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A HYPSOMETRIC PERSPECTIVE IN COMPREHENSING THE GEOMORPHIC DEVELOPMENT OF TAMBRAPARNI RIVER BASIN, WESTERN FLANK, SOUTH WESTERN GHATS

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ABSTRACT

This paper deals with a part of the author's research work dealing with the geomorphometry and geomorphology of the Tambraparni River Basin (TRB) of Kanyakumari District of southern Tamil Nadu, located on the western flank of South Western Ghats. The Western Ghats Mountain chain is today internationally recognized as a region of immense global importance for the conservation of its biological diversity, besides its association of areas of great geological, cultural and aesthetic importance. Hypsometric analysis quantifies the geologic stages of development and erosional proneness of a river basin. In this study, efforts were made to estimate the hypsometric values of the Tambraparni River Basin and so as to understand the geologic as well as geomorphic evolution and stages of the basin. In the present study as the value of hypsometric integral is 0.0484, which is associated with a highly concave hypsometric curve, it indicates that the major portion of the basin of Tambraparni River lies at a comparatively low relief. Typically, the basin is associated with highly dissected and eroded landscape as a result of fluvial action.

KEYWORDS: Analysis, Geomorphometry, Geomorphic Stages, Hypsometry, TRB, Western Ghats

INTRODUCTION

Hypsometry is a term that pertains to elevation measurements of the Earths terrestrial surface. Hypsometric analysis is the study of the distribution of ground surface area, or horizontal cross-sectional area, of a landmass with respect to elevation (Strahler, 1952). Langbein (1947) appears to have been introduced the hypsometric curve, which is an empirical cumulative distribution function of elevations in drainage basin. However it was Strahler who popularised the study of hypsometric curve through his excellent paper (Strahler 1952) in which he has demonstrated the usefulness of hypsometric curve in geomorphometric research of drainage basins. Hypsometery is used to evaluate different measurements for different natural drainage basins, or well defined areas, to determine the types and rates of different processes that shape the Earth's surface over time.

The two common approaches used to measure the landscape hypsometric studies are (1) the hypsometric curve and (2) the hypsometric integral. Hypsometric curve is simply a histogram that depicts the distribution of basin area with elevation, usually as a proportion of area above a unit of elevation (Langbein, 1947 and Strahler, 1952). Hypsometric integral, on the other hand measures the percentage volume of earth material remaining after the erosion of an original landmass having volume equal to the reference solid with base equal to basin area and the height equal to total height range in the basin. It was Strahler who proposed the dimensionless hypsometric integral. This is used as a measure of landscape evolution.

Strahler suggested the *percentage hypsometric curve* in which he showed concretely how a detailed analysis of percentage hypsometric curve can provide valuable indications of the stage of evolution of a particular drainage basin associated with uplift and denudation. In very detailed studies, Strahler (1952) and Schumm (1956) have demonstrated the multiple possibilities of interpretation of hypsometric curves regarding the stage of basinal evolution.

HYPSOMETRIC CURVE

A hypsometric curve is an empirical cumulative distribution function of elevations of a watershed or drainage basin. A hypsometric curve is essentially a graph that shows the proportion of land area that exists at various elevations by plotting relative area against relative height. There are basically two kinds of hypsometric curves employed in geomorphometric studies. The first one is *hypsometric curve in absolute units*, and the other one being the *percentage hypsometric curves.*

Hypsometric Curve in Absolute Units: The simplest form of hypsometric curve is that prepared in absolute units of measure. It is also known as hypsographic curve. It is obtained by plotting on ordinate (y-axis) elevations in feet or meters) and, and on abscissa the area (in square miles or kilometers) lying above a contour of given elevation.

Percentage Hypsometric Curves: Typical drainage basins in homogeneous materials have generally pear-shaped outline. For hypsometric study, a geometric unit of reference consists of a solid bounded on the sides by the vertical projection of the basin perimeter and a set of parallel planes on the top and base, the former passing through the summit and the latter through the river mouth respectively. Although these reference planes may be expected to change as with the evolution of the basin with time with progressive degradation, they are real reference surfaces of a drainage basin which can always be determined. Apart from the fact that the hypsometric curve provides a comprehensive idea of the three dimensional form of a drainage basin, subsequent studies have also revealed that hydrograph peak (flood) and travel time (Harlin, 1984), dominant erosion process (Moglen and Bras, 1995) and the regional ground water base flow (Marani *et.al,* 2001) are also related to the configuration of the hypsometric curves.

