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Implication of drainage basin parameters for the Bunbuni River Basin in Chotanagpur Plateau region, India

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Abstract : A morphometric evaluation of Bunbuni basin was carried out to determine the drainage characteristics. Total study area is 58.75 Km². Rivers are the active processes which have a tendency to change the channel morphology and hydrological characteristics by the attrition and deposition. The average slope of the study area varies from 0° in the North West to above 8° towards south west. The slope variation is controlled by the local lithology and erosion cycles. Basin morphometry is a means of numerically analyzing or precisely quantifying different aspects of a drainage basin. The morphometric parameters considered for analysis includes the areal and relief aspects of the basin. The study has strengthened in perceptive the hydrological, geological and geomorphological characteristics of the Bunbuni drainage basin.
Keywords *- Morphometric evaluation, areal & relief aspects, attrition, Bunbuni river basin*.

I. INTRODUCTION

Morphometric investigation reveals to quantitative evaluation of form exclusivity of landscape. Drainage basin provides an perfect unit of the landscape and as such the quantitative evaluation of drainage networks of a basin can give useful clues to perceptive the earth surface form and processes. Supplementary, river channels being the most responsive geomorphic features responding to any change in geographical factors viz. lithology and tectonics as well as climate, morphometric parameters are projected to reflect mutual control of these factors. The composition of the stream system of a drainage basin is expressed quantitatively with Area ratio, Drainage density. It incorporates various components such as, stream segments, basin length, basin parameters, basin area, altitude, volume, slope, profiles of the land which indicates the nature of development of the basin. There are overabundance of literature on drainage basin morphometry that have contributed towards understanding drainage development in the light of controlling variables in a particular geological terrain and a number of general bivariate relationship have been established (Strahler 1952, 1957, 1958, and 1964; Schumm, 1956; Morisawa, 1957, 1958; Scheidegger, 1965; Hack, 1973; Shreve, 1967; Gregory, 1968; Gregory and Walling, 1973 and Keller and Pinter 1996). Here we present the Areal and relief morphometric parameters of Bunbuni river basin of Chotanagpur plateau region to see their conformity with available understanding on drainage development and landform evolution.

II. MATERIALS AND METHODS

The Survey of India Toposheet number is 72 L/2 on the scale of 1: 50,000 were used for the present study. The different Areal and relief aspects of the morphometric parameters have been used. Microsoft Excel 2007 is use to enumerates the data analysis and MapInfo-11.0 software has helped in the preparation of different thematic maps.

III. LOCATION OF STUDY AREA

The Bunbuni river basin bordered between latitude 24°39´45´´N to 24°45´05´´N and longitude 86°6´55´´E to 86°10´01´´E in Survey of India Toposheet numbers 72L/2 and having area of about 58.75 km² (Fig. 1). The Bunbuni river is one of the tributary of the Bhoriwajor river and Bhoriwajor river is a tributary of river Kiur. This study area has a striking climate. For five to six months of the year, from October onward the days are bright and stimulating. The mean temperature in December is 23 °C (73 °F). The nights are cool and temperatures in winter may drop below freezing point in many places. In April and May the day temperature may cross 38 °C (100 °F) but it is extremely dry and no humid as in the adjoining plains. The rainy season (June to September) is pleasurable. The study area receives an yearly average rainfall of around 1,400 millimetres (55 in), which is less than the rain forested areas of much of India and almost all of it in the monsoon months between June and August. The Bunbuni river basin shows well developed dendritic to sub dendritic type drainage pattern (Fig 1). In the present paper the authors had made an attempt to morphometric analysis of Bunbuni river basin.

