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Analysis of Morphometric Characteristics of Vamanapuram River Basin, Kerala

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Abstract: ***Morphometric analysis is an integral part of geomorphological studies. It can provide vital clues concerning the landscape evolution. The present paper examines the implications different morphometric parameters of the Vamanapuram River Basin including laws of stream order, stream length, and basin area, bifurcation ratio, drainage density, elongation ratio, circularity ratio etc. The Vamanapuram river basin is extends between 8^0 35' to 8^0 51' north latitudes and 76^0 45' to $77^0$12' east longitudes. The Vamanapuram River rises on the peak Chemmunji Mottai, located at an altitude of 1717m above mean sea level and debouches into Arabian Sea through Muthalapozhi estuary.***

Keywords: Morphometry, landscape evolution, Vamanapuam River Basin, estuary, drainage density

1. Introduction

Morphometry is the measurement of the shape or geometry, of any natural form-plant, animal or relief features (Strahler, 1969). Morphometric analysis has evolved as a recurring theme in geography since 1940's. This mainly indebted to three fundamental reasons; recognition of drainage basin as a basic geomorphic unit in the land form evolution studies, high demand for quantitative data to accompany the processes in process-response models and finally a general philosophical and methodological shift of geomorphology from subjective and deductive science based upon observations to an objective and inductive science based up on measurements. (Sharma, 1981).Numerous studies have been proved that morphometric parameters can give vital clues regarding stages of landscape evolution.

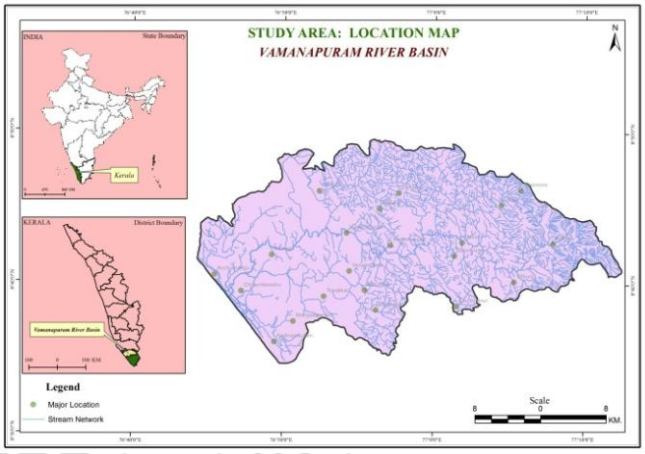

Figure 1

2. Study Area

The Vamanapuram river basin is extends between 8^0 35' to 8^0 51' north latitudes and 76^0 45' to $77^0$12' east longitudes. The Vamanapuram River forms the prominence of Chemmunji Mottai, located at an altitude of 1717m above mean sea level. The drainage basin is interposed between Karamana river system on the south and Kallada river system on the north. The basin is bounded by Arabian Sea forms the western margin. The water divide of Tamraparni River in Western Ghats is exactly coinciding with the eastern boundary of the Vamanapuram river basin. It is the longest river in Thiruvananthapuram district. The river has a total catchment area of 799 sq.km. The river ranks 16 th in catchment area. It has a length of 88 km. Among the forty four rivers in Kerala Vamanapuram ranks 11th in length and 15 th in Run-Off. An interesting peculiarity of the river is it is undammed. Around 93.33 per cent of the drainage basin lies in Thiruvananthapuram district and only 9.67 per cent is in Kollam. Finally the river the empties into Arabian Sea at Muthalapozhi.

3. Methodology

The basic thematic maps of the study area have been derived from the Survey of India topographic maps of 1:50,000 scale. The drainage net of Vamanapuram River was manually drawn from SOI Toposheets 58D/10, 58 D/14, 58D/15, 58 H/1 and 58 H/2. These maps were scanned and digitized in GIS platform. Strahlers method has been applied for stream ordering. Hortonian law of stream order versus stream number and stream order versus mean stream lengths were validated. Miller' method was employed to derive the implications of elongation ratio. Relative relief maps were prepared from SRTM data. The important morphometric parameters including bifurcation ratio, drainage density, stream length ratio, and circularity ratio has been computed using standard equations.