The percentage hypsometric method, which has been used as early as 1947 by Langbein (1947), deals with the area enclosed between a given contour and the upper segment of the basin perimeter to the height of that contour above the basal plane. Two ratios are involved in this hypsometric method: (1) ratio of area between the contour and the upper perimeter to total drainage basin area, represented by the abscissa on the coordinate system, and (2) Ratio of height of contour above base (h) to total height of basin (H), represented by values of the ordinate.

THE TAMBRAPARNI BASIN (TRB)

The Western Ghats Mountain chain is today internationally recognized as a region of immense global importance for the conservation of its biological diversity, besides its association of areas of great geological, cultural and aesthetic importance. The Ghats form a mountain chain running parallel to India's western coast, located approximately 30-50 km inland, and extends from the state of Gujarat in the north up to Tamil Nadu in the south , over a distance of 1600 km uninterruptedly (except only by the 30 km Palghat Gap at around 11˚N). The southernmost sector of the Western Ghats, south of the Shencottah Gap, is known as Agastyamalai Hills or Ashambu Hills (Agasthyamalai Sub-Cluster). This mountain sector supports one of the richest concentrations of biodiversity in the whole Western Ghats chain.

The Tambraparni basin is located in Kanyakumari district of Tamil Nadu (Figure 1). The Tambraparni river basin which is located in the south-west of Indian peninsula and occupying the western flank of the Sahyadri Ranges is composed of the basins of Kodayar, Paraliar and Kuzhithuraiar. The geographic location of the basin is between the north latitudes 8°10'58"to 8°34'39" and the east longitudes of 77°05'47" to77°29'31". The basin has an areal extent of 867.52 sq. km.

Geologically, TRB can be broadly subdivided into two types of terrains, namely (a) Sedimentary terrain and, (b) hard rock terrain (Figure 2). Sedimentary rocks, referable to Tertiary and Quaternary ages of Phanerozoic age cover about 15 percent of the area of TRB and are found restricted along the coastal tract and adjoining lowland zone of the basin. The sedimentary rocks of the coastal belt include younger fluviatile, fluvio-marine sequences, of Quaternary and of Recent age together with a small occurrence of aeolian sediments (at Kalingarajapuram) and a succession correlated with Cuddalore Sandstone Formation. The last one is considered as homotaxial equivalent of Warkalli Sandstone Formation of Kerala coast. Crystalline rocks of Archaean to late Proterozoic age occupy the major portion of TRB and the region of exposure of these rocks constitutes the *hard rock terrain* of the basin. These rocks make up the bulk of the Western Ghats sector of the basin and its associated foothills and further southward up to the border of the sedimentary terrain. The major rock types exposed in the hard rock terrain are those of granulitic and gneissic metamorphic rocks referable to (a) charnockite and khondalite groups, (b) garnetiferous quartzo-feldspathic gneiss and, (c) garnet- biotite gneiss.

