Hypsometric Analysis of Bunbuni River, Chotanagpur Plateau, in India

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Abstract: ***Hypsometric analysis reveals the distribution of horizontal cross-sectional area of river morphology with reverence to elevation (area-altitude analysis). Morphology of a river basin playing most important roles in the dynamics of surface and subsurface water runoff set up. It is also an important tool to determine and represent the form of a watershed and its evolution. Aspire of the paper is to bring out the Hypsometric analysis of The Bunbuni river is one of the tributary of the Bhoriwajor River and Bhoriwajor river is a tributary of river Kiur. Hypsometric integrals/elevation relief ratios indicating a mature to old stage landscape, medium to complex denudational processes, the linear river morphological changes of this river basin. This paper reveals the rainwater harvest practices and management for the watershed at appropriate locations for scheming further erosion, dropping the runoff and increases the groundwater probable.***

Keywords: Hypsometric analysis, Bunbuni River, groundwater, denudational processes

1. Introduction

Hypsometric analysis was first time introduced by Langbein, [1] to convey the overall slope and the forms of drainage basin. Hypsometric analysis (area-altitude analysis) is the study of the distribution of horizontal cross-sectional area of a landmass with high opinion to elevation [2]. In nature, hypsometric analysis has been used to make different between erosional landforms at different stages during their evolution [2][3]. The numerical characteristic in the hypsometric analysis includes the hypsometric integral (*I*), hypsometric curve, hypsometric skewness, etc. [4] Comparisons of the shape of the hypsometric curve for different drainage basins under similar hydrologic conditions provides a relative insight into the past soil movement of basins. Thus, the shape of the hypsometric curves explains the temporal changes in the slope of the original basin. Strahler, [2] interpreted the shape of the hypsometric curves by analyzing numerous basins and classified the basins as young (convex upward curves), mature (S-shaped hypsometric curves which is concave upwards at high elevations and convex downward at low elevations) and peneplain or distorted (concave upward curves). There is frequent variation in the shape of the hypsometric curve during the early geomorphic stages of development followed by minimal variation after the watershed attains a stabilized or mature stage. Hypsometric analysis is carried out to determine the receptiveness of watershed to erosion and prioritize them for treatment. The slope of the hypsometric curve changes with the stage of watershed development, which has a greater bearing on the erosion characteristics of watershed and it, is indicative of cycle of erosion. The hypsometric integral (Hsi) is also a suggestion of the 'cycle of erosion's [2][5]. The cycle of erosion is the total time essential for reduction of land area to the base level i.e. lowest level. This entire period or the cycle of erosion can be divided into the three stages viz. mondnock (old) (His 0.3), in which the watershed is fully stabilized;

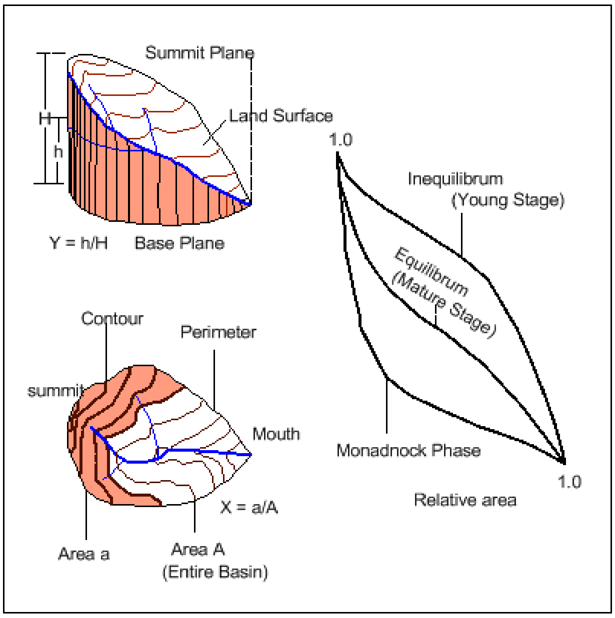

Figure 1: The concept of hypsometric analysis and model hypsometric curves (Ritter, 2002)

equilibrium or mature stage (Hsi 0.3 to 0.6); and in equilibrium or young stage (Hsi> 0.6), in which the watershed is highly susceptible to erosion Strahler, (1952).Hypsometric curves and hypsometric integral is important watershed health indicator. Hypsometric analysis using GIS has been used by several researchers in India dealing with erosional topography [6][7] Further, there is lack of hypsometric based studies to watershed health, which is attributable to the tedious nature of data acquisition and analysis is concerned in assessment of hypsometric analysis.

