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Morphometric analysis of the Sisi river basin, North-East India and some geo-environmental implications

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ABSTRACT

Morphometric analyses of the 6th order Sisi river basin, an important tributary to the Subasisiri river in the North East india, were carried out involving measurement of linear aspects, areal aspects and relief (gradient) aspects of drainage basin and channel network of the main Sisi river basin, its three constituent 5th order sub-basins and statistical analysis of the 3rd order basins. The Laws of drainage Composition have been tested for the 5th order basins. Implications of certain morphometric parameters for assessment of certain geo-environmental hazards like flood have also been assessed.

Keywords : Basin morphometry, drainage density, basin elongation, relief ratio, Sisi river

Introduction

Morphometry involves measurement and mathematical analyses of the configuration of the earth's surface and of the shape and dimensions of its landforms. A complete and comprehensive lay out of an area can be obtained from morphometric analysis. Systematic description of the geometry of a drainage basin and its stream channel system needs a thorough study of the basin morphometry for understanding the dynamic behaviour of the river regime. This involves measurement of linear aspects of drainage network, areal aspects of the drainage basin, and relief (gradient) aspects of channel network (Strahler, 1964). The present study is an attempt to study the various morphometric parameters belonging to each of these three aspects of the Sisi river basin, a 6th order drainage basin, and to assess some geo-environmental implication like flood hazard.

The Sisi river basin, lying in the north bank of the Brahmaputra river and extending from the hilly terrain (West Siang district) of Arunachal Pradesh to the alluvial plains (Dhemaji district) of Assam, encompasses an area of 737 km2. 79% of the basin area falls within the state of Assam. It is bounded by north latitudes 270 05/00// and 270 50/ 00// and east longitudes 940 20/00// and 940 45/ 00//. The location of the area is shown in Figure 1.



Figure 1: Location map of the Sisi river basin

Materials and Methods

Morphometric parameters were estimated from Survey of In-

dia Toposheets of 1:50,000 scale surveyed during 1970. The base map of stream network of the Sisi River has been prepared using SOI Toposheet Nos. 83 I/6, 83 I/9, 83 I/11 and 83 I/12.

Different morphometric parameters of altogether 42 third order basins belonging to three different geomorphic zones of the Sisi river were statistically analysed, the results of which were used to evaluate the control of different geomorphic zones on the morphometric parameters (Kumar and Verma, 1977; Goswami et al., 1998). Drainage patterns of the river basin have been classified following Howard, 1967.

Table 1: Tectnostratigraphic succession of the Palaeogene sequence of Arunachal Pradesh (GSI, 2010)

AGE	GROUP / FORMATION			
Permian Palaeogene	Gondwana Group Thrust			
remain rancogene	Ringging Formation/Kimi Bed Main Boundary Fault			
Neogene	Lower Siwalik (Dafla Formation)			
	Middle Siwalik (Subansiri Formation)			
	Upper Siwalik (Kimin Formation)			
Quaternary	Assam Alluvium			

Results and Discussion

Drainage basin morphometry: Morphometric parameters used for defining the linear, areal and relief aspects of drainage basin were evaluated for the main Sisi river basin, its three constituent 5th order and all the 42 third order subbasins. Morphometric parameters relating to the linear, areal and relief aspects of the Sisi river and the three 5th order subbasins viz. the Yanto, Siji and Kanibil are presented in Table 2, Table 3 and Table 4 respectively.

Analysis of 5th and 6th order basins: The Sisi, an important tributary of the Subansiri with a mainstream length of 133 km, is a 6th order stream draining an area of 737 km2. The length, width and perimeter of the basin are 77.5 km, 22 km and 164 km respectively. The basin is elongated in shape with a basin elongation value of 0.23. The average values of drainage

density, stream frequency and drainage texture for the whole basin are 1.25 km. Km-2, 1.40 km-2 and 1.75 km-3 respectively. Channel slope of the river in plain area is low (1.03 m/ km) while it is high (38.6 m/km) in the hills, the average for the river being 9.86 m/km.