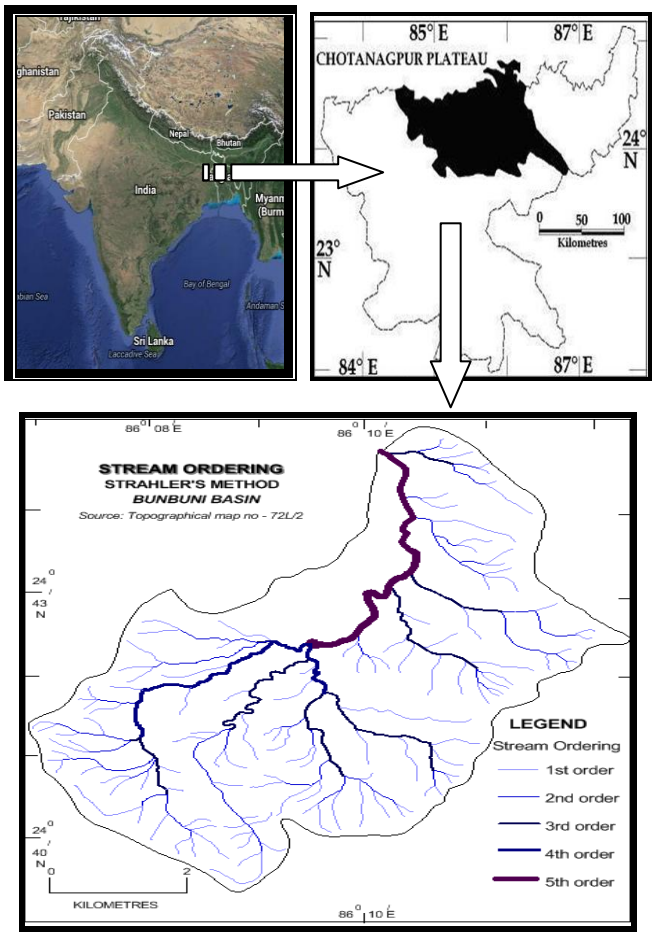


Fig: 1 Location map of the study area.

IV. RESULTS AND DISCUSSIONS

Some selected techniques are adopted to show the areal and relief aspects of the basin as follows –
Areal aspects: Area ratio, Drainage density.
Relief aspects: Relative relief, Dissection index, Ruggedness index, Average slope etc.

4.1 Areal aspects of the basin

The areal aspects of a drainage basin expose regional features like lithology, geological structure, climatic conditions and denudation history of the basin. These aspects control the spatial arrangement, geometrical shape and form of drainage systems, river discharge and runoff characteristics [1]. Areal aspects of a drainage basin includes Area ratio, Drainage density. These aspects suggest immediate necessity of water conservation measures in the upstream catchment areas of the Bunbuni river basin, to enhance infiltration of surface runoff into the sub-surface for restoration and provisions of the spring sources.

4.1.1 Area ratio (Ar)

Area ratio reveals ratio of increase of mean basin areas between two successive orders and it can be expressed by following equation. [1]

$$Ar = Au/Au\text{-}1 \qquad [1]$$

Where, Au is mean area of a given order of the basin.
When, $Au = \sum Au / Nu$
Nu = Number of all segments of a given order.
$\sum Au$ = Total area of all stream segments of the same order.

Table: 1 Showing Stream Order wise area of the Bunbuni River basin

Stream Order	Basin Area in Km²	Basin Area in %	Cumulative Basin area in %
1st	0.65	1.11	1.11
2nd	3.25	5.53	6.64
3rd	6.85	11.65	18.29
4th	12.55	21.37	39.66
5th	35.45	60.34	100

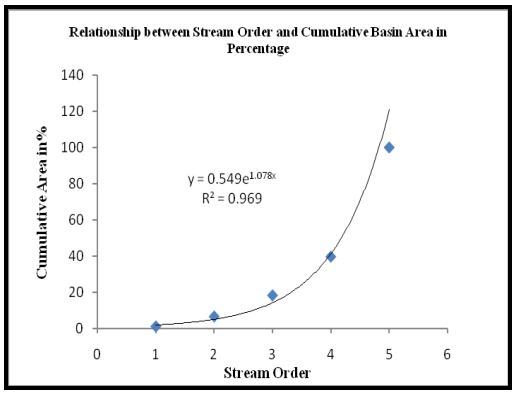


Fig: 2 Relationship between Stream order and Cumulative basin area of the study area.

4.1.2 Drainage density (Dd)

Drainage density indicates to the total stream lengths per unit area. Drainage density as a ratio of total length of all stream segments in a given drainage basin to the total area of that basin [3] [4] and thus it can be Expressed as follows - Dd =Lu/A

Where, Lu =Total stream length of all orders, A =Total area of the basin, Km².

