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INFERRING HYDROLOGICAL CHARACTERISTICS OF GABHARU RIVER BASIN, NORTH-EAST INDIA, BASED ON THE APPLICATION OF SOME IMPORTANT MORPHOMETRIC PARAMETERS

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ABSTRACT The Gabharu river basin is a sixth order basin lying on the northern side of the Brahmaputra. The basin is constituted predominantly of Siwaliks in the upper catchment whereas, the lower part is constituted of Quaternary sediments. On the basis of analysis of some morphometric parameters using GIS techniques, it is understood that the river basin has a high retention or storage capacity and, therefore, low run-off generation ability. High values of the relief parameters such as, basin relief (1800m) and relief ratio (36.13m/km) provide a contrary picture suggesting appreciable run-off. But, in the present study area, the dominant presence of soft and permeable Upper Siwalik rocks reduces run-off potential and the relief effect is thus negated.

KEYWORDS : Gabharu river basin, morphometric parameters, run-off

INTRODUCTION

The northeastern region of India is characterized by high rainfall especially during the monsoon period causing erosion, landslides and floods. In order to take up mitigation measures for such natural calamities, proper hydrologic information becomes necessary. However, setting up hydrological monitoring stations for generation of hydrological data becomes difficult in inaccessible areas thereby, necessitating application of some alternative measures for gaining the required hydrologic data. Morphometric analysis is one such approach to describe the hydrological characteristics of any watershed (Esper, 2008). Morphometric analysis of watershed or drainage basin is concerned with quantitative evaluation of fluvial landforms which make up a substantial part of the earth's surface. With the application of remote sensing and geographical information system (GIS) techniques, morphometric analysis has become more accurate and, therefore, has gained increasing attention.

In the present study, morphometric parameters have been extracted and analyzed using GIS techniques for understanding some important hydrological characteristics of the Gabharu river basin.

STUDY AREA

The Gabharu river basin is a tributary basin of the Brahmaputra lying on the northern side of the Brahmaputra. It is a sixth order basin lying partly in the West Kameng district of Arunachal Pradesh and partly in the Sonitpur district of Assam (Fig.1). It is constituted of four fifth order sub-basins (Fig.2) and has an area of 330.712 km^2.

The Gabharu river originates from the west Kameng district of Arunachal Pradesh and flows down for about 52 km along a NNW-SSE course through the alluvial plains of Sonitpur distriict before meeting the Brahmaputra near Gabharumukh. The present study is based on Survey of India (SOI) topographic maps- 83A/8, 83A/12, 83B/5, 83B/9 and 83B/10 of 1971 on 1:50,000 scale.

Geologically the area is constituted of the Siwaliks in the upper catchment whereas, the lower part is constituted of the Quaternary. There are also the presence of granite inselbergs in the south near the Brahmaputra. The inselbergs comprise feldspathic gneisses and gneissic granite rocks. The Quaternary formation consists of mainly unconsolidated sediments which can be subdivided into older and younger alluvium.

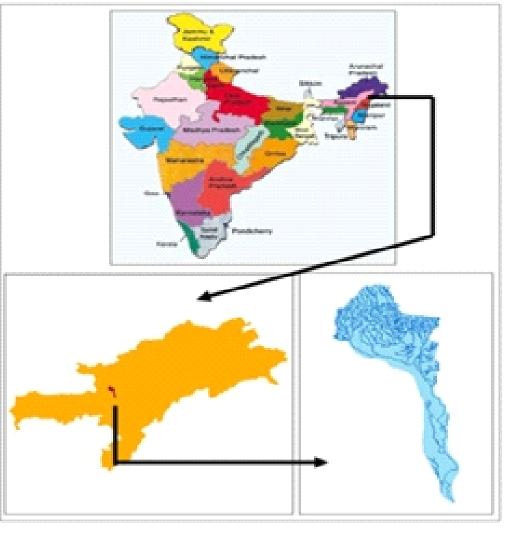

Figure 1: Location of Gabharu river basin
Sources: www.googleimages

DATABASE AND METHODOLOGY

These topographic maps were rectified/referenced geographically and mosaiced and the entire study area was delineated in GIS environment with the help of Arc-GIS software assigning Universal Transverse Mercator (UTM), World Geodetic System (WGS dating from 1984 and last revised in 2004) and 46N Zone Projection System. Digitization of the drainage basin was carried out in GIS environment using Arc GIS 9.3 software. The attributes were assigned to create the digital data base for drainage layer of the basin.

