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MORPHOMETRY AND ITS IMPACT ON FLOOD IN NANOI RIVER BASIN, ASSAM USING GIS TECHNIQUES

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INTRODUCTION

Rivers have been unstable entities producing geomorphological changes in land and hydrological regimes. A drainage basin being the best unit for hydro-physical studies among many (Horton, 1945, Chorley, 1969), bears a great significance in today's hydro-environmental investigation of channel network and drainage morphology along with flood events and their relationship with land, water and man (Chorley,1969b). Hydro-geomorphic processes play key roles in creating, modifying, or destroying aquatic habitat and act as ecological disturbances that shape ecosystem characteristics and dynamics. Within the broad regional context set by general patterns of climate, physiography (geology and topography), and vegetation, the combined influences of the hydrologic, geomorphic, and vegetation regimes dominate the variability of river systems. In the northern plains of Assam the river Nanoi plays serious threat and challenge in terms of long and recurring floods hazard on floodplain dweller's. Despite a long history of flood problems mitigation and management in the river more than 30 years the river continuously suffering from a lot of problems on flood plain areas and along with floodplain dweller's through extensive flooding. The intensity of the impact, the size of the area affected, and the frequency of occurrence together define the disturbance regime associated with particular hydrogeomorphic processes. In addition, river restoration efforts need to be founded on an understanding of characteristics and functional relationships that structure aquatic habitat, the influence of routing on impact propagation and legacies on current conditions and restoration potential. Geographic variations of climate,

physiography (geology and topography), and vegetation impart a strong hydrological problem to Nanoi river systems.

Therefore, a detail investigation is required to know such type of hydro-geomorphic characteristics by using remote sensing and GIS technique. Geographical Information System and Remote Sensing are being increasingly used in evaluation of river morphometry and hydraulic characteristics to improve the quality and quantity of the research study of river basin area.

Key words: Bank erosion, Channel characteristics, Flood, Environment, Hydrology, Morphology.

STUDY AREA

The river Nanoi originates from the Bhutan hill Tangchar, southern part of the Bhutan hill (1220m). The topography along the stream is such that the valley gradients decline steeply as the rivers advance from the hills to the plains of the Brahmaputra valley. From the origin point it flows towards the south and eastern Assam at the 103 no. boundary stone. In the hilly area its takes numbers of small tributaries.

Although the river originates from Bhutan hills the river Nanoi is very significant in nature .It always takes new shape and size and change her direction. So locally at the downstream part the river is known as Nanoi, means new river that the river is newly born in every direction. But at early times, before eighteenth century the river name was Digauge.

The Nanoi river basin, a part of reverine built-up plain of Brahmaputra valley composed of fine alluvial sediments, which has been washed by sheet flood causing river bank erosion and channel shifting almost every year due its hydro-geomorphic factors. The hydro-geomorphic characteristic of the river basin has caused serious geomorphic, hydrologic and environmental problem in the southern part of the Darrang district. The total length of the Nanoi River is 104.275 kilometer with the basin area of 959.460 sq km (Fig. 1). The basin extending from $26^0\ 15'\ 45.14''$ N

The relief and drainage regimes play dominants roles to create characteristics of environment on the land of the concern basin area. The basin area receives an annual mean rainfall of 210 cm. the master stream i.e. is the Nanoi is fed by a number of sub tributaries which supply water to the basin mainly during rainy season.

