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Sinuosity Analysis using Geographic Information System (GIS): Case Study of a Tropical River Basin

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Abstract: In this paper an attempt has been made to study the channel pattern of Bharathapuzha River, Kerala, India using Geographical Information System (GIS). The study also aims at understanding the topographical and hydrological characteristics of the drainage basin based on sinuosity indexes. Sinuosity analysis has been performed in the fifteen sub watersheds of Bharathapuzha river basin by measuring the sinuosity parameters such as channel length, valley length and air length from the topo sheets using ArcGIS 9.2. Using these parameters, hydraulic sinuosity index (HSI), topographic sinuosity index (TSI) and standard sinuosity index (SSI) was evaluated. HSI and TSI have been used in understanding the topographical and hydrologic characteristics of the subwatersheds. River channel has been classified into straight, sinuous, meandering and braided depending on the SSI.

Keywords: *Bharathapuzha, channel pattern, geographical information system (GIS), meandering, sinuosity*

1. Introduction

Rivers are one of the greatest blessings of nature. Today, due to human impact and many other reasons, most of the rivers are on the edge of deterioration. The accelerated deterioration of rivers and river ecosystems are largely ignored, while other global environmental problems such as climate change, deforestation etc have been subject of much concern and debate. Declining health of world's major river systems are one of the most critical symptoms of global environmental crisis, flood disasters, reduction in drinking water supply etc. As a result of increasing population, industrialization and urbanization, water demand is increasing day by day. All these indicate the necessity of assessing the quality and quantity of water for its optimal utilization. It is high time to think about restoration of rivers and watershed management programmes for improving the pathetic condition of our river systems. To develop an effective watershed management plan, it is necessary to understand the topography, erosion status, and drainage pattern of the river basin. Sinuosity studies help in understanding the topographical and hydrological characteristics of the drainage basin.

Although rivers are usually described as being straight, meandering or braided, there is in fact a great range of channel patterns from straight through meandering to braided and anabranching or anastomosing. Sinuosity analysis helps in defining the channel pattern of a drainage basin. The study of sinuosity index of a drainage line enables us to evaluate the effect of terrain over the river course and vice versa. Sinuosity analysis of Bharathapuzha river basin has been carried out to identify the sinuous, meandering and braided channel patterns in the river basin. The study also aims at understanding the topographical and hydrological characteristics of the drainage basin based on sinuosity indexes.

2. Study Area

Bharathapuzha originates from Anamalai hills in the Western Ghats at an elevation of 2600 m above mean sea level and flows through Coimbatore district of Tamilnadu, and Palakkad, Malappuram and Thrissur districts of Kerala and empties into Arabian Sea at Ponnani. Bharathapuzha river basin lies between $10^0 25'$ and $11^0 15'$ N latitude and $75^0 50'$ and $76^0 56'$ E longitudes, covering an area of about 5533 Km Sq of Which 4400 Km^2 is in Kerala and remaining in Tamil Nadu. The River has a total length of 209 Km.

3. Data Used

Survey of India (SOI) topographic maps of scale 1 : 50000, 1967 edition(58 A/4, A/8, A/12, A/16, E/4, B/1, B/5,B/9,B/13, B/2, B/6,B/10, B/14,F/2, B/11, B/15, F/3; 49 N/13and N/14) in which the river basin is spread have been collected. Sinuosity analysis has been carried out using ArcGIS 9.2 and ERDAS IMAGINE

4. Methodology

The drainage basin has been delineated from SOI topo sheets using ArcGIS 9.2. Bharathapuzha river basin has been divided into 15 sub watersheds based on stream order (Fig 1).Sinuosity parameters such as channel

length; valley length and air length for each sub watershed have been measured from the topo sheets using ArcGIS 9.2. Using these parameters, hydraulic sinuosity indexes (HSI), topographic sinuosity index (TSI) and standard sinuosity index (SSI) were evaluated. HSI and TSI have been used in understanding the topographical and hydrologic characteristics of the sub watersheds. River channel has been classified into straight, sinuous, meandering and braided depending on the SSI.

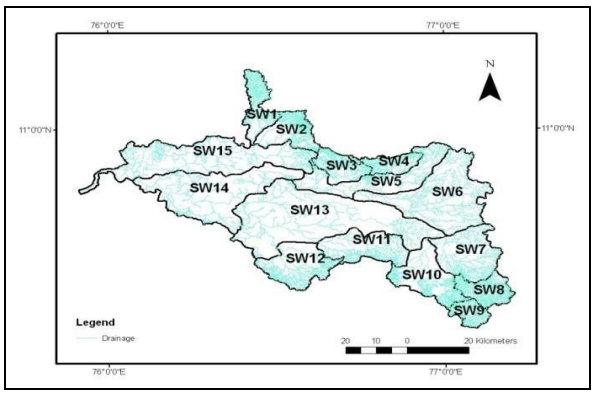

Fig1: *Bharathapuzha river basin with its sub Watersheds*

5. Results and Discussions

Sinuosity parameters and indexes for the fifteen sub watersheds of Bharathapuzha river basin are given in Table 1 Based on the value of SSI, river channels in sub watersheds are classified into straight (1 < SSI < 1.09), sinuous (1.09 < SSI < 1.28), meandering (1.28 <SSI < 2), and torturous (SSS > 2). Among the fifteen sub watersheds, SW 1, 3, and 9 comes under the category of straight channel. SW 2, 4, 7, 8, 10, 11, 12, 13, and 14 are characterized by sinuous pattern whereas SW5, 6, and15 can be categorized into meander pattern (fig 2).

