Morphometric Analysis of the Katakhal and Sonia watershed, using Spatial Techniques

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Abstract: *Present study makes an effort to carry out the morphometric analysis for Katakhal and Sonia channel which was carried out with the DEM. The length of all the streams, area of the watershed was measured by using ArcGIS-10.2 software and stream ordering has been generated using Strahler (1975) system, and ArcHydro tool in ArcGIS-10.2 software. Morphometric analysis of a drainage system requires delineation of all existing streams. Quantitative analysis has been done based on DEM & different morphometric parameters (linear, areal and relief) have been generated in GIS environment. The morphometric analysis of the drainage basin and channel network play an important role in understanding the geo-hydrological behavior of drainage basin and expresses the prevailing climate, geology, geomorphology, structural antecedents of the catchment. Morphometric analysis of a drainage basin expresses fully the state of dynamic balance that has been attained due to dealings between matter and energy. It finds out geomorphologic and structural control of flow and runoff and is helpful in predicting floods, their extent and intensity*

Keywords: Morphometric Analysis, Katakhal channel, Sonia channel, GIS

1. Introduction:

Water "the blood of the Earth" a substance vital for the very existence of man has played a vital role in society's progress Nautiyal, M. D. (1994. Watersheds can be classified using any measurable characteristics in the area like- size, shape, location, ground water exploitation, and land use Naiman et al . Remote sensing techniques using satellite images and aerial photographs are convenient tools for the morphometric analysis which requires measurements of linear features, gradient of channel network, and ground slopes of the drainage basin Biswas et al. Geographical Information System (GIS) is computer based system design tool applied to geographical data for integration, collection, storing, transforming and display spatial data for solving complex and management problems Ian, H. (2010). . Geographic Information System (GIS) endow with a practical approach because it provides an agenda for gathering, storing, exploring, transforming and exhibiting spatial and non-spatial data for particular purposes Torrens, P. M. Accordingly the use of GIS technology as a spatial data management and an analysis tool provides an effective mechanism for hydrologic/ hydraulic studies. Applications of Geographical Information Systems (GIS) to geomorphological study have been ever-increasing since the 1990s. Increasing accessibility of Digital Elevation Models (DEMs) at various resolutions has facilitated this development. GIS and DEMs have enhanced the cartographic illustration of landforms, which is not a simple description of topography however a positive support for edifice scientific hypotheses at an premature stage of research Barr, I., & Kervyn, M. The additional fundamental contribution of GIS and DEMs is their potential of quantitative analyses. Main aim of this study is to conduct the morphometric analysis of two watersheds (Katakhal and Sonia), and the morphometric parameters include linear aspect, areal aspect and relief aspect.

2. Study area

This study was conducted at Silchar region. In terms of geography it is located in Cachar district of Assam, India as shown in Figure 1. It lies between 24.5840° N to 24.6333° N latitudes and 92.7789° E to 92.8397° E longitude. Area of study is divided into two watersheds namely Katakhal with an area of 1429 square kilometers and Sonai with an area of 2230 square kilometer. At Silchar, climate has warm temperature and significant rainfall throughout the year i.e., climate is tropical in nature. In summer there is a lot of humidity mixed with heavy rainfall and thunderstorm. By the end of November month winter gets started and it lasts till late of February, and then at the month of mid-April the clouds of rain getting started to cover the skyline. Silchar is covered with flood waves due to excessive rainfall in the area. From the last three decades, four major floods have occurred one in 1986, and other followed in 1991, 2004 and 2007 and have severely damaged the area. The average annual rainfall recorded in the last thirty six years is approximately 2940.78 mm, of which 90% of the rainfall is received from May to September.