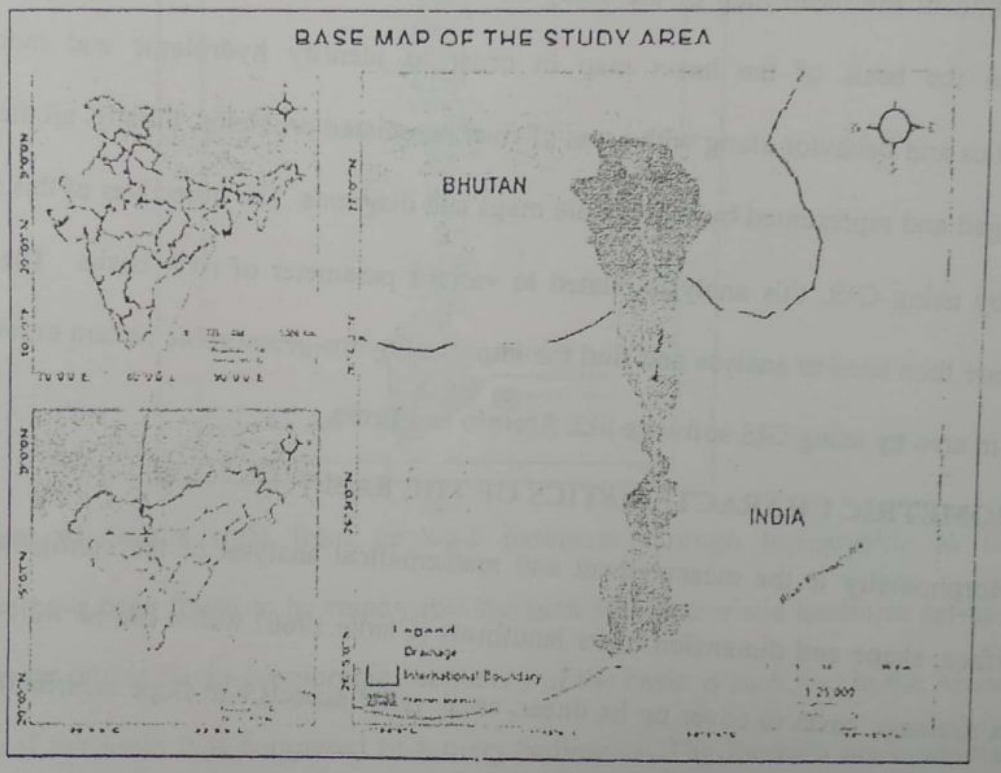

Fig.1 Location Map of Nanoi River Basin

OBJECTIVES

The main objectives of the study are-

i) to investigate the morphometric characteristics of the Nanoi river and its basin,

ii) to examine the hydrologic characteristics and its impact on river basin,

iii) to examine the impact of basin morphometry and hydro-geomorphic characteristics on flood,

iv) to formulate strategies to understand and mitigate the fluvio-geomorphic problems.

METHODOLOGY

Drainage basin analysis has been done with the help of the basin morphometric parameters such as linear aspects of the river basin were determined and computed. The Survey of India (SOI) topographical map (R.F.1:50,000) of 1972 and along with IRS LISS-III image of 2008 are used for the preparation of the basin map of the study area. The drainage networks of the basin are then digitized on the basis of the basin map in order to identify hydrologic and morphometric characteristics and behavior along with areas of river associated problems. Finally, all the data have been arranged and represented by appropriate maps and diagrams. The objectives of this study were achieved by using GIS, this analysis related to various parameter of river basin. The maps and diagrams are then used to analyse and find the impact of hydro-geomorphic pattern on environment in the basin area by using GIS software like ArcInfo and Erdas.

MORPHOMETRIC CHARACTERISTICS OF THE BASIN

Morphometry is the measurement and mathematical analysis of the configuration of the earth surface, shape and dimension of its landforms (Clarke.1966) which can be well extended in case of a drainage basin to cover up its linear, areal, relief aspects and slope contribution(Nag and Chakrabarty,2003).

The Nanoi river basin placed in the middle of the high hills and the grand river Brahmaputra in the south and the adjacent riverine plains in the east and west being characterized by south sloping hilly terrain in its upper part, the swelling plains in the upper middle part and flat plains on the lower middle and lower parts of the basin (Fig. 2).

