Drainage Basin Morphometric Analysis using SRTM DEM (90m.): A Comparative Study of Kosi (Bihar) and Kanshabati (West Bengal) Basin, India

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Abstract
The morphometric analysis was carried out to determine the drainage characteristics of Kosi (Bihar) and kanshabati (W.B) watershed, India; with emphasis on comparative analysis using Geocoded DEM data of SRTM. The main idea is to examine the stream properties based on the measurement of various stream attributes. The different drainage parameters studied and the measurements related to Perimeter, Area of Sub-Basins, Basin length and number of rivers were determined by using arc gis10.1 techniques. The mean Bifurcation ratio indicates that the Drainage pattern is not much influenced by geological structures. The Shape parameters reveal the elongation of the basin and. The applicability of Horton's Laws on Stream numbers, Stream lengths and Stream areas is tested by estimating theoretically Bifurcation ratio, Length ratio and Area ratio.
Keywords: Morphometric Analysis, Kosi River, kanshabati River, Stream properties, Perimeter, Area of Sub Basin, Basin length, Mean Bifurcation Ratio, Length Ratio, Area Ratio.

1. Introduction

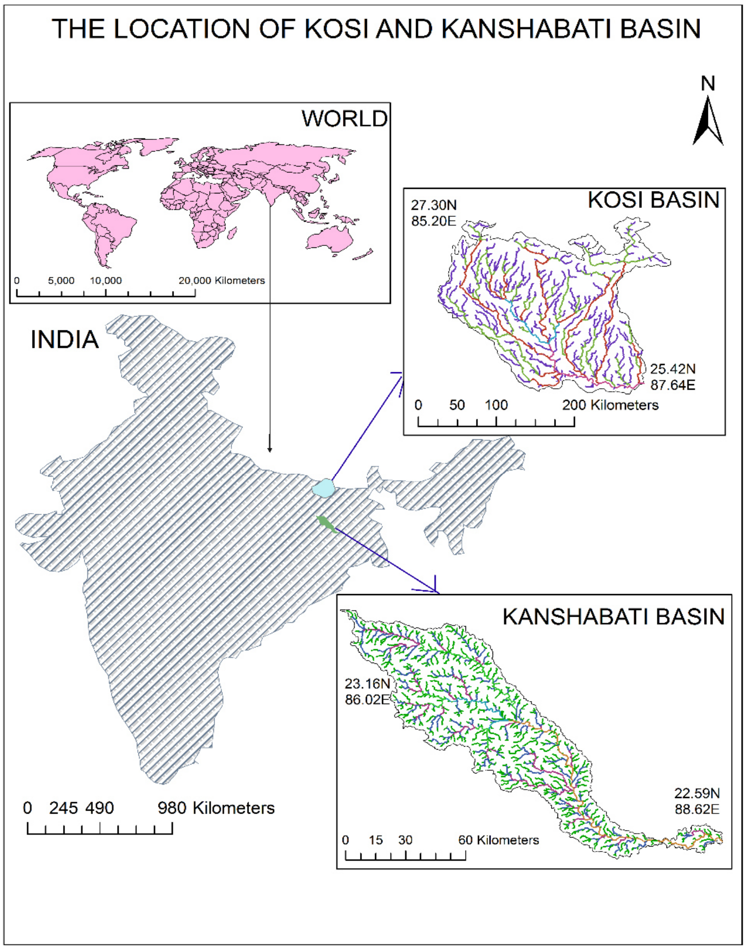
The morphometric analysis of a drainage basin and channel network play a significant role in understanding the hydrogeological behavior of the basin and expresses the prevailing climate, geology, geomorphology and structure, etc. The relationship between various drainage parameters and the above factors are now almost well established (Horton,1945; Strahler,1957; Melton,1958; Pakhmode, 2003; Gangalakunta, 2004). Recently several workers have used remote sensing data and GIS on morphometric parameters and have concluded that remote sensing has emerged as a powerful tool in analyzing the drainage morphometric (Agarwal, 1998; Nag, 1998; Das and Mukherjee, 2005). The present study mainly aims to analyze the morphometric attributes of the Kanshabati river basin and kosi river basin. As yet, no detailed work on the morphometric of the area has so far been carried out

Fluvial landforms are produced by the erosion and deposition of streams that are connected into networks (Strahler and Strahler, 2009). The morphometric studies on river basins were first introduced by Horton (1932) and the idea was later developed by Coates (1958) and Strahler (1964). The drainage parameters studied include drainage pattern, stream order, stream number, strength length, mean stream length, drainage pattern, drainage density, stream frequency, stream length ratio, relief ratio, elongation ratio, bifurcation ratio, form factor and circularity ratio. Quantitative description of basin geometry, river characteristics, initial slope or inequalities in rock hardness, structural controls, recent diastrophism geological and geomorphic history of the drainage basins can be understood by the morphometric analysis. The Basin of kosi and kanshabati is an environmentally and anthropologically distinct place with a spectacular environment, whereas for kanshabati is an area under eastern chotonagpur plateau. Which is more or less stable. Whereas for kanshabati is an area of neo tectonic upliftment of Himalayan region.

Dynamics of the Kosi River (Bihar, India) was initially reported by Shilling field (1893) and followed by several workers who focused on the westward movement of the Kosi River in north Bihar plains. Shillingfield (1893) suggested that the progressive westward movement of the Kosi River would be followed by the eastward movement in one great sweep. Leopold and Maddock (1954) attributed the lateral shift of Kosi River to the tendency of a braided stream, which depends on the rate of sedimentation. However, the continuous movement of Kosi river in one direction remained unexplained. Mookerje (1961) first mapped the position of Kosi river channel at different times in and this map was brought to prominence the past by publication in the Holmes' popular book (Holmes, 1978 p. 351). Gole and Chitale (1966) reported that the Kosi has shifted by about 150 km in the last 200 years and related the shifting process with the cone (megafan) building activity. The morphometric characteristics of kanshabati as a part of Bankura district (W.B, India) is carried out by subrata pan et al., (2013). And also the hydro-geological study of subsurface water storage characteristics for kanshabati as a part of purulia district is carried out by suharta ghosh et al.,(2014).but the whole basin study have so far not carried out.

2. Materials and Methods

2.1 Study Area: For comparative study of the river characteristics the two different river is selected which have deferent geological and geomorphological background so that the river morphological characteristics is best compare.



