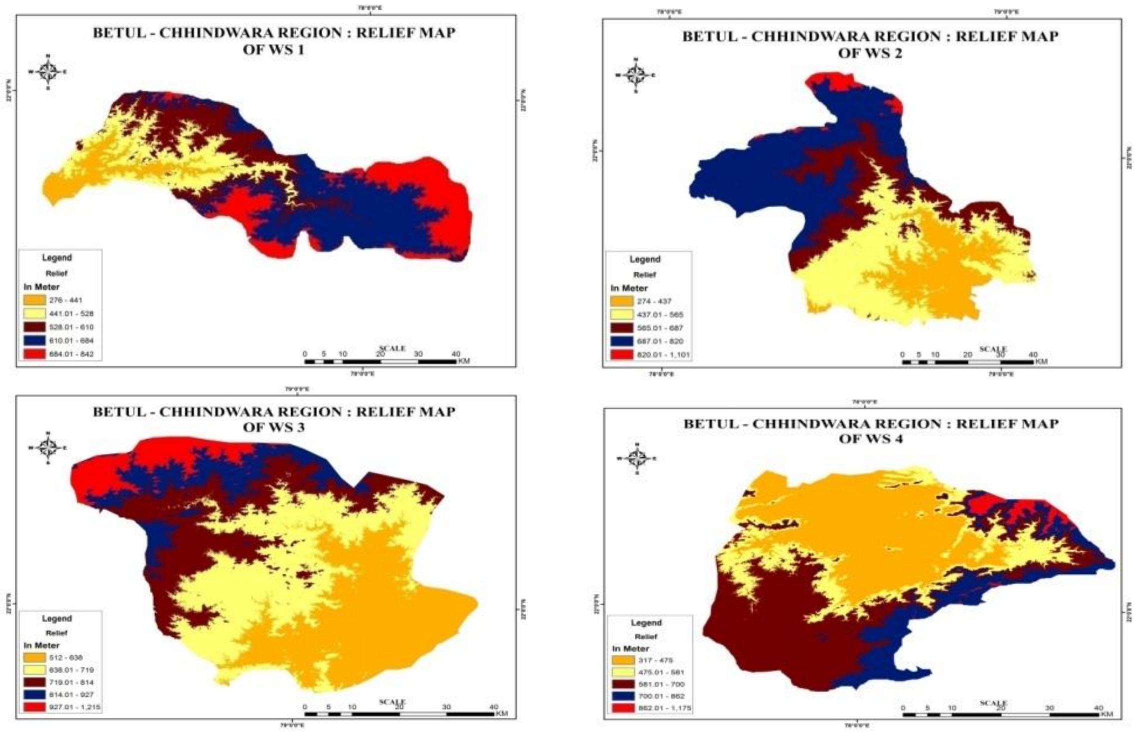


Fig. 7: Relief Map

4.11 Relief Ratio (Rh)

The relief ratio is a number calculated to describe the grade of a river or stream. The calculation is just the difference in elevation between the river's source and the river's confluence or mouth divided by the total length of the river or stream. The relief ratio has been widely accepted as a effective measure of gradient aspect of the area, despite uncertainties surrounding definition of its component measurements and may be unduly influence by one isolated peak within the basin (Sharma, 1981). Schumm (1956) defined relief ratio as the ratio of maximum relief to horizontal distance along the longest dimension of a basin parallel to the main drainage line and it measures the overall steepness of the study area. In the study area, the relief ratio computed for WS1, WS2, WS3, & WS4 is 0.005km, 0.009km, 0.008km, & 0.013km.