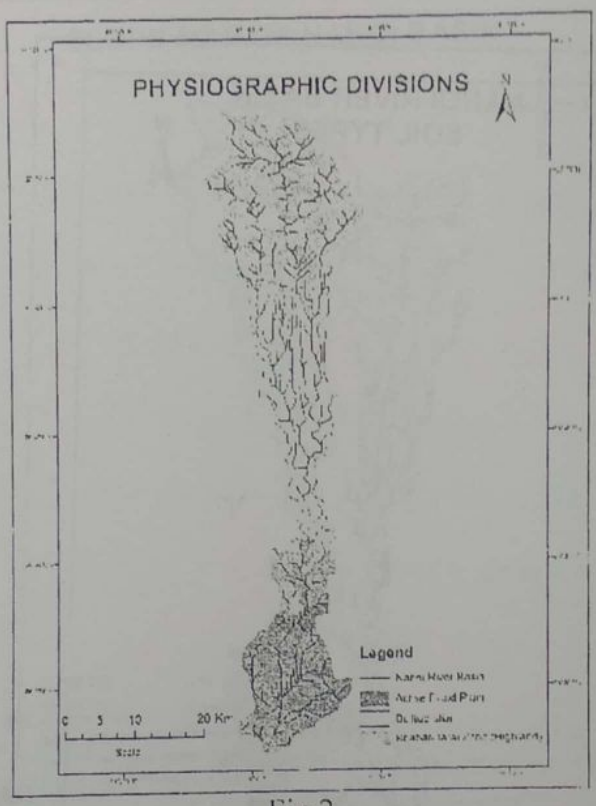

Fig.2

A number of factors right from geologic basement through topographic to fluvio-geomorphic ones have been found to be responsible for such a characteristic landform set-up. The geological basement of this fluvio-geomorphic peculiarity of the basin is such that in the Arunachal Himalayan part of the basin it is composed of tertiary sediments. The foothills are composed of boulders, gravels, pebbles, cobles, grit and sand, while the plain part is composed of thick layers of river born alluvial deposits.