Channel index for the main channel in all the sub watersheds are high (CI > 1.2) except for SW4. SW4 has a low CI of 1.18. Low valley index is observed for SW 4, 8, 10, 12, 13 and 15 and the same is high for other sub watersheds. The analysis showed that the difference between channel index and valley index is considerable for sub watersheds 5, 6, 11 and 15 indicating the main channels in these sub watersheds have fully developed valleys. On the other hand other sub watersheds have not much difference between CI and VI, pointing to the fact that their valleys are yet not fully developed. Most of them are highland tributaries which support their least chance to have a fully developed valley.

The hydraulic sinuosity index and topographic sinuosity index are valuable tools in determining the stage of basin development as well as the controlling factors of sinuosity. HSI and TSI showed an interesting range. TSI is highest for SW 1, 3 and 9, which is due to fact that these rivers passes through hilly terrain, and are highly controlled by the topography. From the sinuosity analysis, it can be noticed that the influence of topography on sinuosity decreases as the river channel shift from upper to lower reaches of the basin. Consequently, role of hydraulic factors become prominent in the lower reaches. It is clear that as elevation decreases, TSI decreases and consequently HSI increases. From the value of SSI, it is clear that sinuosity increases towards the lower reaches of the basin.

Table 1 *Sinuosity parameters*

SW	CL (Km)	VL (Km)	AL (Km)	CI	VI	HSI	TSI	SSI
1	38.02	35.3	28.83	1.31	1.22	29	71	1.08
2	32.26	25.66	20.35	1.58	1.26	55.1	44.9	1.26
3	20.17	18.68	14.8	1.36	1.26	22.8	77.2	1.08
4	19.5	17.64	16.56	1.18	1.07	61	39	1.11
5	74.86	57	40.9	1.83	1.39	53.01	46.99	1.31
6	69.96	52.05	40.22	1.73	1.29	60.27	39.72	1.34
7	34.63	30.55	23.69	1.46	1.29	37	63	1.13
8	19.13	15.9	13.48	1.42	1.18	57.14	42.85	1.2
9	15.36	14.01	9.54	1.61	1.47	22.95	77	1.09
10	36.52	29.3	27	1.35	1.09	74.28	25.71	1.25
11	47.91	38.59	27.13	1.76	1.42	44.74	55.26	1.24
12	91.1	72.34	61.73	1.46	1.17	63.04	36.95	1.26
13	29.78	23.19	22.16	1.34	1.05	85.3	14.7	1.28
14	72.8	61.05	49.45	1.47	1.23	51.06	48.94	1.19
15	113.5	81.9	77.3	1.4	1.06	87.2	12.7	1.39

SW: Sub Watershed
CL: Channel length
VL: Valley length
AL: Air length
CI: Channel Index
VI: Valley Index
HSI: hydraulic sinuosity index
TSI: Topographic sinuosity Index
SSI: standard sinuosity index

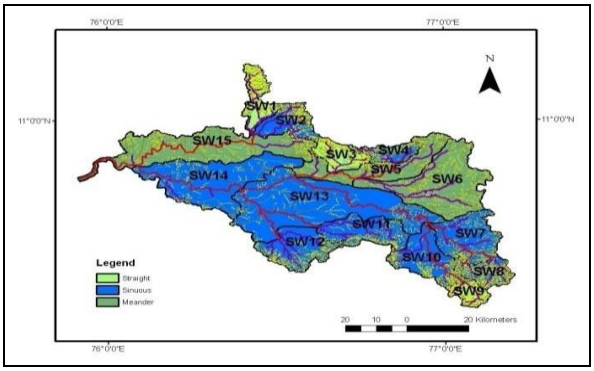

Fig 2: *Channel patterns of Bharathapuzha River Basin*

6. Conclusions

Sinuosity analysis revealed that out of the 15 sub watersheds, the main stream in 3 sub watersheds (SW1, 3, and 9,) showed straight channel pattern, 8 sub watersheds (SW 2, 4, 7, 10, 11, 12, 13 and 14) are sinuous and 3 sub watersheds (SW5, 6 and15) are meandering. Hydraulic and topographic sinuosity index exposed that the channel pattern in the higher reaches of the basin are mainly controlled by topography, whereas, as the stream reaches midland and coastal belt, the hydraulic sinuosity gains strength.

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