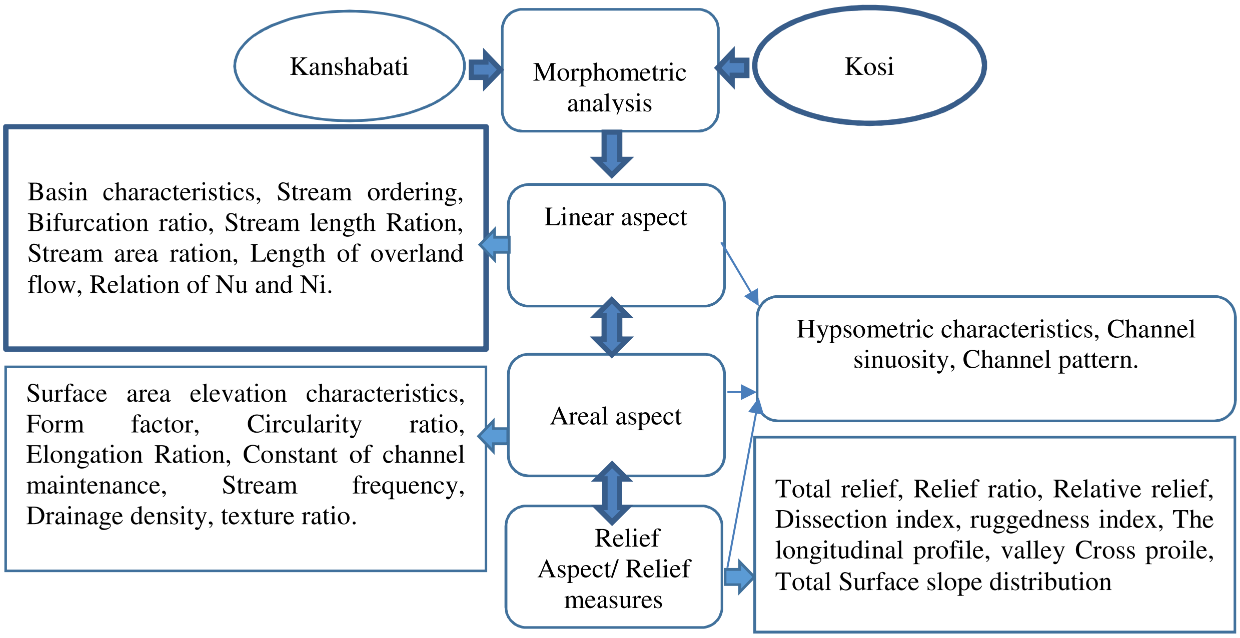
The Kosi which is a tributary of ganga flowing through the Himalayan and sub Himalayan region mainly the north Bihar plain which have the latitudinal and longitudinal extension of 25.42N,87.64E to 27.30N,85.20E. Whereas kanshabati is a fluvial system of dissected plateau region of chhotonagpur plateau. kanshabati flows through the purulia, Bankura and medinipore district of west Bengal. The latitudinal and longitudinal extension of kanshabati basin is 22.59N88.62E to 23.18N88.02E longitude.

The two drainage system is very much different in terms of its geology, geomorphology, climate, vegetation, soil and rock characteristics which is the sole reasons to select the study of this recent studies.

2.2 Data Source:
For morphometric analysis of Kanshabati the SRTM DEM 90m. Have been used (SRTM3N22E086V2, SRTM3N22E087V2, SRTM3N23E085V2, SRTM3N23E086V2, SRTM3N23E087V2) respectively. .For kosi the SRTM DEM 90m.(SRTM3N25E084V2 To…SRTM3N29E088V2) Have covered.

Fig1: The location of Kosi and Kanshabati Basin

2.3 Methodology



3.0 Morphometric analysis and Discussion

3.1 Linear aspect of channel system

The defining the perimeter of a drainage basin in the above terms is important

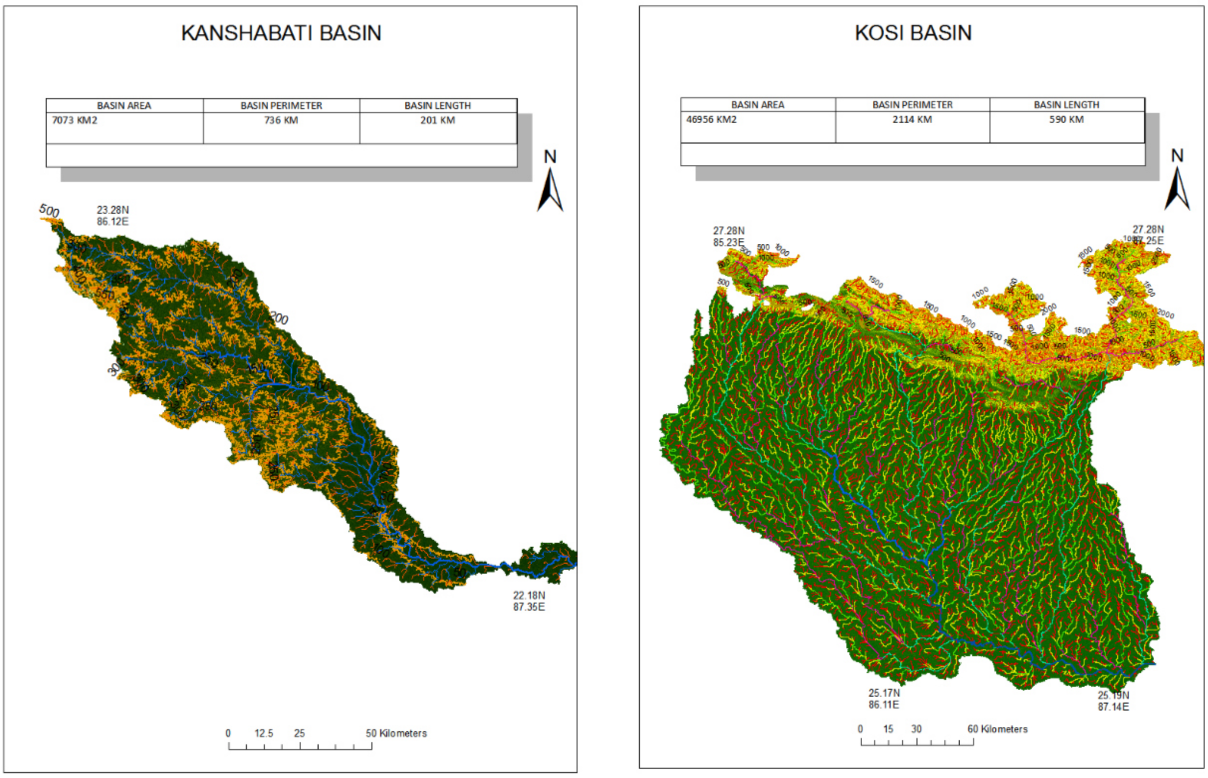
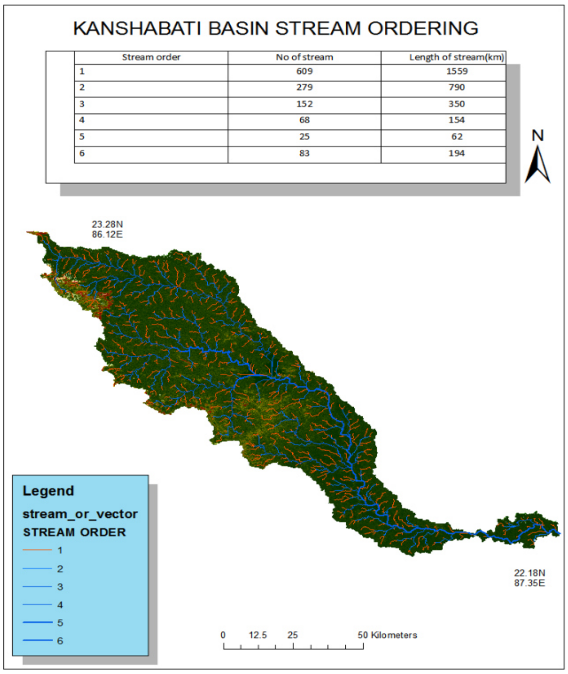
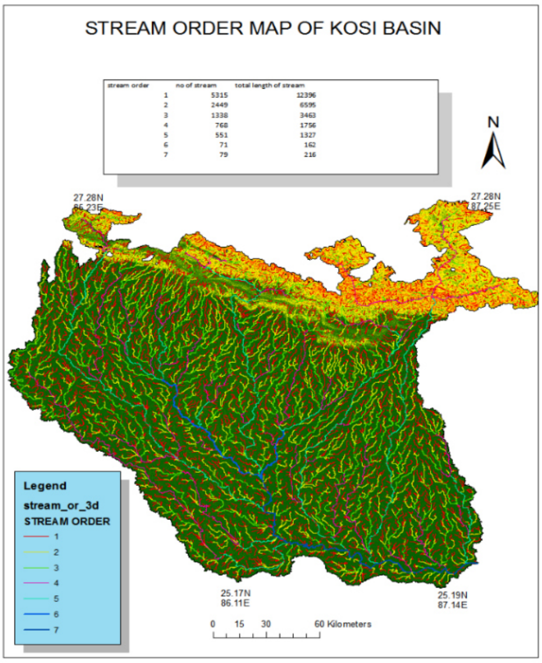


