

A Geomorphological Analysis of the Longitudinal Profile of Tambraparni River, Agasthyamalai Sub-Cluster, South Western Ghats

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Abstract: This paper is a part of the author's research work dealing with the geomorphometry and geomorphology of the Tambraparni River Basin (Kanyakumari district), located on the Western flank of South Western Ghats. The Western Ghats mountain chain running parallel to India's western coast extends from the state of Gujarat in the north up to Tamil Nadu in the south, over a distance of 1600 km uninterruptedly. The present work endeavors to interpret the geomorphology of the Tambraparni River through longitudinal profile approach. The study of longitudinal profile shows a smooth, parabolic curve, gently concave to the sky, practically flat at the mouth and steepening towards the source for the Tambraparni River that helped the classification of the river channel into four reaches namely lower, middle, upper and higher reaches. Moreover, a notable irregularity that affected the gradient of the longitudinal profile of the stream has been identified as knickpoints enabling further detailed study in the linear distribution pattern and the genetic relationship of waterfalls in the southern tip of Western Ghats mountain chain.

Keywords: Geomorphology, Longitudinal profile, River basin, Western Ghats, Knickpoints

1. Introduction

The simplest morphological expression that contains the greatest amount of information on the Geomorphology of a river system is the study of longitudinal profile of the river. A river longitudinal profile or long profile shows the shape of the river's course from its source to its mouth. It shows the changing width, depth and gradient of the channel from upstream to downstream. The long profile shows how, in the upper stage of a river's course, the river's gradient is steep but it gradually flattens out as the river erodes towards its base level.

The most striking observable fact related to long profiles is their form. The plotting of these profiles displays altitude (from amsl) against distance (from stream mouth) and resulting form is a curve more or less regular, the concavity of which increases towards the source region of the stream. The stream profile concavity is assumed to be a common, most obvious and persistent feature and it is considered as a universal feature, regardless of the climatic condition, length of the river or the nature of the country rocks over which the river flows. This, largely generalized observation on long profiles of the streams is a fascinating topic of research for geologists, geomorphologists and geographers everywhere.

Gilbert in 1877 provided a significant explanation for the form of the long profile for the first time. Numerous laboratory studies conducted during the subsequent years showed that the slope of the long profile is inversely proportional to the discharge of the associated stream. Further studies were made to assess the influence of variables other than discharge, on long profiles. These variables included the nature of the river bed material, the stream load (suspended or bed load), the type of the rock forming the stream channel etc. These studies led to the

conclusion that the variation of the discharge (Q), the mean diameter of the river bed material and the sediment load are the most important factors influencing shape of the long profile of streams. However, studies also revealed the fact that a number of other factors, such as the erodibility of the rocks, presence and proximity of tributaries, neotectonic movements and structural discontinuities etc., also account for any deviations from the general form of the long profile, without fundamentally modifying it.

The concavity in the long profile of rivers has traditionally been explained through the introduction of the concept of grade, in which the slope declines downstream as a consequence of the interplay between discharge, bed material size, sediment load and morphological characteristics of the channel (Mackin, 1948). Subsequently, the concept of equilibrium profile was introduced in place of the term graded profiles. The term equilibrium profile is defined as a smooth curve without important discontinuities. In natural conditions, many rivers with long profiles with no discontinuities, deviates strongly from the supposed equilibrium curve, because of local influences of the tributaries, changes in the quality of river bed material, the influence of vegetation, neotectonism, base level changes and so on.

The form of longitudinal profile or long profile of rivers and their scientific descriptions began to appear in geomorphology during 1950s - 70s (Shulits, 1941; Yatsu, 1955; Hack, 1957 and Brush, 1961). In 1990s the study of river profiles were resumed with new arguments and new research methods (Snow and Singerland, 1987; Ohmori, 1991; Scheidegger, 1991; Susan Rhea, 1993 and Morris and Williams, 1999).

2. The Study Area

The Western Ghats Mountain chain is today internationally recognized as a region of immense global importance 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 Agasthyamalai 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 River Basin (TRB) (with an areal extent of 867.52 sq. km.) located in the south-west of Indian peninsula (Fig: 1) and occupying the western flank of the Sahyadri Ranges is composed of the basins of River 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" to 77°29'31".