4.12 Drainage density (Dd)

Drainage density (Dd) is a measure the total stream length in a given basin to the total area of the basin (Strahler 1964). Drainage density is related to various features of landscape dissection such as valley density, channel head source area, relief, climate and vegetation (Moglen et al. 1998), soil and rock properties (Kelson and Wells, 1989) and landscape evolution processes. The drainage density of the WS1, WS2, WS3, & WS4 is 0.826, 0.774, 0.831, & 0.803, which indicates that WS1, WS2, WS3, & WS4 area has a very high resistant permeable subsurface material with intermediate drainage and low to moderate relief. Higher drainage density is associated with the basin of weak and impermeable subsurface material, sparse vegetation and high relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture, high runoff and erosion potential of the basin area (Strahler 1964). Drainage density of each watershed is given in the Table 3. Higher density (0.831) is identified for Pench River watershed whereas low drainage density (0.774) is calculated for Kanhan River watershed of Betul – Chhindwara region (Table 3).

4.13 Stream frequency (Sf)

Stream frequency (Sf) is the total number of stream segments of all orders per unit area (Horton 1932). Reddy et al. (2004)) stated that low values of stream frequency Sf indicate presence of a permeable subsurface material and low relief. The channel segment numbers for unit areas are difficult to be enumerated (Singh 1980), but an attempt has been made to count stream frequency of WS1, WS2, WS3, & WS4 of Betul – Chhindwara region. The stream frequency value of the WS1, WS2, WS3, & WS4 is 0.657, 0.605, 0.681, & 0.622. Stream frequency mainly depends on the Lithology of the basin and reflects the texture of the drainage network. The value of stream frequency (Fs) for the basin exhibits positive correlation with the drainage density value of the area indicating the increase in stream population with respect to increase in drainage density. Channel frequency density serves as a tool in establishing the erosion processes operating over an area; to be more specific, the same in relation to the stream orders and their characteristics provides data which can throw light even on the sequences of relief developments and the degree of ruggedness in the area (Singh 1980).

4.14 Form Factor (Rf)

Form factor is used to predict the flow intensity of a watershed of a defined area (Horton, 1945; Gregory and Walling, 1973). The index of Rf also illustrates the inverse relationship with the square of the axial length and a direct relationship with peak discharge (Magesh et al., 2012). It is the ratio of a basin area (A) (Horton, 1932) to the square of the basin length (Lb). The basins with high form factor value have high peak flow for short duration whereas elongated basin with low form factor will have a flatter peak flow of longer duration. Flood flows in elongated basins are easier to manage than that of the circular basins (Nautiyal, 1994). The factor value of 0 indicates a highly elongated shape and the value of 1.0, a circular shape. The value of form factor of the WS1, WS2, WS3, & WS4 is 0.245, 0.558, 0.452, & 0.695.

4.15 Circularity Ratio (Rc)

Circularity Ratio is defined as the ratio of basin area (A) to the area of circle having the same perimeter (P) as the basin (Miller, 1953). Miller (1958) used a dimensionless circulatory ratio Rc, defined as, the ratio of basin area to the area of a circle having the same perimeter as the basin. It is influenced more by the length, frequency and gradient of streams of various orders rather than slope conditions and drainage pattern of the basins. The value 0.0 indicates a highly elongated shape and the value 1 is a circular shape. Circulatory ratio in the WS1, WS2, WS3, & WS4 is 0.579, 0.579, 0.759, & 0.699. Hence, WS1 and WS2 are moderately elongated and circular but WS3 are more circular and WS4 are moderate circular in shape.

Table 3: Linear aspects, areal aspects, relief aspects and tectonic parameters of Betul – Chhindwara region watersheds (WS 1, WS 2, WS 3, & WS 4)

Watersheds Number		**WS 1**	**WS 2**	**WS 3**	**WS 4**
Linear Parameters	Perimeter (P,km)	324.579	413.602	275.933	274.861
	Basin Length(Lb, km)	107.046	90.450	87.837	65.018
	Average stream length ratio(AvgRl)	0.546	0.485	0.552	0.471
	Average Bifurcation ratio(AvgRb)	1.832	2.683	2.619	2.068
	Area (A, km2)	2811.41	4573.1	3494.33	2938.6
	Drainage density(Dd)	0.826	0.774	0.831	0.803
Areal	Streamfrequency (Fs)	0.657	0.605	0.681	0.622