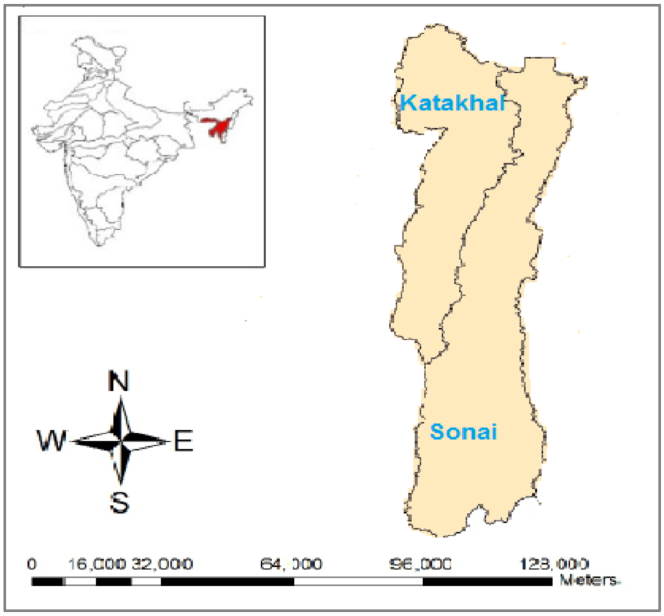

Figure 1: Location Map of Study Area

3. Materials and Methods:

DEM (Digital Elevation Model) data was downloaded from the website *http://gdex.cr.usgs.gov/*, and was subsequently utilized for preparation of digital elevation model to extract the basin of the study area using product NGA SRTM(finished) 3 arcsec(90 m spatial resolution) in GeoTiff format. The morphometric analysis of the Barak basin was carried out with DEM. The lengths of the streams, areas of the watershed were measured by using ArcGIS-10 software, and stream ordering has been generated using Strahler (1957) system, and ArcHydro tool in ArcGIS-10 software. Morphometric analysis of a drainage system requires delineation of all existing streams. Quantitative analysis has been done based on DEM & different morphometric parameters (linear, areal and relief) have been generated in GIS environment. Table 1 presents the formulae for morphometric analysis. The data inputs were collected digitized and were converted to shape files. All data layers were standardized to a common projection (Universal Transverse Mercator-UTM, zone 46N) and spheroid datum (WGS84).

Table 1: Formulae's used for the morphometric analysis

S.No	Morphometric Parameters	Formula	Description
1	Bifurcation Ratio	$Rb = Nu/Nu + 1$	N_u =number of stream segments present in the given order
2	Drainage Density	$Dd = \sum Lu/A$	
3	Drainage Texture	$Dt= N_u/P$	N_{u+1}=number of segments of the next higher order
4	Texture Ratio	$T=\sum N_1/P$	
5	Stream Frequency	$F_s=\sum N_u/A$	N_{u-1}=number of segments of the next lower order
6	Circulatory Ratio	$R_c =4\pi A/P^2$	
7	Compactness coefficient	$Cc = P/2\sqrt{\pi A}$	L_u=Total stream lengths of all orders(km)
8	Length of overland flow	$L_o=1/2D_d$	
9	Constant channel maintenance	$C=1/D_d$	A=area of the basin(km^2)
10	Stream Length Ratio	$R_l=L_u/L_{u-1}$	P=perimeter of the basin (km)
11	Elongation Ratio	$R_e=2(\sqrt{A/\pi})/L_b$	L_b= watershed length (km)
12	Shape Factor	$S_f=L_b^2/A$	
13	Form Factor	$R_f= A /L_b^2$	B_h=Elevation Difference.
14	Basin Relief	B_h	
15	Relief Ratio	$R_h=B_h/L_b$	
16	Ruggedness No	$R_n= B_h*D_d$	

4. Results and discussion:

4.1 Morphometric Analysis of the study area

The various morphometric (linear, areal and relief) parameters were computed and are discussed below.