Drainage density values for the Bunbuni river basin is 0.37 Km-1 representing low drainage densities. The type of rock also affects the drainage density usually lower values of Dd tend to take place on granite, gneiss, and schist regions. But the single values for the whole basin which does not agree to the accepting of spatial variation of these aspects over the whole basin. In case the spatial variation can be originate out by dividing the basin into one square Kilometer grids and then by assemblage the data so derived into different categories. For Bunbuni river basin following zone has been recognized. (Fig 3)

Table: 2 Showing Drainage density of the Bunbuni River basin

Drainage density	Area (in km²)	Area in Percentage
1 - 2	1.39	2.36
2 - 3	15.81	26.90
3 – 4	38.46	65.49
4 – 5	2.69	4.57
Above 5	0.40	0.68

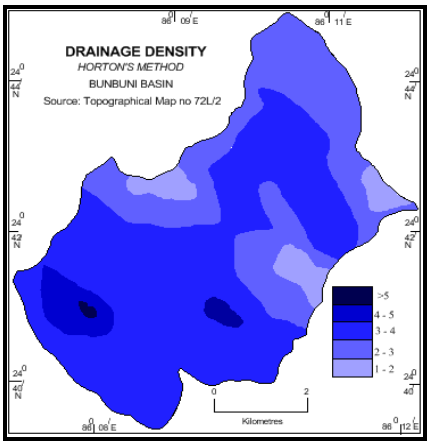


Fig: 3 Drainage Density map of the study area.

4.2 Relief aspects of the basin

Relief aspects of a drainage basin reproduce the topographical gradient characteristics of the basin and present a bird's eye view of the whole area. The relief aspect of drainage basin includes elevation of highest and lowest point in the basin, Relative relief, Dissection index, Ruggedness index, Average slope etc.

4.2.1 Relative relief:

Relative relief is defined as the difference in height between the highest and the lowest points (height) in per unit area. The Relative relief of Bunbuni river basin is 397 m. The Relative relief represents an actual differentiation of elevation in a unit area with reverence to its local base level. Relative relief is an indicator of the general steepness of a basin from high point to mouth. It is more noteworthy and also valuable in accepting morphogenesis. For Bunbuni river basin subsequent categories is recognized. (Fig 4)

Table: 3 Showing Relative relief of the Bunbuni River Basin

Relative relief	Area (in km²)	Area in Percentage
0 - 20	6.85	11.65
20 – 40	32.375	55.11
40 - 60	2.95	5.02
60 - 80	3.05	5.19
80 - 100	3.175	5.41
Above 100	10.35	17.62

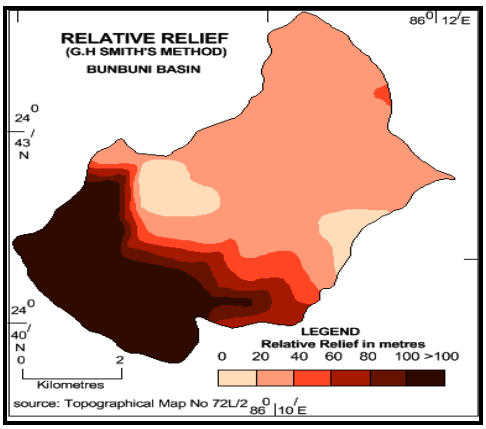


Fig: 4 Relative Relief map of the study area.

Table: 4 Showing Dissection index of the Bunbuni River Basin.

Dissection index	Area (in km²)	Area in Percentage
0.1 -0.2	35.45	60.34
0.2 - 0.3	7.45	12.68
0.3 – 0.4	11.95	20.34
0.4 – 0.5	3.15	5.36
Above 0.5	0.75	1.28

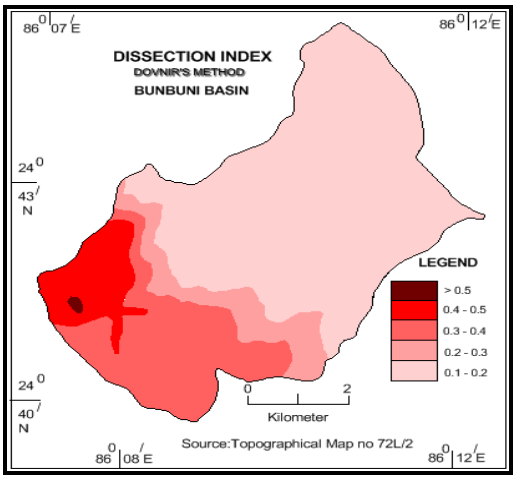


Fig: 5 Dissection Index map of the study area.