Fig2: The Basin area and Basin Perimeter Kosi and kanshabati Basin

3.1.1 Stream Order

The first step in drainage basin analysis is designated to stream order, following a system introduced by "strahler"





3.1.2 Bifurcation Ratio

It is obvious that the no. of stream segment of a given order will be fewer than for the next lower order but more numerous for the next higher order. The ratio of a no. of segments of a given order (u) to the no. of segment of the higher order (Nu+1) is termed as the Bifurcation ratio. Rb=Nu/Nu+1.

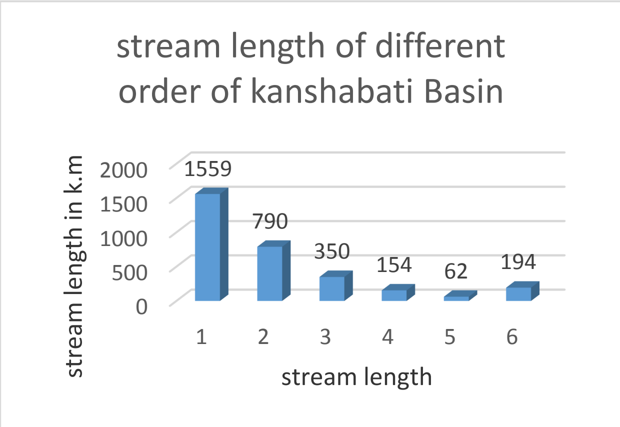
Table1.Table showing the Bifurcation characteristics of two basin

BASIN	KANSHABATI BASIN						KOSI BASIN						
Stream Order(u)	1	2	3	4	5	6	1	2	3	4	5	6	7
Stream No(Nu)	609	279	152	68	25	83	5315	2449	1338	168	551	71	99
Mean Bifurcation ratio	-	2.18	1.83	2.23	1.30	0.30	-	2.17	1.83	1.74	1.39	7.76	0.71
Bifurcation ratio	1.56						2.6						

Abnormally high Bifurcation ratio is expected in regions of steeply dipping rock strata of Kosi basin where narrow strike valley are confined between hogback ridges. The kanshabati shows the low bifurcation ratio compared to the kosi.

3.1.3 Stream Length Ratio

Mean length Lu of a stream channel segment of order u is a dimensionless property revealing the characteristics size of components of a drainage network and its contributing basin surfaces.To obtained the mean length of channel Lu of order u, the total length is divided by the no. of segments Nu of that order, thus, Lu= ∑Lu/Nu.



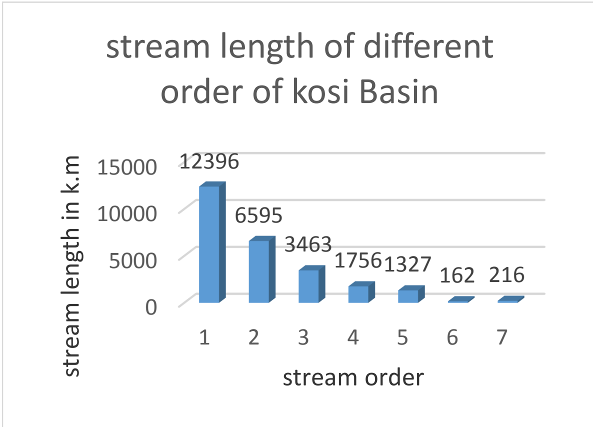


Fig4: Histogram showing the length of different stream order.

Table 2: Showing the mean stream length ratio of kanshabati and kosi basin

BASIN	KANSHABATI BASIN						KOSI BASIN						
Stream Order(u)	1	2	3	4	5	6	1	2	3	4	5	6	7
Stream length(Nu)	1559	790	350	154	62	194	12396	6595	3463	1756	1327	162	216
Stream length ratio(Nu/Lu)	-	1.97	2.25	2.27	2.48	0.31	-	1.87	1.90	1.97	1.32	8.19	0.75
Mean stream length ratio	1.85						2.66						

The stream length ratio of two different drainage basin shows variation. For kanshabati it is 1.85 which shows the pleatu basin characteristics. Whereas the kosi basin shows the high ratio as 2.66. The vast plain covered kosi is the main responsible for this high value.

3.1.4 Stream Area Ratio

Horton inferred that mean drainage basin areas of progressively higher orders should increases in a geometric sense, as do stream length

Table3: The stream area ratio of Kanshabati and Kosi basin basin

BASIN	KANSHABATI BASIN						KOSI BASIN						
Stream Order(u)	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Stream area ratio(au/au+1)	**-**	**1.90**	**2.22**	**2.23**	**2.37**	**0.32**	**-**	**1.87**	**1.90**	**1.97**	**1.32**	**8.19**	**0.69**
Mean stream lengthratio	**1.80**						**2.60**						

3.1.5 Length of overland flow

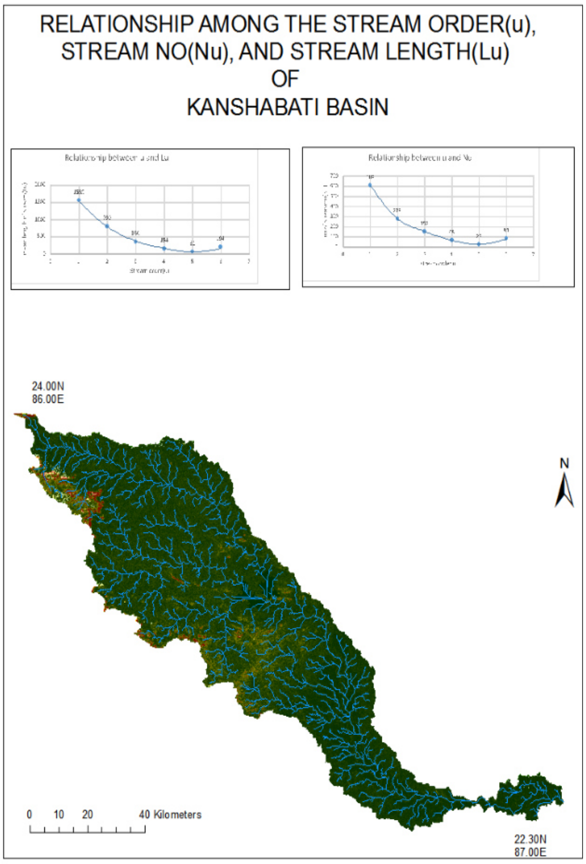
Horton defined length of overland flow (Lo) as the length of overland flow path, projected to the horizontal or non-channel flow from a point on the drainage divided to the point of adjusted stream channel

Table4: Showing the length of overland flow of two drainage basin

BASIN	KANSHABATI BASIN	KOSI BASIN
Length of overland flow	1.16	0.89

As kosi have the high drainage density due to the high relief it shows less value of length of overland flow and for kanshabati it is vice versa.