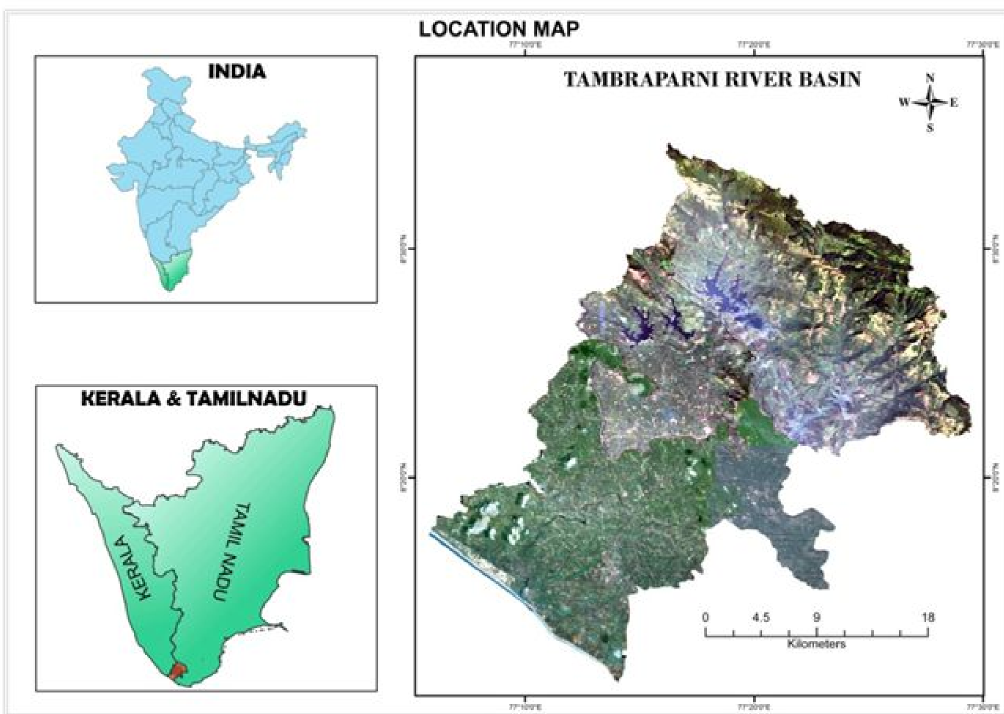

Figure 1

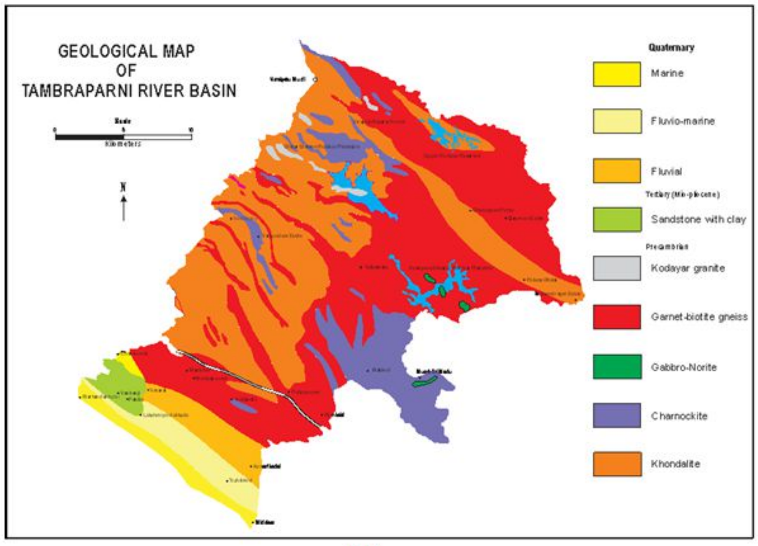

Figure 2

TOOLS AND TECHNIQUES

The entire basin of Tambraparni River has been captured from the latest available Survey of India topographic sheets of 1:25,000 scale and delineated with the of ArcGIS 9.3 software. In the subsequent phase of hypsometric study of the basin GIS has been used extensively in the present work. All the elevation data relevant the drainage basin has been transferred to GIS platform (Figure 3). These data were then converted to vector format to enable further analysis. With the help of ArcGIS software, quantitative parameters were gathered and processed through Microsoft Excel. These were then computed and tabulated and various sets of hypsometric graphs were generated using CorelDRAW X6 and ArcGIS 9.3.

RESULTS AND ANALYSIS

The measured area-elevation data of TRB is given in table 1 and shown as histogram in figure 4. Using this data, the proportions of each elevation class with respect to the aggregate basinal area, have been calculated and the values are tabulated in table 2 and shown in figure 5.

The resulting hypsometric curve drawn for TRB is shown in figure 3. It expresses simply the manner in which the volume lying beneath the ground surface is distributed from base to top. The curve must always originate in the upper left-hand corner of the square (x = 0, y = 1) and reach the lower right hand corner (x = 1, y = 0). It may, however, take any one of a variety of paths between these points, depending upon the distribution of the landmass from base to top. The computation of the hypsometric integral (HI) of TRB, based on the hypsometric curve (Figure 6) has resulted in a value of 0.0484 (Figure 7).