The morphometric parameters studied are as follows-

Morphometric parameters	Formula & definition	Reference	Values in study area
Total stream number	ΣN_u; N_u is the number of streams of any order 'u'	Strahler (1964)	615
Total stream length	ΣL_u; L_u is the length of streams of any order 'u'	Horton (1945)	567.53 km

Bifurcation ratio	$R_b = N_u / N_{u+1}$; R_b is the ratio of number of streams of order 'u' (N_u) to that of the next higher order (N_{u+1})	Horton (1945)	3.58
Stream length ratio	$R_L = L_u / L_{u-1}$; R_L is the ratio of mean stream length of streams of order 'u' (L_u) to that of the next lower order (L_{u-1})	Horton (1945)	3.28
RHO coefficient	RHO = R_L / R_b; RHO is the ratio of stream length ratio (R_L) to bifurcation ratio (R_b)	Horton (1945)	0.91
Stream frequency	$F_s = \Sigma N_u / A$; Fs is the ratio of total stream number (ΣN_u) of all orders in a basin to the basin area (A).	Horton (1932)	1.85
Drainage density	$D_d = \Sigma L_u / A$; Dd is the ratio of total stream length of all orders (ΣL_u) in a basin to the basin area (A).	Horton (1932)	1.7
Infiltration number	$I_f = F_s \times D_d$; Infiltration no. is the product of stream frequency and drainage density.	Faniran (1968)	3.145
Elongation ratio	$R_e = 2\sqrt{(A/\pi)}/Lb$; A is the basin area and Lb is the basin length. It is expressed as the between the diameter of a circle of the same area as the basin to the basin length.	Schumm (1956)	0.40
Basin relief	R = H-h; it is the difference in elevation between the highest (H) and the lowest (h) point of the basin	Hadley & Schumm (1961)	1800 m
Relief ratio	$R_r = R/L$; it is the ratio of basin relief to basin length.	Schumm (1963)	36.13 m/km
Time of concentration	$T_c = G\,(1.1 - c)\,L^{0.5} / (100\,S)^{1/3}$ G = 1.8 (a constant); c = 0.15; L = longest watercourse length; S = average slope of the watercourse in m/m.	Federal Aviation Administration (FAA) of USA	223 mins

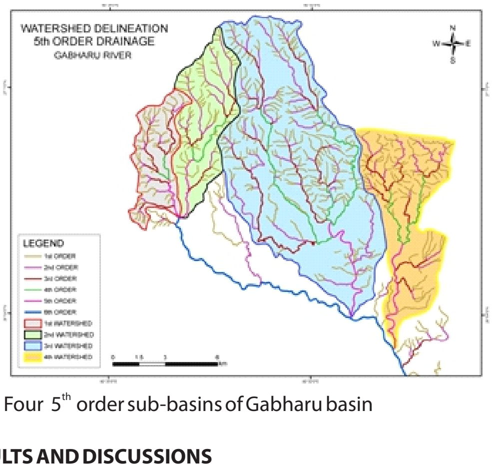

Fig:2 : Four 5th order sub-basins of Gabharu basin

RESULTS AND DISCUSSIONS

The inter relationship between the morphometric parameters considered in the present study and the hydrological characteristics have been explained as follows:

BIFURCATION RATIO (Rb)

This is a very important parameter which indicates the proneness of a drainage basin to flooding (Kusre, 2016). Higher value of bifurcation ratio indicates more complexity and degree of dissection of a drainage basin and, therefore, greater proneness to flooding. According to Strahler (1964), in areas of negligible structural influence, the Rb ranges between 3 & 5. The modest Rb value of 3.58 in the present study indicates dominance of overland flow and lesser proneness to flooding.

STREAM LENGTH RATIO(Rl)

Stream length ratio, according to Horton (1945), has an important relationship with surface flow and discharge. It indicates if there is a major change in the hydrological characteristics of the underlying rock surface in the areas of consecutive stream orders (Pakhmode et al. 2003). Determination of Rl and Rb are important for extracting the RHO coefficient, a very important hydrologic parameter.

RHO COEFFICIENT

RHO coefficient (ρ) of a watershed is an important parameter relating drainage density to physiographic development of a hydrographic basin which facilitate evaluation of water storage capacity of drainage network and hence, a determinant of ultimate degree of drainage development in a given watershed (Horton, 1945). Low values of RHO indicate low capacity for storage of water, while high values of RHO indicate high capacity of storage of water and the climatic, geologic, geomorphologic, and anthropogenic factors determine the changes in this parameter (Melton, 1958). High RHO value of the Gabharu drainage basin (0.91) indicates higher hydrologic storage during floods and attenuation of effects of erosion during elevated discharge.

STREAM FREQUENCY (F_s)

It is also a measure of surface run-off apart from relief, lithology, permeability and vegetation. Higher value of stream frequency indicates higher run-off. In the study area, the derived value is low (1.85) indicating lower run-off.