3.1.6 Relationship Between Stream order (u) to Stream no(Nu) and Stream Length(Lu)



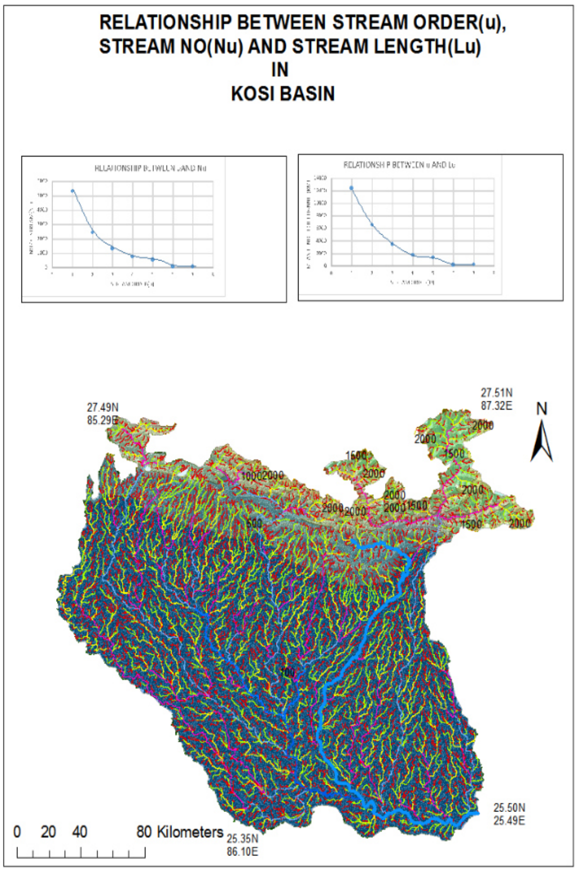


Fig5:Relationship between stream order (u) to stream no.(Nu) and stream length (Lu) of Kosi and Kanshabati

3.2 Areal aspect of Drainage Basin

Basin is hierologically important because it direct affect the size of strong hydrograph and the magnitudes of peak and strong runoff. . It is interesting to know that the maximum flood discharge from a unit area is inversely proportional to the size because the most instance strome are usually the smallest in size

3.2.1 Surface Area Elevation Characteristics

The relationship between deferent surface elevation covered areas is important because it gives the idea of the basin surface area and elevation characteristics of kanshabati basin shows that the large proportion of area lies in between the 200-300m. surface elevation which shows the quite mature drainage development in old Eastern chotonagpur palteau region. The high relief shows the less proportion of the area. 500m., >500m. is less in the areas.

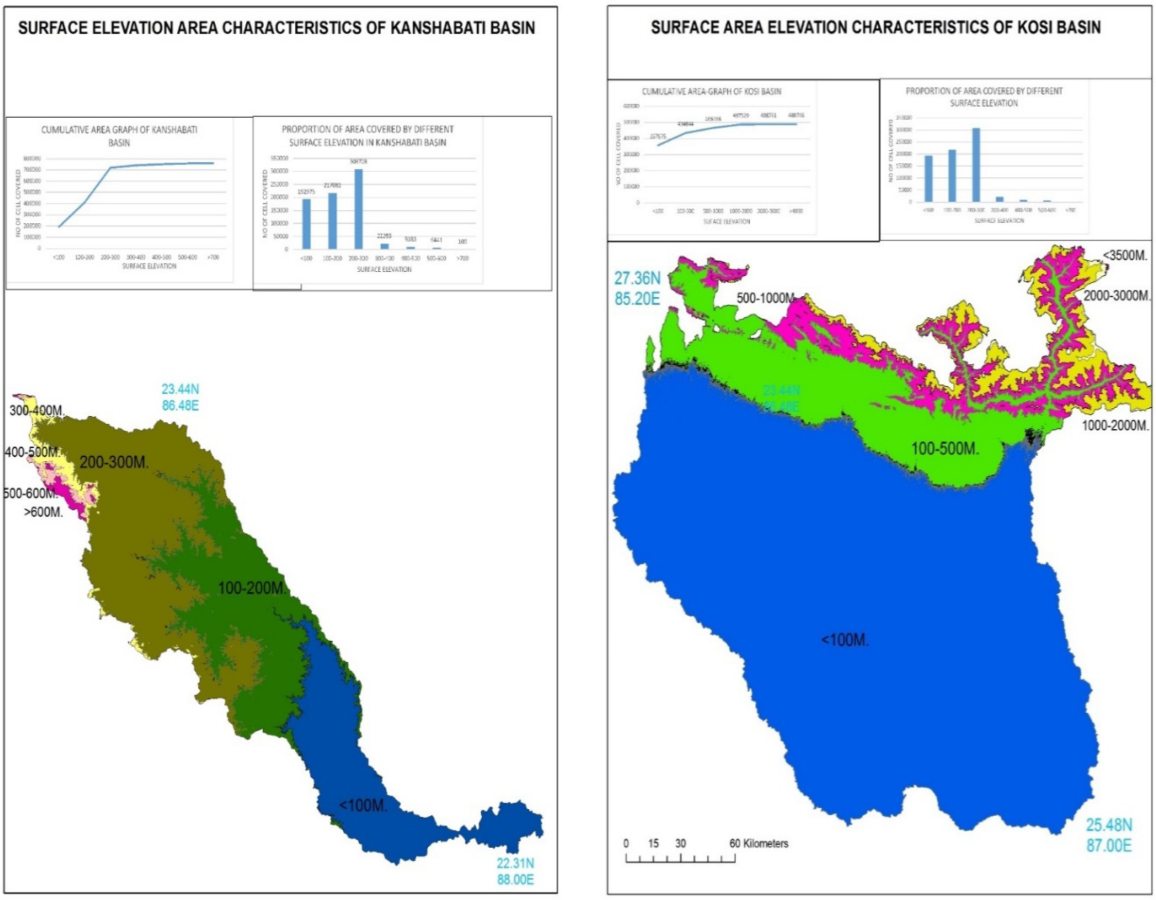


Fig 6: The Surface Area Elevation Characteristics of Kosi and Kanshabati Basin

The surface and elevation characteristics of kosi basin shows the different from the kanshabati basin areas. It Shows that the large proportion of area is under the <100m. it is the plain region of himalayan foot hill region as compared the area covered by the high relief as high as >3000m. is less the area covered by the region. Which is the hightail peaks of Himalayas**.**

3.2.2 Basin Shape (Outline Form)

The shape or outline form of drainage basin, as it is projected upon the horizontal datum plane of a map, may conceivably affact the stream- discharge characteristics. As explained above, long narrow basin with high bifurcation ratios would be expected to have attenuated food discharge periods, where as rotund basin of low bi-furcation ratio would be expected to have sharplly peked flood discharges

3.2.2.1 Form Factor

Quantitative expression of drainage basin outline form was made by horton through a form factor Rf, which is the dimensionless ratio of basin area Au to the square of basin length Lb, thus, $Rf= A/Lb2$, A=area, Lb=length of basin

Table5: showing the form factor of kosi and kanshabati

BASIN	KANSHABATI	KOSI
Form factor(Rf)	0.175	0.13

The kanshabati shows the high value as it is more normal than the kosi basin.