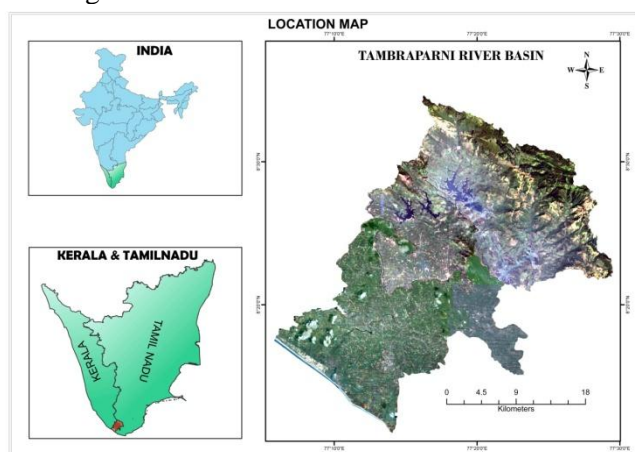


Figure 1: Location Map of Tambraparni River Basin

Geologically, the basin consists of two types of terrains, namely (a) Sedimentary terrain and, (b) hard rock terrain (Fig: 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 fluvial, fluvio-marine sequences, of Quaternary and of Recent age together with a small occurrence of aeolian sediments and a succession correlated with Cuddalore Sandstone Formation.

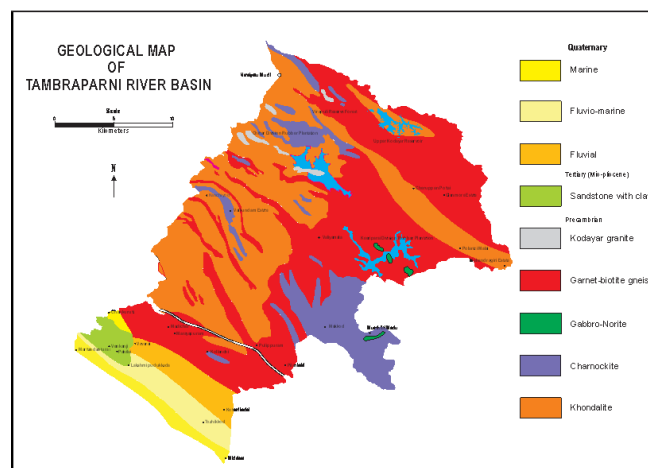


Figure 2: Geological Settings of TRB

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.

3. Methodology Adopted

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 help of ArcGIS 9.3 software. In the subsequent phase of geomorphic study, GIS has been used extensively in the present work. The database for plotting the longitudinal profile of Tambraparni River consisting the measurements of the river altitude against distance downstream has been generated from ArcGIS 9.3. These data have been used for plotting and calculations of the parameters of the longitudinal profile form of the river for the work and the profile graphs have been plotted using CorelDraw X6. Subsequent field studies have also been carried out to compare the results generated with the actual study area.

4. Results and Discussion

In the present study, the long profile of the master stream of the TRB has been carefully prepared with the intension of analyzing its geomorphologic significance. Although, there are notable irregularities (displaying deviations from a smooth geometric curve) in the long profile in the Tambraparni River, when one disregards these deviations, the general shape is a smooth, parabolic curve, gently concave to the sky, practically flat at the mouth and steepening towards the source, as shown in Figure 3. Notable changes in the altitude of the river channel of the Tambraparni River occur at seven locations, with increasing distance from the river mouth at following portions of the river stretches: between 23 and 24th kilometers, 30 and 31st kilometers, 35 and 36th kilometers, 48 and 49th kilometers,

52nd and 53rd kilometers, 62 and 63rd kilometres and 69 and 70th kilometers.

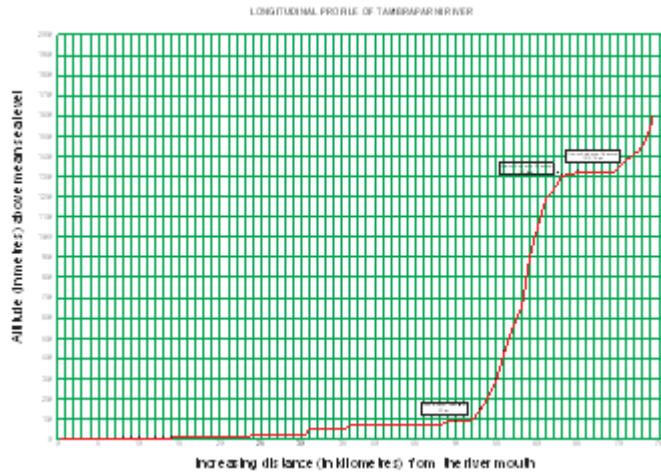


Figure 3: Longitudinal Profile of Tambraparni River

The overall inclination of the stream bed of Tambraparni River over the stretch from the mouth to a distance of 52 km has a mean value of 11° and that between 52nd to 62 km has a mean value of 65° and that between 69 km to the ultimate source has a mean value of 55 degrees. However, between 30 and 31 km from the river mouth there is a break of lesser magnitude, where there is a sudden rise of the channel bed amounting to 30 metres. The four major breaks among the seven breaks noted in the above paragraph are taken into consideration in classifying the river channel into four major reaches (via; lower, middle, upper and highest reaches) as indicated in the Figure 4.