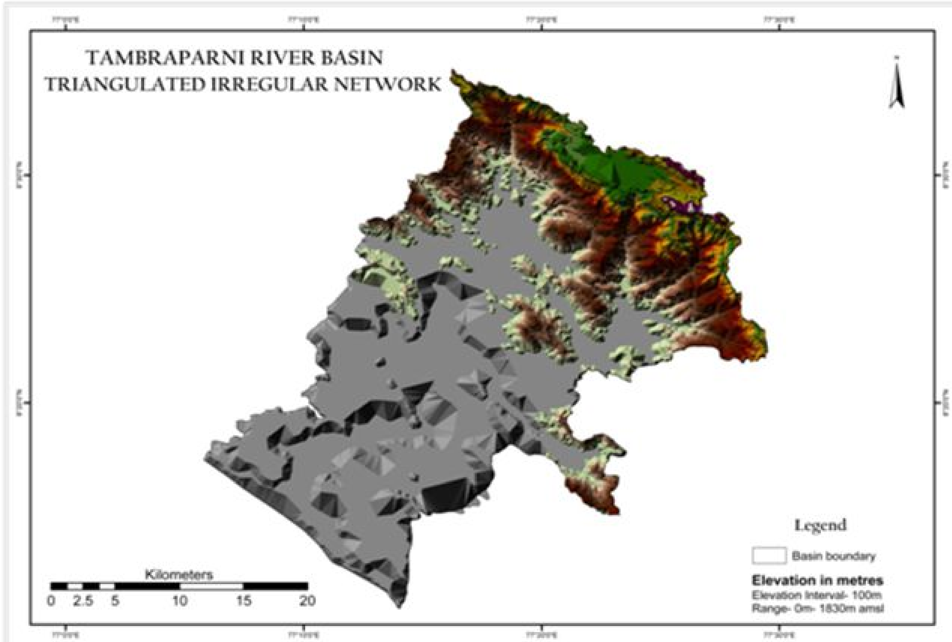

Figure 3

Table: 1 Area- Elevation Data of Tambraparni River Basin

Sl. No. of Elevation Classes	Range of Altitude of Each Elevation Class (in metres)		Total Area of the Basin Covered by Each Elevation Class (km^2)	Percentage of the total Area of the Basin Occupied by Each Elevation Class (%)
	From (amsl)	To (amsl)		
1	0	200	587.28	67.70
2	200	400	84.93	9.79
3	400	600	63.16	7.28
4	600	800	39.67	4.57
5	800	1000	26.16	3.01
6	1000	1200	22.71	2.6
7	1200	1400	14.50	1.67
8	1400	1600	21.30	2.45
9	1600	1800	7.77	0.89
10	1800	2000	0.04	0.01
Total			**867.52**	**100**

Strahler (1957) described the relationship existing between the hypsometric curve and stages of landscape evolution in terms of three types of geometric curves, convex, straight and concave. According to the scheme of Strahlers' interpretation, convex curves, with hypsometric integral values higher than 0.6 indicate the inequillibrium stage of 'youth'.

Table 2: Values for the Construction of Percentage Hypsometric Curve of Tambraparni River Basin

Elevation Interval	Corresponding Area in km^2 (a)	Area Proportion (a/A)	Cumulative Area Proportion	Relief of Elevation Interval in Metres (h)	Height Proportion (h/H)
0 - 200	587.28	0.67	1.0	0	0
200 - 400	84.93	0.1	0.33	200	0.109
400 - 600	63.16	0.072	0.23	400	0.218
600 - 800	39.67	0.046	0.158	600	0.328
800 - 1000	26.16	0.03	0.112	800	0.437

1000 - 1200	22.71	0.03	0.082	1000	0.546
1200 - 1400	14.50	0.017	0.052	1200	0.655
1400 - 1600	21.30	0.025	0.035	1400	0.765
1600 - 1800	7.77	0.009	0.01	1600	0.874
1800 - 2000	0.04	0.001	0.001	1800	0.984

Smoothly S-shaped curves that cross approximately in the centre of the hypsometric diagram have integrals ranging in from 0.6 to 0.4, expressing the equilibrium stage of 'maturity' or the 'old stage'. Strongly concave curves, with very low hypsomtgeric integral values less than 0.4 results only where monadnock masses or remanents are present.