2. Location of the 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 Apil rand 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

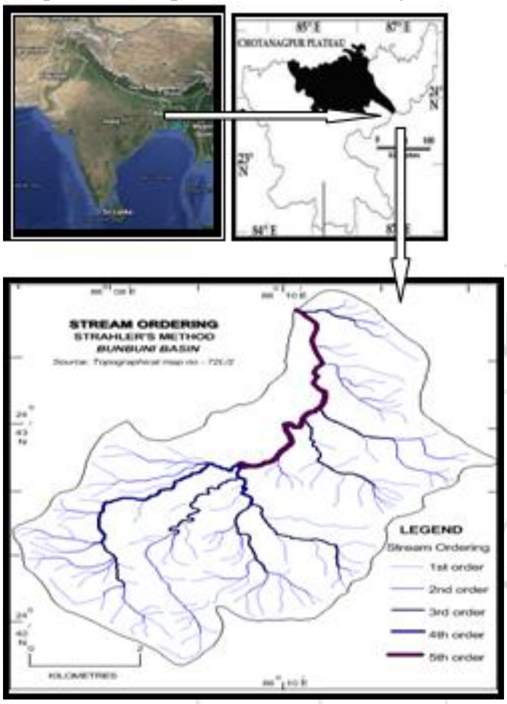

Figure 2: Location map of the study area.

receives a yearly average rainfall of around 1,400 millimeters (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.2). In the present paper the authors had made an attempt to hypsometric analysis of Bunbuni river basin.

3. Data and Method

Base map of the study area was prepared using Survey of India (SOI) toposheet 72L/2 the topographical information of the watershed in 1:50000 scales with contour interval 20 m acquired from SOI toposheet is digitized using capability of Maplnfo Professional 11.0. Subsequently drainage network was also digitized. After that the watershed boundary and sub-watersheds boundaries were delineated. The contours were generating the line feature class in Maplnfo Professional 11.0 and after that it was polygonized to find out the area enclosed by each contour.