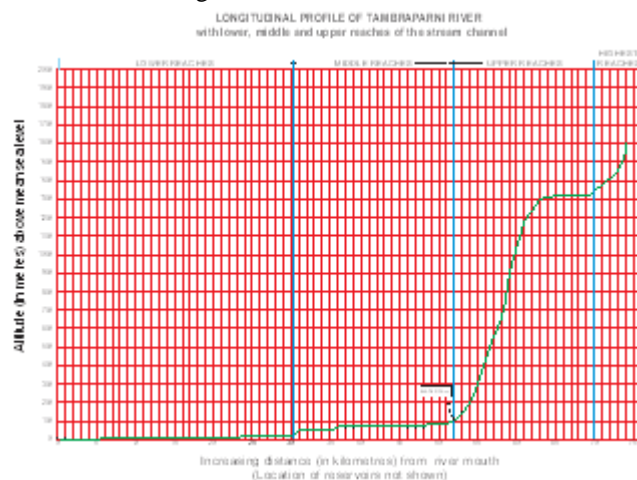


Figure 4: Delineating Reaches of Stream Channel of TRB

There is no indication for the association of structural (faults or major or joints) or lithological features (change of rock type) to account for an explanation for the presence of the break in long profile occurring between 52nd and 62 kilometres. The magnitude of stream erosion in the channel of the Tambraparni River is maximum within the upper reaches between 52 km and 62 km from the river mouth. This observation is made on the basis of the slope of the long profile in the corresponding portion of river channel where there is an aggregate drop in stream channel amounting to 1,150m, over a distance of 10 km. As noted in earlier that this segment of the river channel has an overall inclination of 65°. The river valley in the corresponding

stretch between (52 and 62 kilometres) is therefore characterized by acute V shaped valleys.

The three concrete dams (Pechipparai, Lower Kodayar and Upper Kodayar) built across the river course and located at 90m, 300m and 1320m amsl respectively, act as local base levels and thereby prevent the lowering (deepening) of the river channel upstream from their locations as well as put a stop to the lengthening of the channel downstream.

Drainage networks maintain a connection to base level and that any changes in the base level affects erosion and therefore, in turn affects the gradient of the longitudinal profile of the stream. In this specific case, the presence of 5m waterfall at 53rd km from the river mouth is an unmistakable indication of a knick point there, which is in the process of migrating upstream and this aspect of has been further analysed through satellite imageries and subsequent field checking.

The presence of knickpoints in the long profile is further studied and analysed. These are points where the gradient of the river changes suddenly and can be caused by landforms like waterfalls or lakes, where the lithology of the river changes and differential erosion takes place. the location of a 5m waterfall occurring at the south of Kodayar Kiltangal is also influenced by an abrupt lithological change across the course of Kodayar River. This waterfall is located where the channel enters a region of khondalite from that of charnockite, which favoured the site of the fall.

The study of longitudinal profile enabled the identification and study of other waterfalls falling within TRB and its spatial location through GPS. A careful field study of the location of the famous waterfall at Triparappu, indicated that its location is also controlled by an abrupt lithological change of the country rocks over which the Kodayar River flows. The incision of the river channel is probably facilitated by the border line separating the zone of khondalite from that of the adjoining garnet-biotite-gneiss. When the study is extended towards the northwestern direction beyond the margin of the TRB into the geographic area covered by the neighbouring river basins of Kerala and also towards the southeast of Kanyakumari the geomorphic significance of the distributional pattern of the waterfalls increased and became clearer as these are found aligned along a set of two imaginary parallel straight lines (as shown in the Fig.5).