DRAINAGE DENSITY (D_d)

Drainage density is an important indicator of the linear scale of landform element in stream eroded topography (Horton, 1932). It is a measure of fluvial dissection and is influenced by numerous factors, among which resistance to erosion of rocks, infiltration capacity of the land and climatic conditions rank high (Vestappen, 1983). Drainage density measures basin efficiency in removing excess precipitation inputs. High flood-prone regions are characterized by high drainage density values. The low value in the study area (1.7) suggests low run-off generation capabilities and high permeability.

INFILTRATION NUMBER (I_f)

It is a parameter which gives an idea of the infiltration characteristics of a basin. Higher value indicates lower infiltration capacity and consequent high surface run-off and vice versa. Infiltration number of the study area is low (3.145) indicating high infiltration capacity and, therefore, lower runoff.

TIME OF CONCENTRATION (T_c)

This parameter refers to the time taken by the water to flow from the remotest point of a drainage basin to the river mouth or outlet. Low value of T_c infers susceptibility of the lower catchment areas to flood and flash flood. It also gives an idea of response time to mitigate the adverse impacts i.e, the time available for the communities to move to safer places. The Tc value for the Gabharu river basin is 223 mins which is high considering the small dimension of the basin.

BASIN RELIEF (R) AND RELIEF RATIO (R_r)

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Basin relief controls the stream gradient and, therefore, influences floods patterns and the amount of sediment that can be transported (Hadley and Schumm, 1961). The relief ratio is also directly proportional to surface run-off and flood activity. In the study area, both the basin relief (1800) and relief ratio (36.13 m/km) are towards the higher side, both being important parameters suggesting faster run-off. However, the indications given by the other parameters strongly suggest lower run-off. This contradiction can be explained in terms of lithology. The study area is predominantly constituted of

ELONGATION RATIO (R_e)

For a near circular basin, the R_e value approaches 1. The R_e value of 0.40 in the study area suggests elongated nature of the basin indicating flatter peak flow for a longer duration.

CONCLUSIONS

The present study was undertaken to determine how some morphometric parameters can be helpful in order to ascertain hydrological characteristics of the Gabharu river basin. The morphometric parameters such as bifurcation ratio, stream length ratio, RHO coefficient, stream frequency, drainage density, infiltration number, elongation ratio, time of concentration, basin relief and relief ratio were extracted and their hydrologic implications were ascertained. It has been found that these parameters, except basin relief and relief ratio, imply low magnitude run-off and, therefore, less proneness to flooding or flood potential. High values of the relief parameters normally suggest high run-off potential. But in the present context, the dominant existence of soft and permeable Upper Siwalik formations serve as obstacle to free and rapid flow of surface water thus negating the relief effect thereby, lessening the conversion capability of rainfall to run-off. High infiltration capacity, RHO coefficient, time of concentration and low elongation ratio value infer appreciable retention of water within the basin resulting in high groundwater potential. Elongated nature of the Gabharu river basin with low elongation ratio, causes flatter peak flow for an extended period. Therefore, flood flows can be relatively easily managed than in case of circular basin where the peak flow is much higher.

REFERENCES:

1. Esper, A.M.Y. Morphometric analysis of Colanguil river basin and flash flood hazard, San Juan, Argentina. Environ Geol. 2008; 55:107-111.
2. Faniran, A. The index of drainage intensity - A provisional new drainage factor, Aus. Jour. of Sci.,1968; 31: 328-330.
3. Hadley, R.F. and Schumm, S.A. Sediment sources and drainage basin characteristics in upper Cheyenne River Basin,USGS Water-Supply Paper. 1961; 1531-B: 198.
4. Horton, R.E. Drainage basin characteristics. Trans Amer. Geophys. Union. 1931;13: 350-361.
5. Horton, R.E. Erosional development of streams and their drainage basins : Hydrophysical approach to quantitative morphology. Geol. Soc. Amer. Bull. 1954;. 56:.275-370.
6. Melton M.A., Geomorphic properties of mature drainage systems and their representation in an E4 phase space. Journal of Geology1958; 66: 35 – 54.
7. Pakhmode V, Kulkarni H, Deolankar SB. Hydrological drainage analysis in watershed programme planning: A case study from the Deccan basalt, India. Hydrogeol. J.2003; 11:595-604.
8. Schumm, S.A. The evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey. Geol. Soc. Amer. Bull.,1956;74:597-646.
9. Schumm, S.A. Sinuosity of alluvial rivers on the Great Plains. Bull. Geol. Soc. Amer.1963;74:1089-1100.
10. Strahler, A.N. Quantitative geomorphology of drainage basins channel networks. In. V.T. Chow (Ed.) Handbook of Applied Hydrology1964 Mc Graw Hill Book Company New York; 4.39-4.76.
11. Vestappen, H. The applied geomorphology. International Institute for Aerial Survey and Earth Science (I.T.C), Enschede,1983The york.