4.2.2 Dissection Index

Dissection index indicates a ratio of the maximum relative relief to the maximum absolute height. It is a significant morphometric indicator of the nature and amount of dissection of terrain.

DI =R/Max

Where, R = Relative relief, Max = Maximum elevation of the basin (m)..... (Dovnir 1957)

For Bunbuni river basin following categories is identified. (Fig 5)

4.2.3 Ruggedness Index

RI is an appraised of surface ruggedness, instead of sharpness of local relief and the amplitude of available drainage density and other environmental parameters. RI is calculated by taking into account both relief and drainage [5]. In this analysis shown that the high classes of RI are found in south and south western region of the study area (Fig 6).

Table: 5 Showing Dissection index of the Bunbuni River Basin.

Ruggedness Index	Area (in km²)	Area in Percentage
0 -50	18.25	31.06
50 – 100	16.98	28.91
100 – 150	4.02	6.84
150 - 200	3.74	6.36
Above 200	15.76	26.83

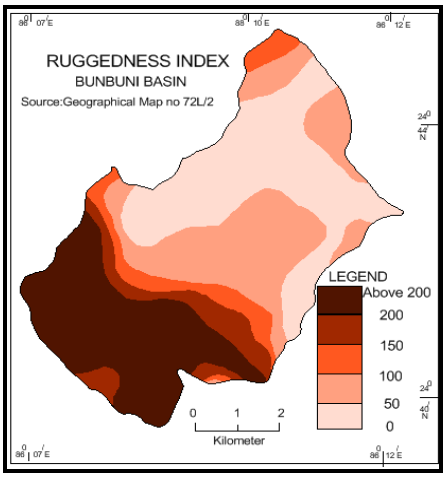


Fig: 6 Ruggedness Index map of the study area.

4.2.4 Average Slope

Slope, separate as angular inclinations of terrain between hill-tops and valley bottoms, significant from the amalgamation of several contributing factors like geological structure, absolute and relative reliefs, climate, vegetal cover, drainage texture and drainage frequency, dissection index etc. are noteworthy morphometric attributes in the study of landforms of a drainage basin. Calculation of slope angles from topographical map or through field dimension involves tedious and time overriding procedures. Numerous technique have been recommended through time to time e.g. J L Rich (1916), C.K Wentworth (1930), G.H.Smith (1938),(1939),E. Raize and J Henry (1937), W.C.Calef (1950) ,W .C calef and R New comb (1953), A . N Strahler (1956) etc , but the techniques of Wentworth being easier and involving lesser measurement and calculating and more swift procedure than other schemes has been widely used by several Geomorphologists.

For the groundwork of the average slope map the study area be divided into 2×2 cm grids each having straight lines at right angles and the number of contour crossing along the boundaries of grids are counted and then substantial from tan values are obtained from log table. (Fig 7)

Slope in degree –tan Q= N/4 ×/C.I /636.6.

Where N/4=Average no of contour crossing.

N- No of contour crossing.

C.I – Contour interval.

636.6 = Constant value.

Table: 6 showing the Average slope of the Bunbuni river basin.

Slope in ◦c	Area (in km²)	Area in percentage
0 - 2	9.74	16.58
2 -4	27.33	46.52
4 - 6	2.1	3.58
6 -8	3.09	5.26
Above 8	16.49	28.08

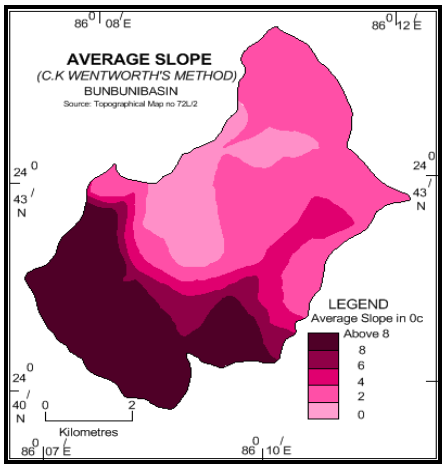
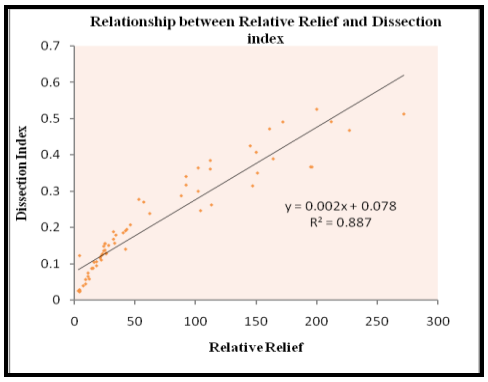
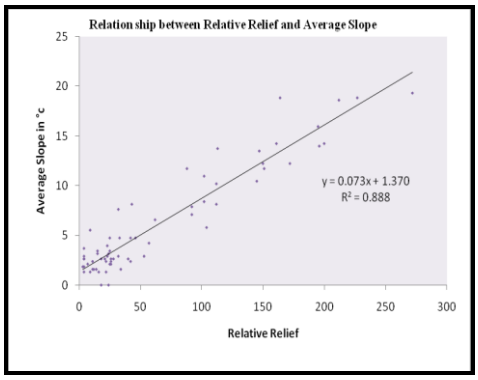