4. Results and Discussion

Drainage pattern

The spatial arrangement of a river and its tributary streams in a drainage network is referred to as the drainage pattern. Dendritic, parallel and sub-parallel are three common drainage patterns indentified in Kerala. (Chattopadhyay and

Chattopadhyay, 1995). The Vamanapuram River Basin shows dendritic drainage pattern. This pattern is characterized by numerous tributary streams in the upper course and only a few tributaries in the lower course. If the rocks do not vary in resistance over the basin, each consequent stream will become the centre of a branching stream and forms dendritic patterns. (Monkhouse, 1954).The predominance of Khondalite and associated rocks having similar resistance throughout the basin is proved this assertion.

Stream order and stream number

Stream order is the position of a stream in the hierarchy of tributaries. The Vamanapuram River is a 7th order stream. The drainage basin consists of 1544 first order streams, 365 second order streams, 87 third order streams, 20 fourth order streams, 8 fifth order streams and 3 sixth order streams (Table.1).

Table 1: Stream order and number of streams

Stream Order	*No. of Streams*
1	1544
2.	365
3	87
4	20
5	8
6	3
7	1

It would be clear from Table.1 that stream orders and stream numbers strictly follow Hortonians law of inverse geometric relationship between stream order and number of streams. It has been observed that number of streams decrease with increase.