3.2.2.2 Circularity Ratio

Miller used the dimensionless circularity ratio Rc, defined as the ratio of basin areaAu to the area of a circle Ac having the same perimeter as the basin. It is found that the circularity ratio remains remarkably uniform in the range 0.6-0.7 for first and second order basin in homogeneous shales and dolomites, indicating the tendency of small drainage basin in homogenious geologic materials to preserved the geometrical similarities. For kosi and kanshabati it is-

Table6: showing the circularity ratio of kosi and kanshabati basin

Basin	KANSHABATI	KOSI
Circularity Ratio (Rc)	0.164	0.13

The kanshabati is circular in compare to kosi as it shows the high value. The control of plateau rigid masses and more or less stable surface is the causes responsible for this. Where as kosi which flows largelly of alluvial plain of himalayan foothills and himalayan region shows the less circularity than the kanshabati.

3.2.2.3 Elongation Ratio

Schumm used an elongation ratio Re, defined as the ratio of a diameter of a circle of the same area as the basin to the maximum basin length. This ratio runs between .2 to .8 over a wide variety of climatic and geologic type , value near to 1 are typically the region of low reliefs, where as value in the range of 0.6 to 0.8 are typically the region of rugged reliefs. And steep ground slopes.

Table7: showing the elongation ratio of kosi and kanshabati basin

Basin	KANSHABATI	KOSI
Elongation Ratio (Rc)	0.472	0.414

The reasult shows that kanshabati is less elongated than the kosi basin due to its pleatu flowing region. All the reasults say- form factor, elongation ratio, and circularity ratio shows the kanshabati is more regular say circular, less elongated compared to kosi.

3.2.2.4 Compactness Constant

Schumm used the inverser of drainage density as a property of constsnt of channel maintenance(c), thus,

$C= 1/D=Au/\sum Lu$, D= drainage density, Au=area, Lu=stream length,

Specifically the constant of channel maintaenance says the the no. of square feet of watershed required to sustained the one linear foot of channel. For kosi and kanshabati it is

Table8: showing the constant of channel maintenance of kosi and kanshabati basin

Basin	KANSHABATI	KOSI
Constant of channel maintanence(C)	2.32	1.78

As the kosi has the mountain flowing region so it required less area to sustain one linear foot of channel as compared to the kanshabati.

3.2.3 Stream Frequency

Horton introduced stream frequency or channel frequency F as the no. of stream segment per unit area, or $F= \sum Nu/Ak$, Nu is the total no of stream segment of the given basin area (Ak). For kosi and kanshabati it is,

Table9: showing the stream frequency of kosi and kanshabati

Basin	KANSHABATI	KOSI
Stream Frequency(F)	0.17	0.25

As kosi flowing throgh the himalayan and alluvial region it shows the high stream frequency as compared to the kanshabati which flows through the plateau region

3.2.4 Drainage Density

An important element of the linear scale of landform elements in stream eroded topography is drainage density D, introduced in the American hydrological literature by Horton.

$Dd = \sum Lu/Au$, where, Lu= length of stream, Au=Basin area.

Thus D is the ratio of total channel segment lengths cumulated for all orders with in a basin to the basin area. Drainage density varies with a wide dimension of geologic and climatic environments. In general the low drainage density is favored in the regions of highly permeable subsoil materials, under dense vegetation covered and where relief is low.

Table10: showing the drainage density of kosi and kanshabati basin

Basin	KANSHABATI	KOSI
Drainage Density (Dd)	0.43	0.56

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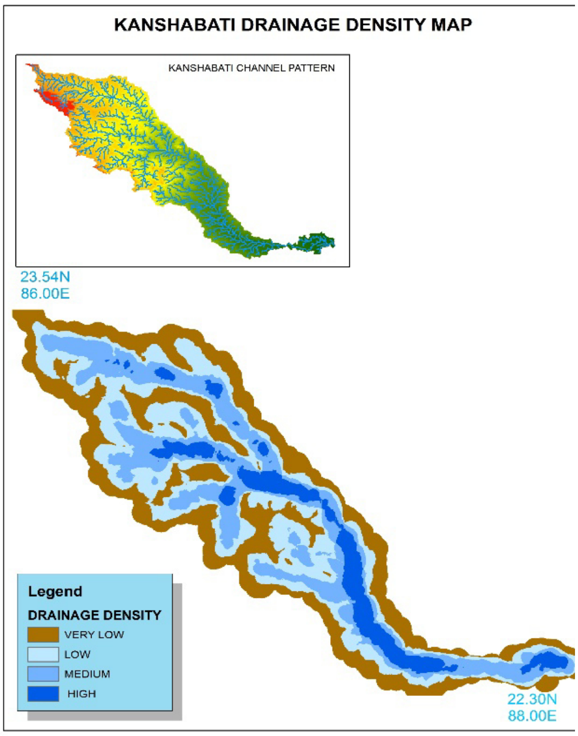
The high relief characteristics of kosi basin shows the high drainage density as compared to the kanshabati basin



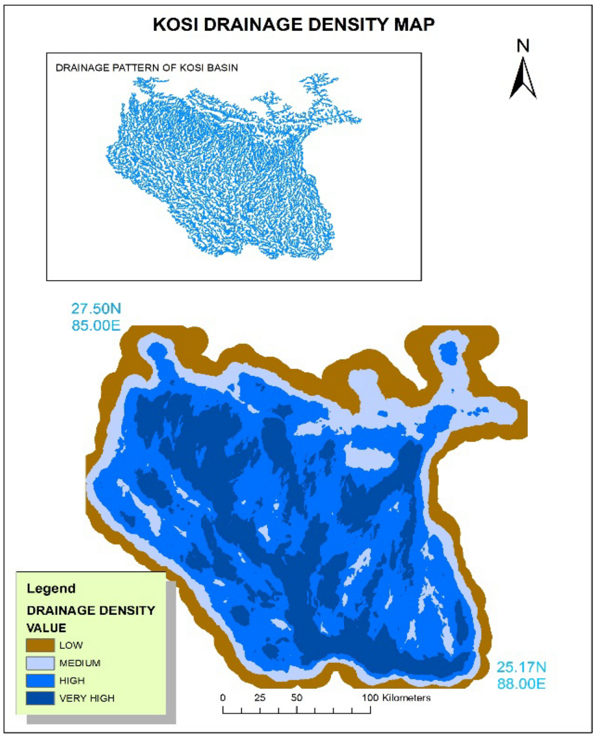


Fig7: The Drainage Density map Kanshabati and Kosi Basin

For kanshabati as it is flowing largely the region of erosional plateau it shows the less drainage density as compared to the kosi which flows through the rugged Himalayan and floodplain region of Himalayan foothills