Parameters	DrainageTexture (T)	0.542	0.468	0.566	0.499
	Length ofoverland flow(Lg)	0.413	0.387	0.415	0.402
	Form factor(Ff)	0.245	0.558	0.452	0.695
	Circulaory Ratio(Rc)	0.579	0.579	0.759	0.699
	Elongation ratio(Re)	0.559	0.843	0.759	0.941
Relief and Tectonic Parameters	Basin Relief(r)Km	0.566	0.827	0.703	0.858
	Relief Ratio (Rr)	0.005	0.009	0.008	0.013

4.16 Elongation Ratio (Re)

According to Schumm (1956, pp. 612) elongation ratio is defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length. Strahler states that this ratio runs between 0.6 and 1.0 over a wide variety of climatic and geologic types. It is the ratio of the diameter of a circle of the same area as the basin to the maximum length of the basin. It is a very significant index in the analysis of basin shape which helps to give an idea about the hydrological character of a drainage basin. Elongation ratio of the WS1, WS2, WS3, & WS4 is 0.559, 0.843, 0.759, & 0.941.

4.17 Length of Overland Flow (Lg)

Overland flow is the movement of water over the land, downslope toward a surface water body. Overland flow is a very important aspect of the water cycle and can be generated under two different physical mechanisms. Typical values of ‘n’ for overland flow on pervious surfaces should be in the range 0.2 - 0.35 and do not represent realistic values of 'n' that might be used in channel flow calculations. It is along the overland flow length that the surface gradient should be estimated. It is one of the most important variables that affect both hydrological and physiographic development of the drainage basins (Horton 1945). It is the distance covered by surface runoff before turning into a stream channel. In the development of drainage basins, length of overland flow (Lg) is usually equal one half reciprocal of the drainage density. The length of overland flow in WS1, WS2, WS3, & WS4 is 0.413, 0.387, 0.415, & 0.941.

5. Aspect

Aspect generally refers to the direction to which a mountain slope faces. The aspect of a slope can make very significant influences on its local climate because the sun’s rays are in the west at the hottest time of day in the afternoon, and so in most cases a west-facing slope will be warmer than sheltered east facing slope. This can have major effects on the distribution of vegetation in the Watershed region of Betul – Chhindwara region. The value of the output raster data set represents the compass direction of the aspect (Mageshet al. 2011). The aspect map of WS1, WS2, WS3, & WS4 is shown in the figure 8. The aspect map of WS1, WS2, WS3, & WS4 is shown North west, South East, south East & North West facing characteristic.