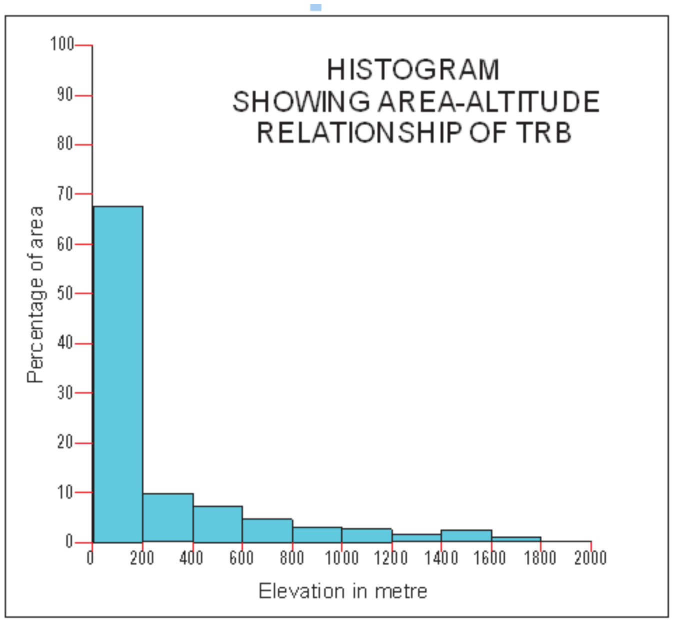

Fig: 4

Figure 4

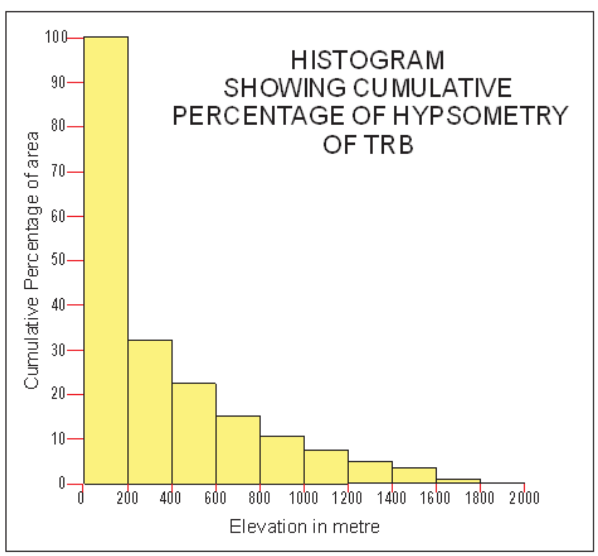

Figure 5

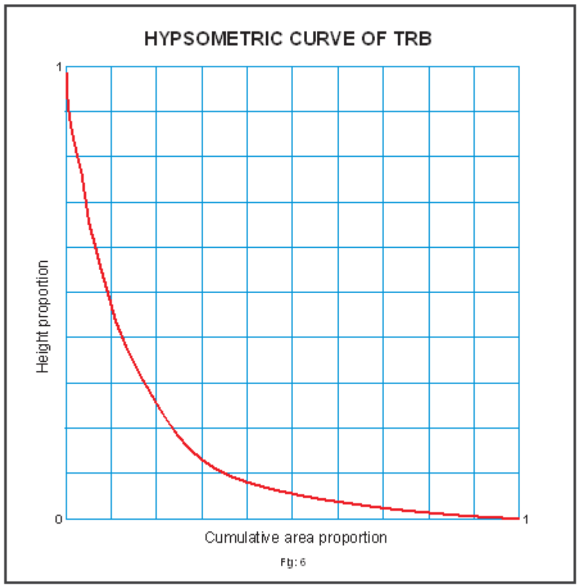

Figure 6

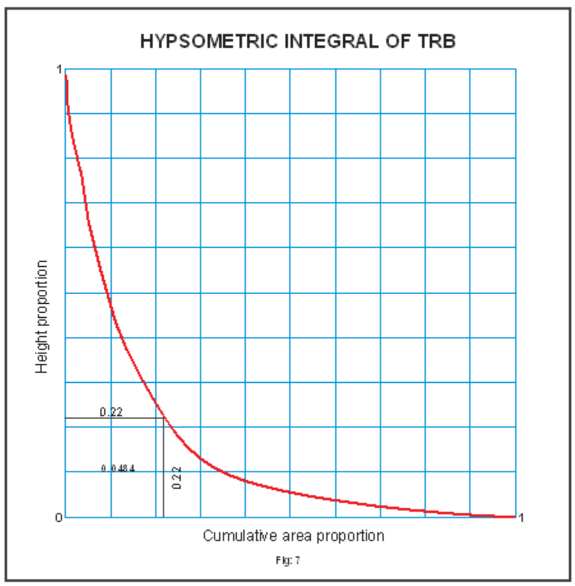

Figure 7

In the present study as the value of hypsometric integral is 0.0484, which is associated with a highly concave hypsometric curve, it indicates that the major portion of the basin of Tambraparni River lies at a comparatively low relief. Typically, the basin is associated with highly dissected and eroded landscape as a result of fluvial action.

CONCLUSIONS

Hypsometric study quantifies the geologic stages of development and erosional proneness of a river basin. In this study, efforts were made to estimate the hypsometric values of the Tambraparni River Basin and so as to understand the geologic as well as geomorphic evolution and stages of the basin. The study projects the value of hypsometric integral as 0.0484, which is associated with a highly concave hypsometric curve. The result of the concludes that except the coastal belt of the basin, the major portion of terrain of the basin under study falls under moderately dissected to very highly dissected terrain category with high maturity to old stage of river basin development and thereby indicating eroded landscape characteristic of fluvial denudation.

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