3.2.5 Texture Ratio

The texture ratio or drainage texture is more or less is same thing which stressed on the number of contour crenulations to the perimeter of the study area. So, the texture ratio Rt=Nu/p, Nu= nos of streams, p=perimeter of the basin It gives the better idea about the basin areas drainage characteristics

Table11: Showing the Texture ratio of Kanshabati and Kosi Basin

Basin	KANSHABATI	KOSI
Texture Ratio (Rt)	1.65	5.0

3.3 Relief Measures

1. Relief H is the elevation difference between difference points defined in any one or several ways. Maximum relief within a given region or boundary is simply the elevation difference between highest and lowest points. Schumm measure basin relief along the longest dimension of the basin parallel to the principle drainage line.
2. Relief ratios: when basin relief H is divided by the horizontal distance by which it is measured, there results a dimensionless relief ratios Rh taking vertical and horizontal distance as legs of a right triangle, relief ratios is equal to the tangent of the lower acute angle and is identical with the tangent of the angle of slope of the hypotenuse with respect to the horizontal. The relief ratio thus measure the overall steepness of a drainage basin
3. Relative relief: when basin relief is divided by the perimeter is called the relative relief.
4. Ruggedness and geometric no: the combine the qualities of slope steepness and length, a dimensionless ruggedness no HD is formed of the product of relief H and drainage density D, where both terms are same in the unit. If D should be increase where H remains constant, the average horizontal distance from divides to adjustment channel is reduced, with an accompanying increases in slope steepness. If H is increased while D remains constant, the elevation difference between divides and adjacent channel will also increase. So that slope steepness increases.
5. Dissection index: miller developed the concept of dissection index. Where the relative relief is divided by the total highest relief of the basin

Table12: the general relief characteristics of kanshabati and kosi basin

RIVER BASIN	KANSHABATI	KOSI
TOTAL RELIEF (H)	657m.	3588m.
RELIEF RATION (H/Lb. max)	0.0019	0.012
RELATIVE RELIEF (H/P)	0.008	0.0016
DISSECTION INDEX (RR/H)	0.996	0.990
RUGGEDNESS NO. (H*Dd)	0.280	2.000

All the measures of relief aspect shows that the kosi is more youth and able to further erosional work. Kanshabati flows mainly on the dissected plateau region of chotonagpur that's why its ruggedness, relative relief, and dissection index value is less compared to kosi which flows largely on youth Himalayan region.

3.4 Relief Aspect of Drainage Basin

3.4.1 The Longitudinal profile

The longitudinal profile of a drainage can be shown graphically by plotting the altitude as a function of horizontal distance. . Altitude is commonly stated as the meter from the sea level datum; distance in mile or kilometers from stream head, stream mouth or some other convenient reference point. For streams of large discharge and hence order, a considerable factor of vertical exaggeration is used, whereas for streams of the order of regions of strong relief, none may be required.

A single channel profile follows one channel contentiously despite the junction tributaries of equal or lower stream order. Within a given basin that particular profile that following the trunk stream of highest order is unambitious, where continue the profile headword into the into channels of lower order requires the choice of one alternative into the at the head of each segment of a given order

The longitudinal profile of kanshabati and kosi shows a different view. Whereas for kanshabati it is quite regular. Or the gradient is less undulating.as its net relative relief is only 657m. and there is no greate devided within a profile as it flows largelly the dissected pleatu region of theeastern chottonagpur plateau.

For kosi the channel gradient is quite different from kanshabati. As the kosi is a river of neotectonic upliftment region of himalayas. So the himalayas shows a great breakethrough on kosi channel gradient. As it is shown that the in between upper course and lower course of the river there is a greater devided on himalayan foothills where it enterns the plain region of the indo-gangatic plains.