Table 2: Linear aspects of the 5th and 6th order drainage basins

Name of 6th order basin	Stream order (u)	Stream number (Nu)	Bifurca- tion ratio (Rb)	Stream length (Lu) km	Mean stream length (Lu) km	Length ratio (LR)	Mainstream length (Lms) km
SISI	1 2 3 4 5 6	792 182 42 9 3 1	4.35 4.33 4.67 3.00 3.00	467.00 157.50 113.75 51.50 17.25 115.00	0.59 0.87 2.71 5.72 5.75 115 00	1.47 3.11 2.11 1.01 20.00	133.00

YANTO	1 2 3 4 5	147 39 11 3 1	3.77 3.55 3.67 3.00	67.00 20.50 10.00 9.00 4.25	0.46 0.53 0.91 3.00 4.25	1.15 1.72 3.30 1.42	12.50
SIJI	1 2 3 4 5	3.0 66 12 3 1	4.59 5.55 4.00 3.00	135.50 38.00 27.00 11.00 4.00	0.45 0.58 2.25 3.67 4.00	1.29 3.88 1.63 1.09	18.00
KANIBIL	1 2 3 4 5	171 32 11 3 1	5.34 2.91 3.67 3.00	61.00 37.50 47.00 31.50 9.00	0.36 1.17 4.27 10.50 9.00	3.25 3.65 2.46 0.86	28.00

Table 3: Areal aspects of the 5th and 6th order drainage basins

Name of	Drainage area	Basin peri- meter	Maxm basin length	Basin width	Basin elonga-tion	Drainage density	Stream frequ-ency	Drainage texture
basin	Au	Р	Lb	w	E	D	F	DT
	km2	km	km	km		km.km-2	Km-2	Km-3
YANTO	43.43	35.00	8.00	6.00	0.93	2.55	4.63	11.81
SIJI	77.45	37.50	13.75	8.25	0.72	2.78	4.97	13.82
KANI-BIL	182.20	57.50	17.50	15.50	0.87	1.02	1.20	1.22
SISI	737.25	164.00	77.50	22.00	0.23	1.25	1.40	1.75

Table 4: Relief aspects of the 5th and 6th order drainage basins

	Sub-basins					
Parameters	YANTO	SIJI	KANIBIL	SISI		
Height of the basin mouth (z), m	204	204	201	89		
Height of the highest point on watershed (Z), m	1300	1100	780	1400		
Total basin relief (H = Z-z), m	1096	896	596	1311		
Relief ratio (H/Lb)	137.00	65.16	33.09	16.92		
Ruggedness number (Rn = D x H)	2.76	2.49	0.59	1.639		
Stream channel slope (θc), m/km	87.68	49.78	20.32	9.86		

Laws of Drainage Composition: The interrelationships between different morphometric parameters defined by the "Laws of Drainage Composition" are tested for the three 5th order sub-basins which reveal that these laws are more or less valid for the study area as well.

Analysis of 3rd order basins: The statistical analysis of various morphometric parameters of altogether 42 3rd order basins located at different geomorphic zones of the study area (27 in Structural Hills, 13 in Transitional Zone and 2 in alluvial plain) shows that certain morphometric parameters belonging to the linear and areal aspects like stream length, of various order, length, area of basins increase from structural hills to alluvial plain. On the other hand, all the parameters belonging to the relief aspect and certain parameters of the areal aspect viz. drainage density, stream frequency and drainage texture show a reverse trend of increase from alluvial plain to structural hills.



Figure 2: Hypothetical basins of extreme and moderate bifurcation ratios, with schematic hydrographs (after Strahler, 1964)

Conclusions:

Evaluation and mutual comparison of the morphometric parameters covering all the three aspects of the Sisi river basin and the 5th order sub-basins viz. the Yanto, Siji and Kanibil show that these parameters vary considerably from one subbasin to another. However, within an individual sub-basin, these values are characteristically high for the hilly region which is due to the overall low permeability of the consolidated Siwalik sandstone occurring in the area. Relatively higher permeability and incoherent nature of the unconsolidated alluvial sediments of the plain areas, on the other hand, attribute low values of these parameters. Different geomorphic settings of the region have significant control over the morphometric parameters of the 3rd order drainage basins

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