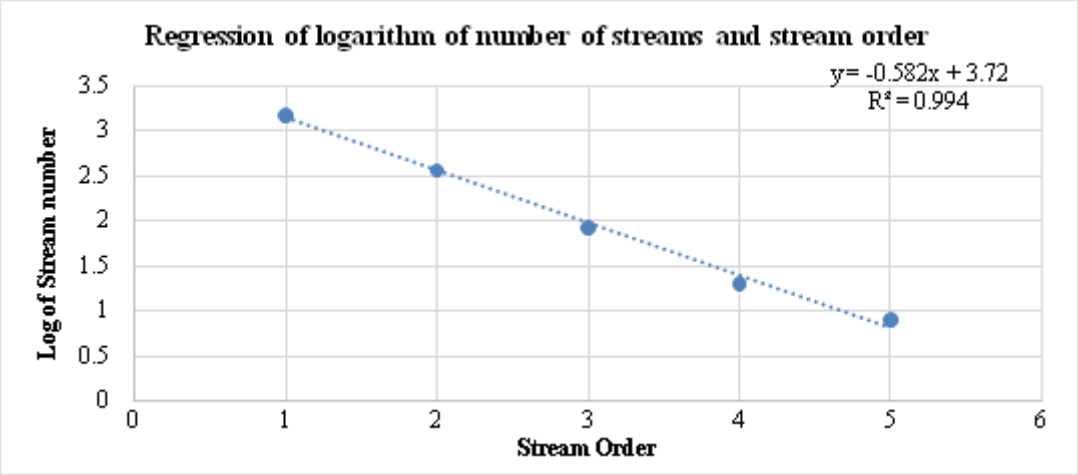

Figure 2: Stream Number versus Stream Order

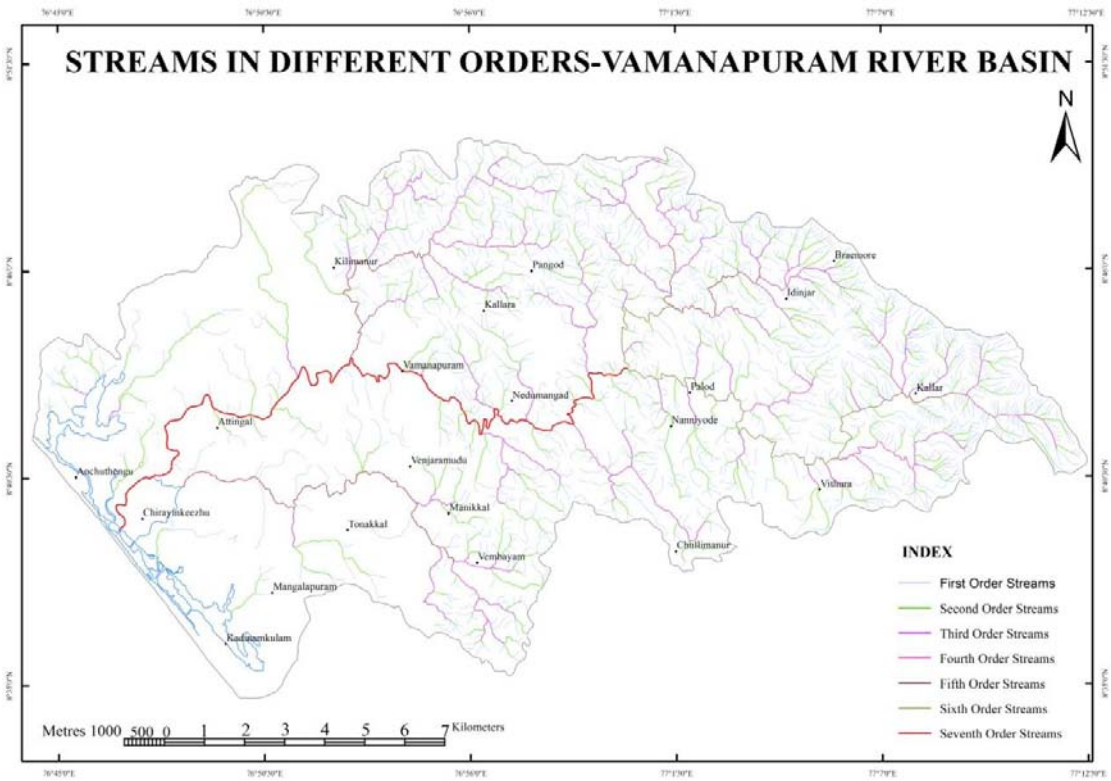

Figure 3: streams in different orders

Stream Length

According to Horton (1945) the average lengths of streams follows a geometric relationship with stream order. It has been observed that total stream length is gradually decreases with increase in stream order and mean stream length increase with an increase in order comply with Hortonian law.

Table 2

Stream Order	Total No. of Streams	Total length (km)	Mean Stream Length
1	1544	868.65	0.56
2	365	341.03	0.93
3	87	149.38	1.72
4	20	68.60	3.43
5	8	48.32	6.04
6	3	30.77	10.26

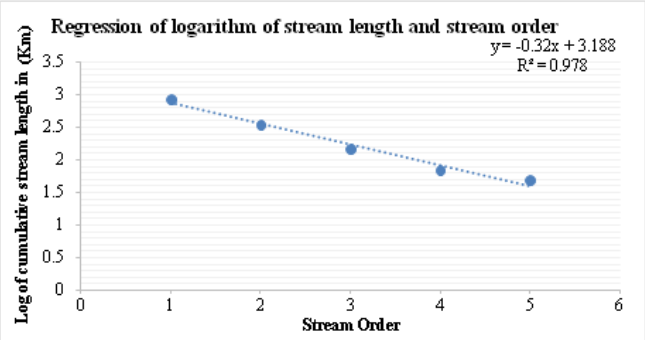

Figure 3: Stream Number versus mean stream length

Stream length ratio

Ratio between two successive streams are called stream length ratio or channel length ratio. The average stream length ratio of the Vamanapuram River Basin is 3.82. It is observed that 4th order river basin registered the highest stream length ratio and the second order basins reported the lowest stream length ratio.

Table 3: Stream length ratio

Stream Order	*Mean Stream Length*	*Stream length ratio*
1	0.56	-
2	0.93	0.58
3	1.72	1.77
4	3.43	2.00
5	6.04	1.76
6	10.26	1.7

Bifurcation ratio

Bifurcation ratio is the ratio between the number of streams in a given order and the number of streams in the next higher order. It would be seen that the bifurcation ratio of the basin ranges between 2.50 to 4.35 with a basin average of 3.5 (Table.4). Horton has been proved that generally flat or rolling terrain has a bifurcation ratio of 2 and it will be ranges between 3-4 in a highly dissected or mountainous terrain. The average bifurcation ratio of 3.5 shows the dissected nature of the Vamanapuram River Basin.