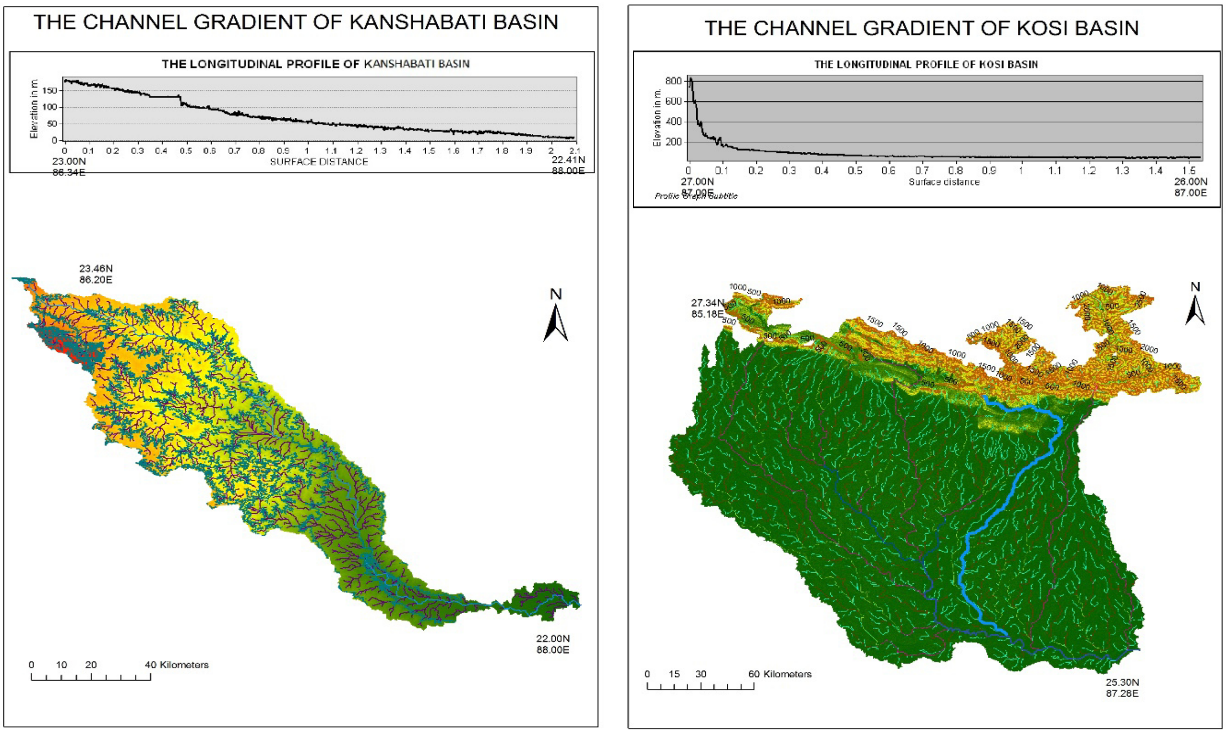


Fig8: The channel gradient of kanshabati and Kosi Basin

3.4.2 Valley Cross Profile

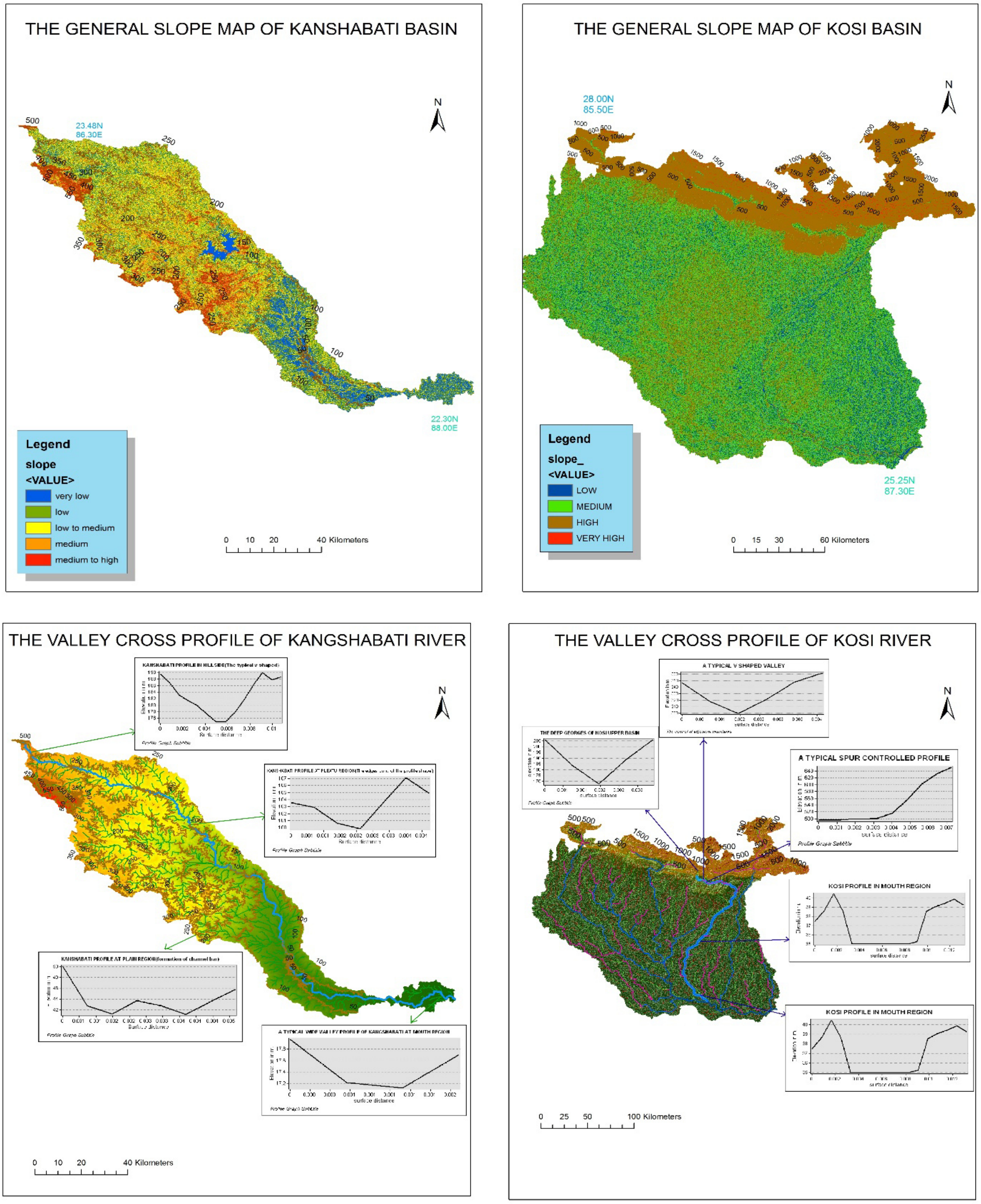


Fig9: valley Cross Profile of Kosi and Kanshabati Basin

3.4.3 Total Surface Slope Distribution

Slope condition over entire watershed may be shown by slope map, which shows the distribution of total surface slope inclination. The gradient and slope both the measure of geometry viewed in lines, gradient is expressed in the form of a ratio, while slope is an angular value, if the ground distance between two points on the map, called the horizontal equivalent is called d, and the elevation differences is called r, so- Gradient, g = 1:d/r, where, d=ground distance and r=relief differentiation, And slope=tan-1(r/d).

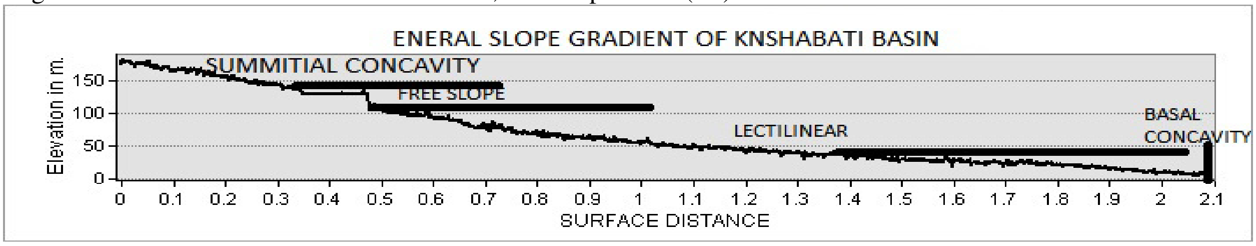


Fig10: The Elements of Slope of kanshabati Basin

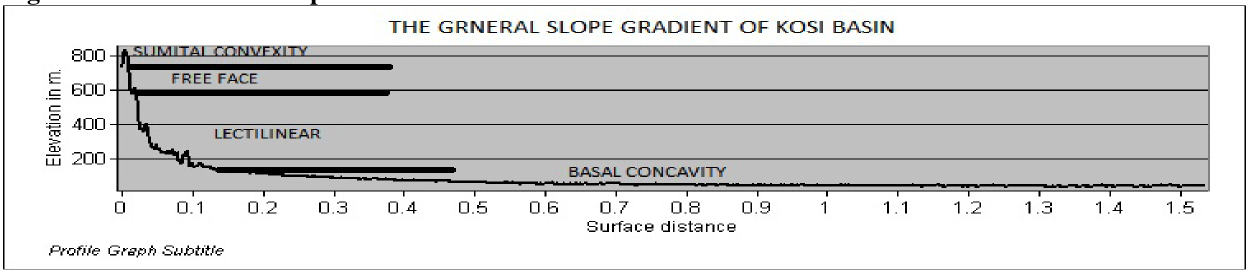


Fig10: The Elements of slope of Kosi Basin

Fig11: The Slope map of Kanshabati and Kosi Basin

The general slope map of kanshabati and kosi shows that the kanshabati is more prone to less or medium slope as it is the river system of eroded eastern chotonagpur plateau. Whereas for kosi as it is the river system of neo-tectonic up liftment is more prone to the high slope which is also indicators of more erosional work.

3.5 Channel Sinuosity:

The shape in the open links in terms of geometric structure of drainage line involves the calculation of derivation of observed path (Ol) from the expected path line (El) of a river from the source of mouth. Channel sinuosity= Ol/El, where, Ol= observed path of stream El= expected path of stream. . The degree of sinuosity gives the vivid idea about the stage of basin development as well as the landform evaluation.