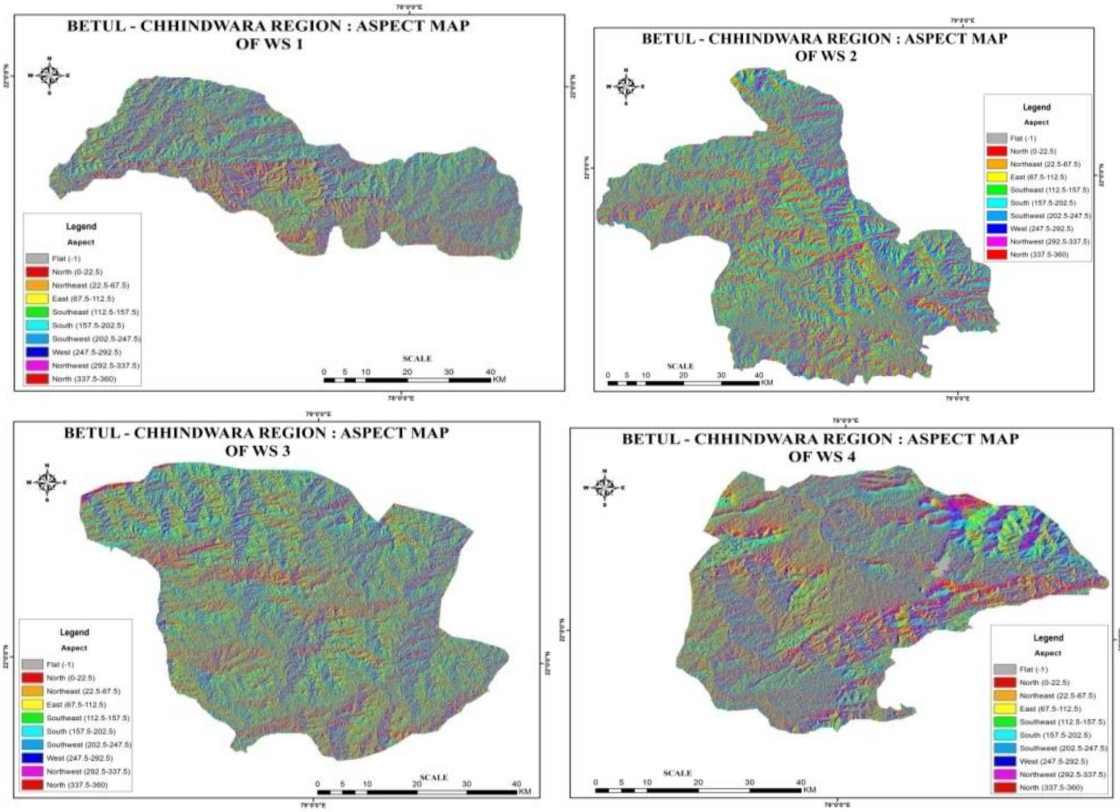


Fig. 8: Aspect Map

6. Slope

Slope analysis is an important parameter in geomorphological studies for watershed development and important for morphometric analysis. The slope elements, in turn, are controlled by the climatomorphogenic processes in areas having rock of varying resistance (Mageshet al. 2011; Gayenet al. 2013). A slope map of the study area is majored on the bases of ASTER DEM data using the spatial analysis tool in ARC GIS-10.2. The slope in Betul - Chhindwara region Basin is shown in Fig.3. The degree of slope of WS1, WS2, WS3, & WS4 (fig.9) is varied from 0° to 55.56°, 0° to 53.22°, 0° to 50.64°& 0° to 62.31°.