Table 4

Stream order	*Total number of streams*	*Bifurcation ratio*
1	1544	-
2	365	4.23
3	87	4.20
4	20	4.35
5	8	2.5
6	3	2.7
7	1	3
Basin Average-3.5		

Drainage density

Drainage density is the total stream length per unit area of basin. Drainage density shows a very wide range of values in nature and controls the surface runoff (Chorley, 1969).Nature of terrain; vegetation rainfall and relief are the four key factors controlling the drainage density of the basin. Drainage density provides vital clues concerning the lithology of the basin. The drainage density of the study area has been grouped into 4 categories – low, medium, high and very high. A wide range of spatial variation has been observed in drainage density. High and very high density have found in the eastern and north eastern portion of the basin. It is attributed to numerous streams, heavy rainfall and nature of lithology. Medium and low category of drainage density could be observed in the mid lands, low lands and coastal belts of the basin respectively.

Basin Area

Basin area plays a decisive role in determining aspect, size and shape of the basin. Analysis revealed that the basin strictly follows Strahler's law of basin as it shows geometric increase in accordance with ascending stream orders. (Table.5).

Table 5: Mean basin area of different sub basins in Vamanapuram River Basin

Sub basins	*Area in sq.km*	*Mean basin area*
3	350	4.02
4	252.6	12.63
5	330.7	41.33
6	253	84.33

Elongation Ratio

It is the ratio between the diameter of a circle with the same area of basin and the maximum length of the basin (Schumm, 1956). A value of around.57 indicates elongated shape, 0.60 to 0.66 shows oval shape and >0.66 shows the circular shape of the basin. As the Vamanapuram River Basin registered an elongation ratio of.61 proves the basin is oval in shape.

Circularity ratio

Circularity ratio is the ratio of circumference of circle with mean area as the basin to the basin perimeter. (Miller, 1953). The circularity index of the Vamanapuram River Basin is 0.56 shows that the basin is passes through early mature stage in the erosion cycle.

Table 6: Circularity Ratio

Circularity Ratio	*Stage of evolution*
Below 1.5	Early
1.5-3	Middle
>3	Youth

Relative Relief

Relative relief indicates the height difference between the highest and the lowest point in a given area. The terms like local relief, relief amplitude, relief energy more or less carry same meaning.(Chattopadhayay, 1995). Figure 2. Provides a very clear picture about the existing relative relief of Vamanapuram River Basin. Six categories of relative relief could be computed for the basin. The six classes were merged in to three major relative relief categories namely low, medium and high (Table.7).It would be seen that low relative relief occupies 91.38 per cent of the study area. Medium relative relief type constitutes 7.57 per cent of the basin. It would found that high relative relief occupies on 0.02 per cent of the study area.

Table 7: Distribution of different classes of relief area in Vamanapuram River Basin

S. No	*Relative Relief range*	*Area in sq.km*	*Area in percentage*	*Relief type*
1	<20	12.12	1.52	Low
2	20-40	718.20	89.86	Low
3	40-60	59.12	7.39	Medium
4	60-80	1.48	0.18	Medium
5	80-100	0.20	0.02	High
6	>100	0.042	0.002	High

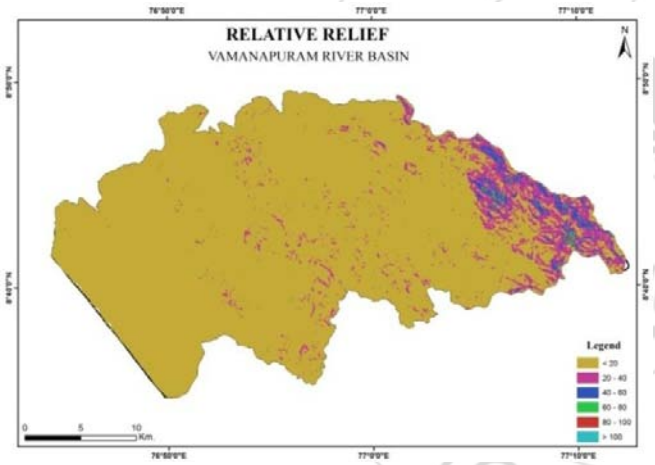

Figure 4: Relative Relief

5. Conclusion

It can be observed that Vamanapuram River is a 7th order stream with bifurcation ratio of 3.5. The river shows dendritic drainage pattern which indirectly indicates uniform lithlogy. This is an oval shaped basin strictly follows Hortonian laws of stream order and stream length. Circularity ratio of.62 proves that the basin is passing through early mature stage in landscape evolution. It can be concluded that morphometric evaluation can provide vital hints regarding landscape evolution of a river basin.

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