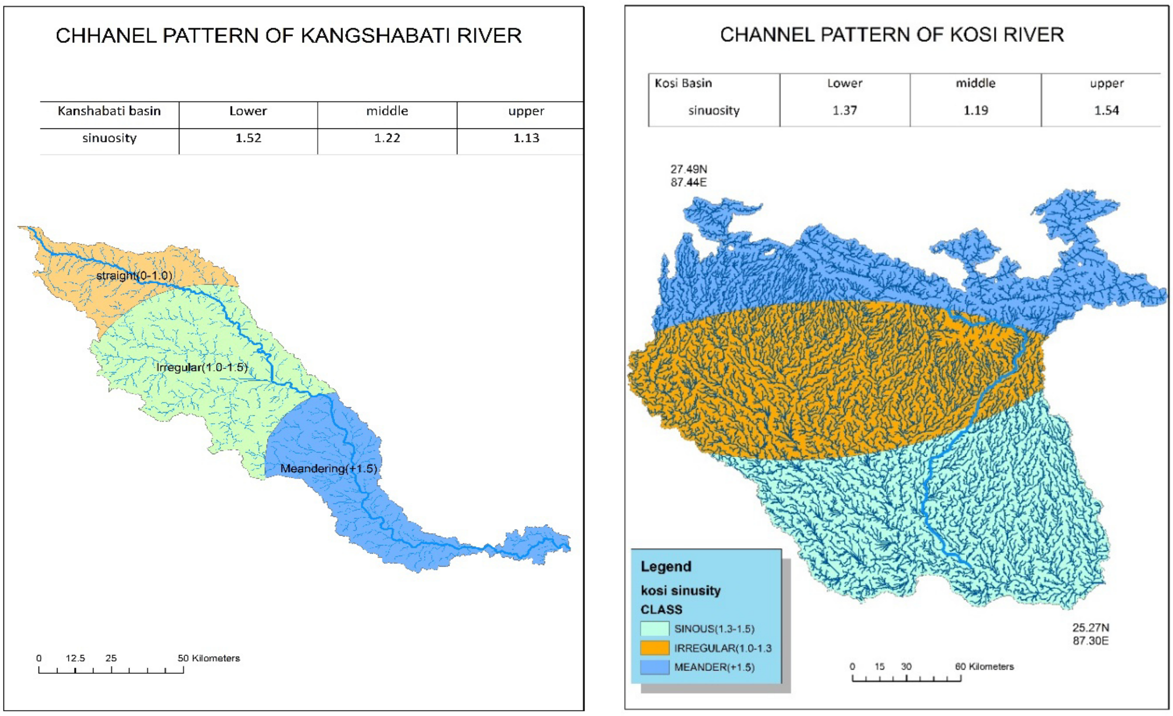


Fig 12: The Channel Sinuosity of Kanshabati and Kosi Basin

The channel sinuosity depicts a grate variation between kanshabati and kosi basin. As for kanshabati, the lower course of river shows the grate meandering due to its alluvial flowing region Whereas for kosi the lower zone shows the sinuous in character due to its plain flowing characteristics. Whereas middle zone shows the irregularity due to its Himalayan effects.

3.6 Hypsometric (Area-Altitude) Characteristics:

The two dimensionless variables involved in hypsometric analysis. Taking the drainage basin to be bounded by vertical side and horizontal base plane passing through the mouth, the relative height y is the ratio of height of a given contour h to total basin height (relief) H. relative area is the ratio of horizontal cross sectional area a to entire basin area A. the percentage hypsometric curve is a plot of continuous function relating relative height y to relative area x. the shape of hypsometric curve varies from early geologic stages of development of the drainage basin, but once a steady state is attained, tends to vary little thereafter . Despite lowering relief. Isolated bodies of resistant rock may rom may from prominent hills rising above a generally subdued surface.

The general hypsometric curve of kanshabati basin shows that the basin is mature to old in nature. Because the curve is not very convex one. The large proportion of area is covered by 200-300m. Elevation. And >300m. Area is less in proportion to the total area of the region. The absentee of high relative relief and rugged surface is prominent of this regio The general hypsometric curve of kosi basin shows the different views from the kanshabati basin. The large proportion of the area is covered by the high elevated contour. The general convexity of the curve shows that the region is more prone to potentiality of erosion.

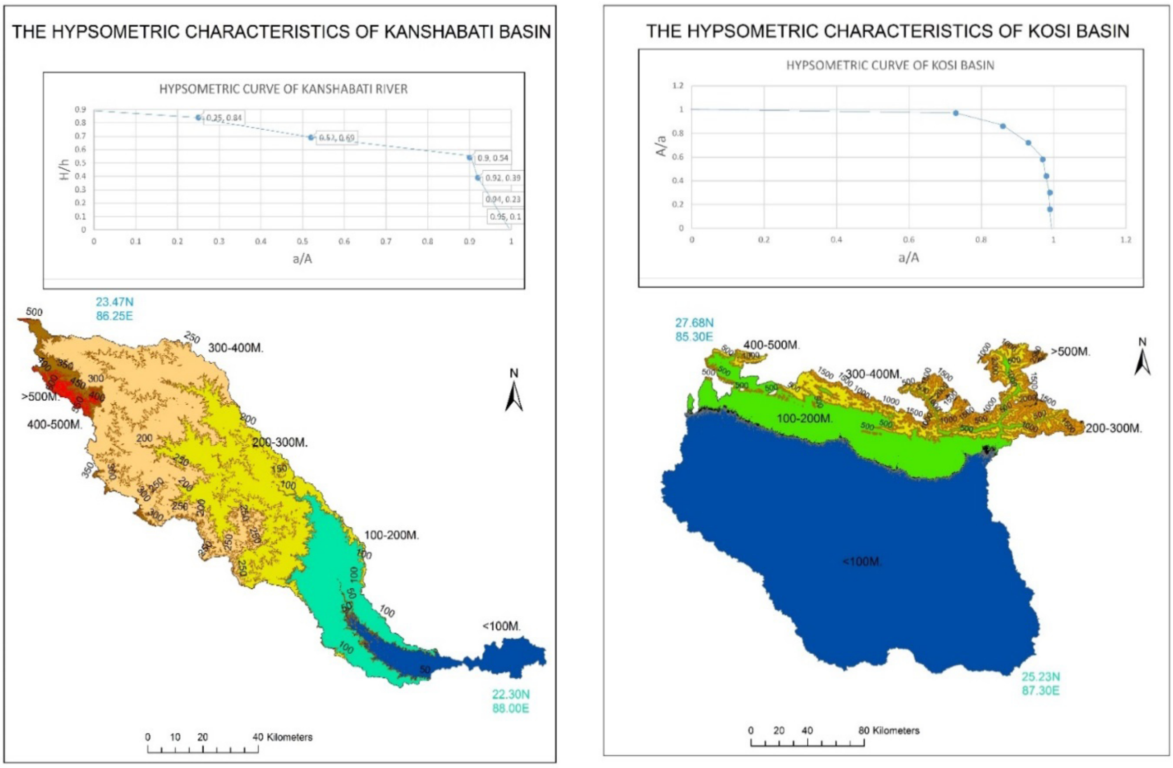


Fig13: The Hypsometric characteristics of Kosi and kanshabati Basin

4.Conclusion:

The quantitative study of drainage morphometric analysis shows a greater variation of drainage characteristics of kanshabati and kosi basin. As the total geological, geomorphological, and climatic condition of kosi and kanshabati is totally different so it delineate the basin relief characteristics. As we shows that the drainage linear and areal characteristics is totally different as we expected earlier in our hypothesis. The neo tectonic upliftment , rugged nature, high relative relief makes kosi a diatinct drainage basin from kanshabati which is the representative typical drainage pattern of erosional plateau of chottonagpur Plateau.

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