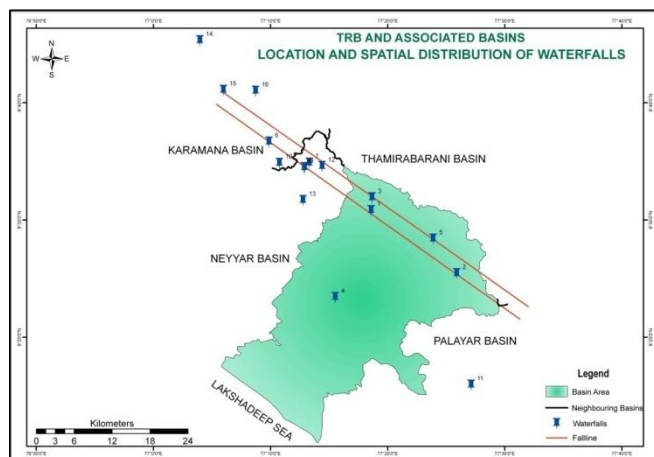


Figure 5: Regional Scale Alignment of Water Falls

Moreover, the trend of these lines is also more or less parallel to the western coast. In geomorphologic literature, the term 'fall line' is applied for the imaginary line or the narrow zone connecting the waterfalls on several successive and near-parallel rivers. However, in the present context, the geomorphologic setting required by the definition is not fully satisfied; and therefore, the term *fall line* is not preferred and used (Karthika, 2015). Therefore, it seems that the spatial distribution of knickpoints within TRB and in the neighboring basins should not be considered as a mere coincidence as a local feature, but forms a part of a regional feature having genetic relationship with the associated regional geological structure.

5. Conclusion

The study of longitudinal profile of the master stream of Tambraparni River shows that, except some notable irregularities, the general shape is a smooth, parabolic curve, gently concave to the sky, practically flat at the mouth and steepening towards the source. The major found in the profile helps in the classification of the river channel into lower, middle, upper and highest reaches. A notable irregularity that affected the gradient of the longitudinal profile of the stream has been identified as knickpoint enabling further detailed study in the linear distribution pattern and the genetic relationship of waterfalls in the southern tip of Western Ghats mountain chain.

References

- [1] BRUSH, L., (1961). Drainage basins, channels and flow characteristics of selected streams in central Pennsylvania, U.S. Geological Survey, Professional Paper, 282-F, pp. 145-181.
- [2] GILBERT, G.K., (1877). Report on the Geology of Henry Mountains, Department of the Interior, US Geographical and Geological Survey of the Rocky Mountain Region, Washington, 151 pp.
- [3] HACK, J.T., (1957). Studies of Longitudinal Stream Profiles in Virginia and Maryland, U.S. Geological Survey, Professional Paper, 249-B, pp. 45-97.
- [4] KARTHIKA KRISHNAN, (2014). Spatial distribution of knickpoints and associated waterfalls of the drainage basin of Tambraparni river and neighbouring river

basins, International Jour. Of Engineering Science and Invention, Vol. 4, No. 1, pp. 01-04.

- [5] MACKIN, J.H., (1948). Concept of the Graded River, Geological Society of America, Bulletin, Vol. 59, pp. 463-512.
- [6] MORRIS, P.E. and WILLIAMS, D.J., (1999). Worldwide correlations for subaerial aqueous flows in exponential longitudinal profiles, Earth Surface Processes Landforms, Vol. 24, 867-879.
- [7] OHMORI, H., (1991). Change in the mathematical function type describing the longitudinal profile of a river through an evolutionary process, Journal of Geology, Vol. 99, pp. 97-110.
- [8] SCHEIDEGGER, A.E., (1991). Theoretical Geomorphology (3rd revised edition): Berlin, Heidelberg, Springer- Verlag, 434 pp.
- [9] SHULITS, S., (1941). Rational equation of river-bed profile, Transactions, American Geophysical Union, Vol. 22, pp. 622-630.
- [10] SNOW, R.S. and SINGERLAND, R.L., (1987). Mathematical modeling of graded river profiles, Journal of Geology, Vol. 95, pp. 15-33.
- [11] SUSAN RHEA, (1993). Geomorphic observations of rivers in the Oregon Coast Range from a regional reconnaissance perspective, Elsevier, Geomorphology, Vol. 6, pp. 135-150.
- [12] YATSU, E., (1955). On the longitudinal profile of the graded profile, Transactions, American Geophysical Union, Vol. 36, pp. 655-663.

Author Profile



Karthika Krishnan completed her graduate degree in Geography from Kerala University in 2009 and master's degree from Madurai Kamaraj University, Tamil Nadu in 2011. The author is currently pursuing her doctoral degree from Madurai Kamaraj University in Geomorphology and Environmental Impact Assessment of Tambraparni River Basin of Southern tip of Western Ghats Mountain Chain.