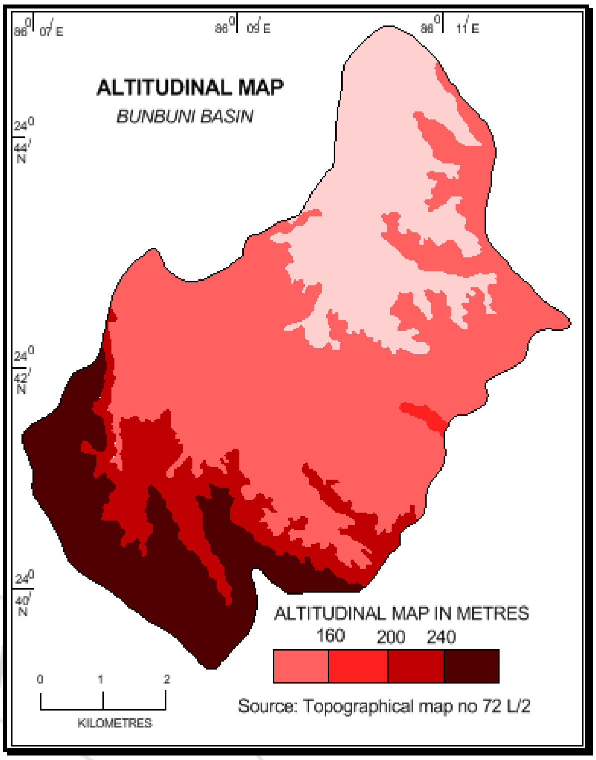

Figure 3: Altitudinal map of study area

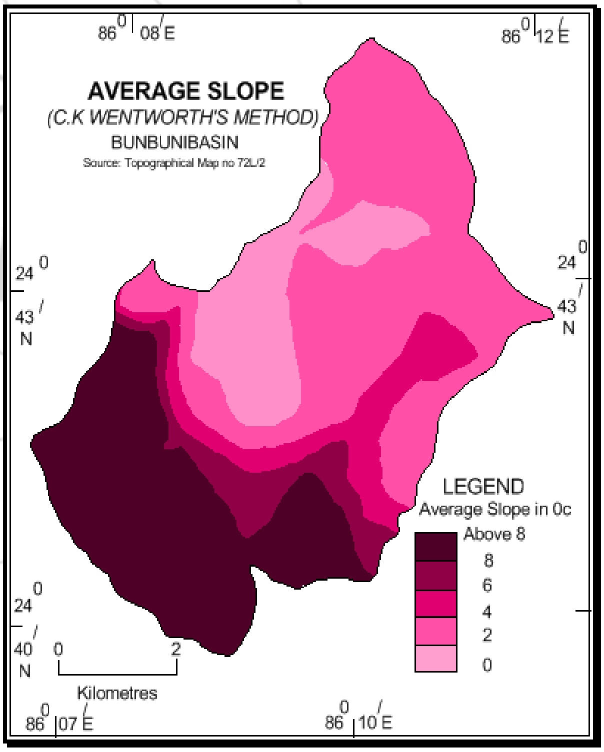

Figure 4: Slope map of the study area

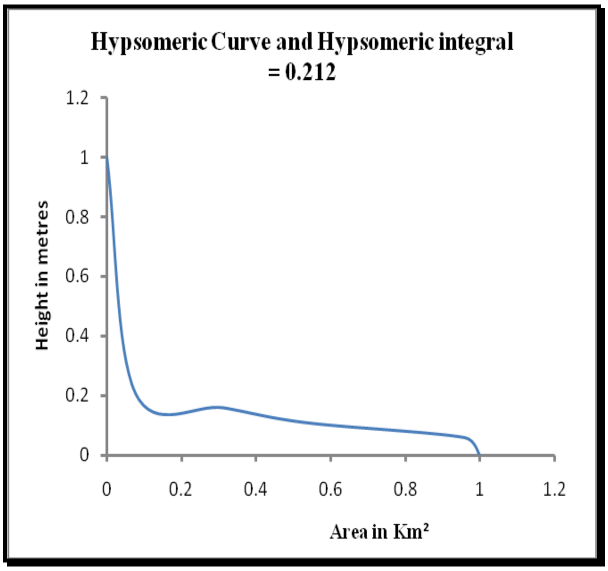

Figure 5: Hypsometric curve and Hypsometric integral

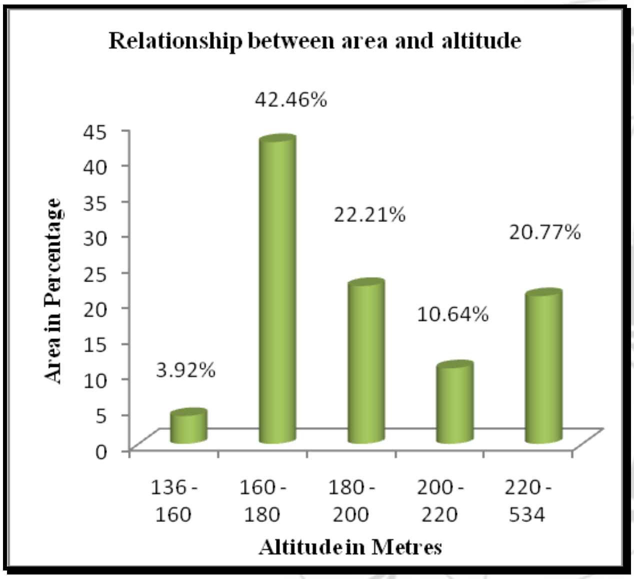

Figure 6: Relationship Between Area and Altitude

4. Results and Discussion

Figure 5 shows the results of hypsometric analysis for the Bunbuni river basin. Hypsometric curves show low hypsometric integrals/elevation-relief ratios indicating a mature to old stage landscape. The hypsometric integral value is 0.212[Table1]. Due to run-off there is less kinetic energy, the ground is cut away later so the curve of elevation versus area falls off more slowly. This could be due to the soil erosion from the basin and down slope movement of topsoil and bedrock material, washout of the soil mass and cutting of stream banks. The hydrologic response of the basin has old stage, will have moderate rate of erosion during peak runoff and require suitable soil and water conservation procedures. The hypsometric curve expresses medium to complex denudational processes and the linear river morphological changes of this river basin. This study suggests that many artificial recharge structures are suggested at many places to increase the groundwater potential and to control the soil erosion. Low hypsometric integral indicates suitable locations for recharge structures and moderate values are suitable sites for preventing soil erosion and also runoff.

5. Conclusions

This revise places of interest the significance of hypsometric analysis for rainwater harvest practice and management for the river basin at appropriate locations for controlling further corrosion, falling the runoff, rising the groundwater potential and assorted stages of landform processes in the Bunbuni river basin. As a result with remote sensing data and open source tools it is becomes less monotonous to make hypsometric integrals and curves. Though, the available data and the software module have some restrictions, it can be well thought-out to be a back-up for more study.

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Table 1: Worksheet for Hypsometric curve and hypsometric integral

Height (m)	Area (a)	Relative area (a/A)	Cumulative a/A		Altitude (h)	Relative height h/H	Cumulative h/H		Remarks
			Above Altitude	x			Below Altitude	y	
136 - 160	2.3	0.039	136	1	24	0.06	136	0	Basin area -58.75 Km²
160 -180	24.95	0.425	160	0.962	20	0.05	160	0.06	
180 -200	13.05	0.223	180	0.536	20	0.05	180	0.11	
200 -220	6.25	0.1063	200	0.314	20	0.05	200	0.16	Basin relief - 398m
220 -534	12.2	0.2076	220	0.207	314	0.79	220	0.21	
	58.75	1	534	0	398	1	598	1	

Computation of Hypsometric integral

Coordinates		Cross Products		H.I =Area of the polygon reduced to scale (of the Graph)
x	y	$x.y_{i+1}$	$x_{i+1}.y$	= (0.528486 -0.0999)/2(reduced to scale)
1	0	0.06	0	= 0.2124775(1×1)
0.96	0.06	0.1056	0.0323	0.2124775
0.536	0.11	0.08576	0.0345	
0.3139	0.16	0.0659	0.0332	
0.076	0.21	0.2076	0	
0	1	Sum = 0.52486	Sum = 0.0999	