4.1.1 Linear aspects

The linear aspects of the channel system are stream order (U), stream length (L_u), stream length ratio, bifurcation ratio, length of main channel, basin length, basin perimeter, and length of overland flow. Classification of streams is important to index the size and scale of watershed. The number of streams of various orders in watershed was counted and their lengths from mouth to drainage divide were measured with the help of GIS software. Sonia watershed is under fifth order stream and Katakhal watershed is under fourth order stream .The number of first-order streams indicates the mature stage of topography Singh, (Singh et al., 2011) In the present study, R_b was estimated for both of the watersheds are presented in Table 2. The high value of R_b indicates structural complexity and low permeability (Pankaj, 2009). The higher value of R_b indicated strong structural control on the drainage pattern. An elongated watershed has higher bifurcation ratio than normal and approximately circular watershed (Singh, 2003). It is indicated that the watersheds chosen for the study are not circular in shape and would produce delayed peak flow. The shorter the length of over land flow, the quicker will be surface runoff. This study shows a low drainage intensity implies that drainage density and stream frequency have little effect (if any) on the extent to which the surface has been lowered by agents of denudation. With these low values of drainage density and stream frequency surface runoff is not quickly removed from the watershed, making it highly susceptible to flooding, gully erosion and landslides. The linear aspects were determined and are presented in Table 2

TABLE 2 Linear Aspects of the study area

Basin	R_l	R_b	N_u	L_u(km)	L_b(km)
Katakhal	1.7	4.13	188.55	592.57	93.36
Sonia	2.183	2.97	239.55	788.74	147.59

4.1.2 Areal Aspect

Areal aspect of morphometric study of the watershed includes the description of arrangement of areal elements, law of stream area, relationship between stream area and stream length, relation of area to the discharge, basin shape. Lower drainage density of the basin indicates towards coarse drainage pattern and humid climate of the study area. The coarse texture gives more time for overland flow and hence to ground water recharge. A low value of the drainage density indicates a relatively low density of streams and thus a slow stream response (Singh, 2004). In the present study, drainage texture ratio is 0.47 and 0.44 for Katakhal and Sonia respectively of the watersheds, which indicates the drainage is of coarse texture (Smith, 1950). The stream frequency was found to be 0.13 and 0.10 for Katakhal and Sonia respectively. The circulatory ratio (R_c) was estimated to be 0.11 and 0.09 for Katakhal and Sonia respectively, whereas, form factor was found to be 0.16 and 0.10 respectively. The value of R_c is influenced by the length and frequency of streams, geological structures, land use/land cover and slope of the basin. Smaller the value of form factor more will be elongated basin and high peak flows of shorter durations (Javed, 2009). The areal aspects were determined and are presented in Table 3

TABLE 3 Areal Aspects of the study area

Basin	L_o	C	F_s	D_d	R_f	T	R_e	R_c	C_c	S_f	D_i	I_f	D_t
Katakhal	1.20	2.41	0.13	0.41	0.16	0.22	0.45	0.11	2.99	6.10	0.31	0.05	0.47
Sonia	1.41	2.82	0.10	0.35	0.10	0.27	0.36	0.09	3.23	9.76	0.30	0.03	0.44

4.1.3 Relief Aspect

The relief ratio (R_h) was found to be 0.013 and 0.012 respectively. The R_h normally increased with the decreasing drainage area and size of the watersheds for a given drainage basin Rudraiah, M. et al .It measures overall steepness of watershed and also considered as an indicator for the intensity of erosion process occurring in the watershed. The high value of relief ratio is characteristics of hilly region. The value of total relief and was found to be1.25 km and 1.86 km respectively. The areas of low relief but high drainage density are regarded as ruggedly textured as areas of higher relief having less density. In the present study, R_n was found to be 0.51 and 0.66 respectively. This number represents that if drainage density is increased, keeping relief as constant then average horizontal distance from drainage divide to the adjacent channel is reduced. On the other hand, if relief increases by keeping drainage density as constant, the elevation difference between the drainage divide and adjacent channel will increase. The relief aspects were determined and are presented in Table 4

TABLE 4 Relief Aspects of the study area

Basin	B_h	R_h	R_n
Katakhal	1.25	0.013	0.518
Sonia	1.86	0.012	0.660

5. Conclusion:

Values of bifurcation ratios are 4.93 and 2.17 and values of drainage densities are 0.41 and 0.35 for Katakhal and Sonia respectively which indicate that the drainage has not been affected by structural disturbances The form factor values computed are 0.13 and 0.10 for Katakhal and Sonia respectively are very low, which suggest that both of the basins are elongated in shape and both of the basins has moderately low peak flows of shorter duration. This type of work can also be used in the prioritization of watersheds, if the soil maps are available.

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