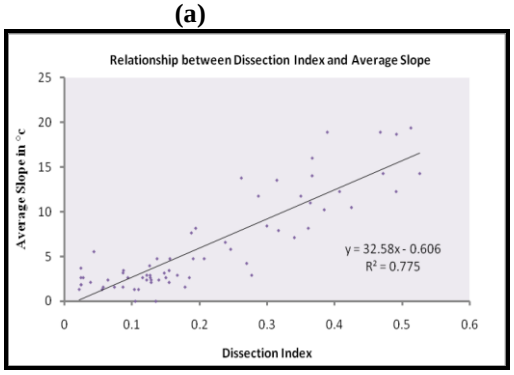
Fig: 7 Average slope map of the study area.



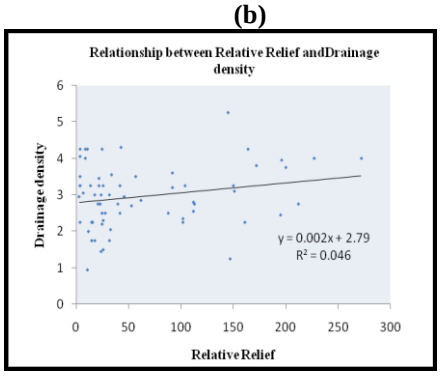
(a)



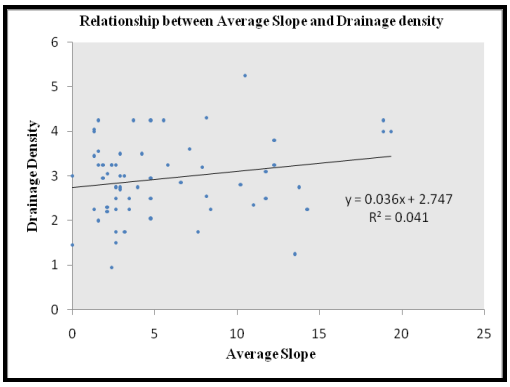
(b)



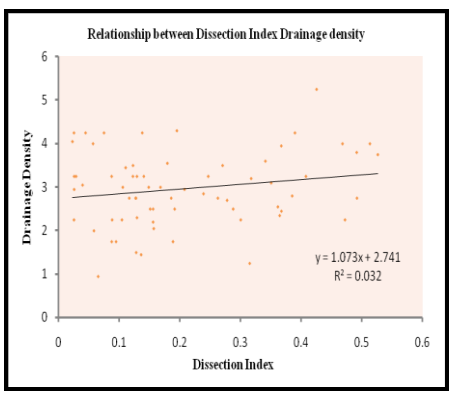
(c)



(d)



(e)



(f)

Fig: 8 (a), (b), (c), (d), (e) and (f) had shown the relationship between different morphometric attributes of the study area.

V. CONCLUSION

Based on the morphometric analysis the results show that the local relief characteristics with some observation of structural landscape pattern of the Bunbuni river basin. It is shown that the high absolute relief area is surrounded in the south western region. Spatial distribution of relative relief at some location indicates symmetrical distribution, which indicates inactive tectonic in the area. Low value of dissection index is found almost whole valley except few places of south western portion of the study area. Higher the value of dissection index and the topographic ruggedness indexes are calculated over the region, indicating less undulation and stability of the terrain/land surface. Therefore, it is suggested that the attained outcome to be utilized in hydrological, physical characteristics, and environmental management in the Bunbuni river basin.

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