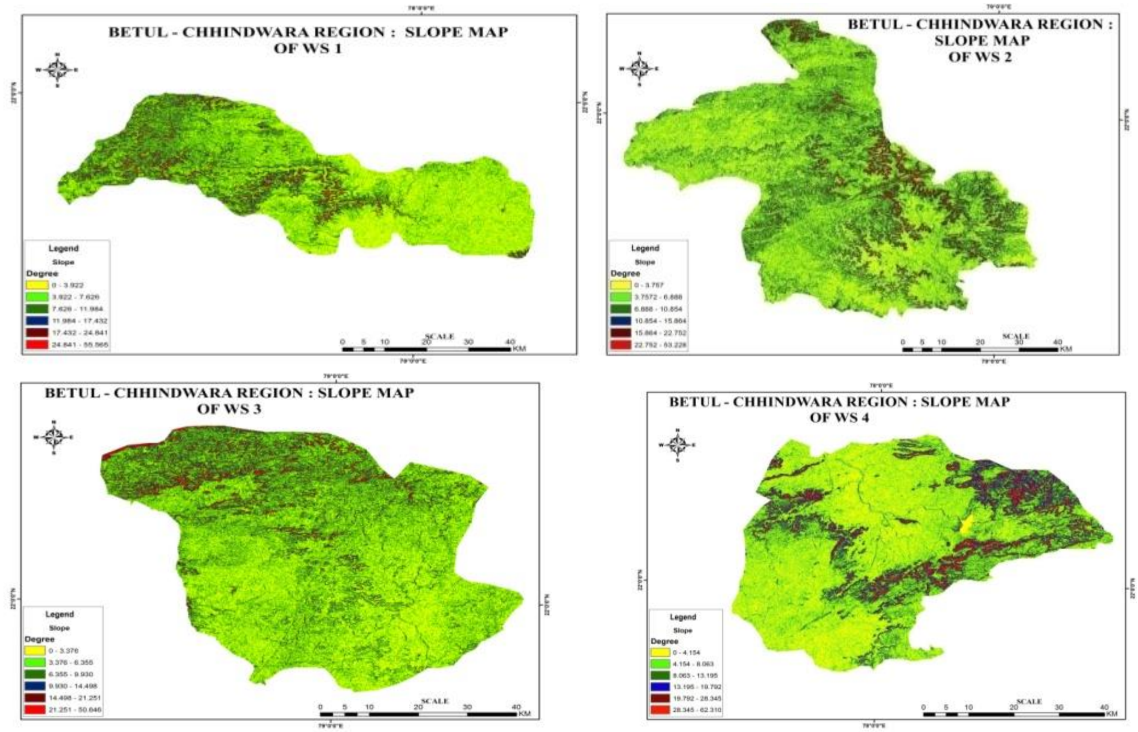


Fig. 9: Slope Map

7. Conclusion

Morphometric analysis of drainage system is prerequisite to any hydrological study. Thus, delineation of watershed and determination of stream networks' behavior and their interrelation with each other is of great importance in many water resources studies. Remote sensing satellite data with its synoptic coverage in multi-temporal domain and GIS techniques have been proved to be an effective tool in Delineation and morphometry analysis. In the present Study, morphometric analysis of the different river watershed, based on several drainage parameters using remote sensing satellite data and latest GIS tools for drainage analysis, has been delineated. It is inferred that the Tapi, Kanhan, Pench, &Tawa River watershed numbered as WS1, WS2, WS3, & WS4 falls under Sixth-order basin. All basins are mainly dominated by lower order streams. The morphometric analysis is carried by the measurement of linear, aerial and relief aspects of basins. Detailed morphometric study of all watersheds shows dendritic to sub-dendritic drainage patterns, which thus indicate homogenous Lithology and variations of values of Rb among the watersheds attributed to difference in topography and geometric development. The maximum stream order frequency is observed in case of first-order streams and then for second order. Hence, it is noticed that there is a decrease in stream frequency as the stream order increases and vice versa. The values of stream frequency indicate that all the basins show positive correlation with increasing stream population with respect to increasing drainage density. The drainage density values of the WS1, WS2, WS3, & WS4 have values below five revealing that the subsurface area is permeable, a characteristic feature of coarse drainage. The variation of stream length ratio might be due to differences in slope/gradients and topographic conditions of the area. The values of stream frequency indicate that all the subwatershed show positive correlation with increasing stream segments with respect to increasing drainage density. Elongation ratio (Re) value of WS1, WS2, WS3, & WS4 is 0.559, 0.834, 0.759, & 0.941. Higher values of elongation ratio show high infiltration capacity and low runoff, whereas lower Re values which are characterized by high susceptibility to erosion and sediment load. The database obtains through analysis of morphometric parameters would be suggested for its proper utilization in the integrated watershed programme aimed at development and management of water resources of the WS1, WS2, WS3, & WS4 of Betul – Chhindwara region in the Madhya Pradesh, by the ministry of water resources, New Delhi (India) in future. The used approaches in this study include a comprehensive morphometric analysis that can be applied for any drainage system elsewhere. They introduce the major elements needed to assess water resources and their hydrologic regime, thus it is recommended to apply similar studies in anywhere in India. The result calculated in this study will suggest and recommend developing a better water usage mechanism for proper watershed management in the Betul – Chhindwara region.

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