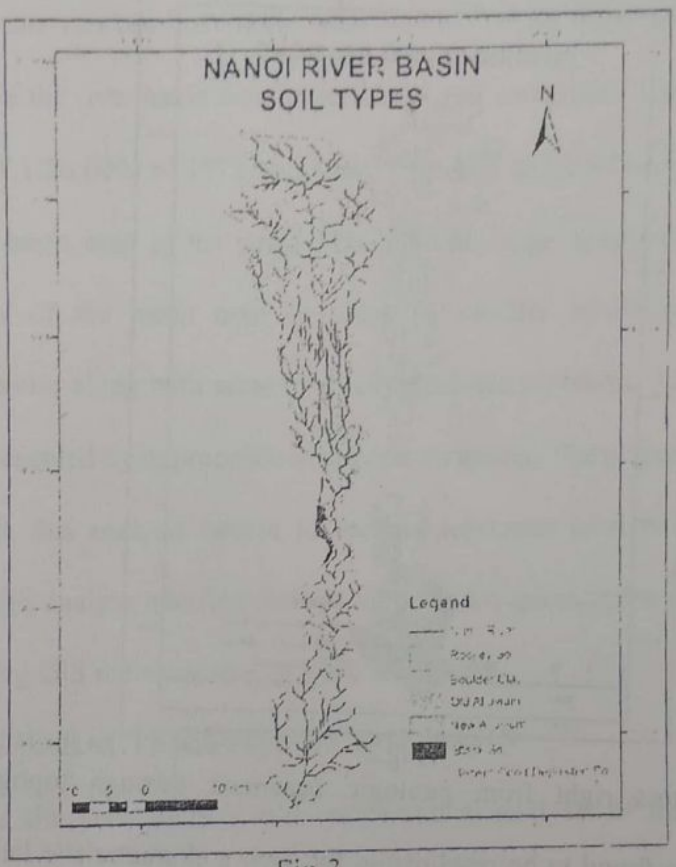

Fig-3

Slope analysis implies that the basin having the equal areas within slope groups of equal interval which is not uniform. It is found that below the 8^0 slopes the basin covers 68.29 percentage of the total areas while 8^0 to 23^0 has the percentage share of 16.12. Beyond 23^0 slope up to about 77^0 the basin covering as large as 25.59 percent of basin area. Such a state of slope pattern of the basin clearly indicates that there is hurriedly changing slope distribution as one goes from mountainous areas to the Nanoi river mouth in the neighborhood of the Brahmaputra. As figure has shown that the height increases the area share decreases abruptly. Such a state of relief change can well be substantiated by the river (Fig.4) or basin profile having abrupt fall with inflexion in the foothill areas and perceptibly very less relief, specially the relative relief in the built-up and floodplain areas down the foothills.

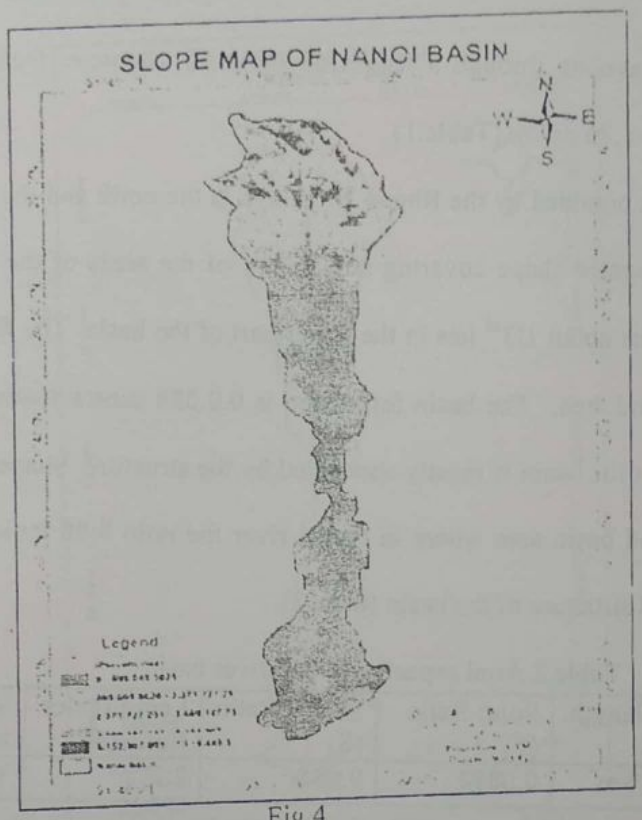

Fig.4

Table.1 Showing Channel and Basin gradient of the river in different sites

River	Total length	Segment length	Maximum channel relief	Channel gradient (m/km) of the segment	Site
Nanoi	104.27 km	26.21	1310.64 m	50.005	Foot hill
		44.04	120 m	2.725	Built-up plain
		34.025	60 m	1.763	Active flood Plain
		104.275	**1310.64 m**	**12.569**	**Entire channel**

The region is steeply downward towards the southern part. In the upstream the topography of the channel is steeply raising which create a new type of valley dimensions. So the stream is such that the valley gradients decline steeply as the stream flowing from the hill to the plains of

Brahmaputra valley. After traveling through a length of about 50 kilometer from the hills their course becomes smooth, only 1.76 m/km (Table.1).

The Nanoi river basin bounded by the Bhuan Himalaya in the north and the Brahmaputra in the south has almost an elongated shape covering about 2/3rd of the areas of the basin above the middle part of the basin, while about 1/3rd lies in the lower part of the basin. The form ratio mainly concerned with the length and area. The basin form ratio is 0.0.088 substantiates that basin is an elongated one. It implies that the basin is mostly controlled by the structure. Shape ratio is the ratio between the basin length and basin area where in Nanoi river the ratio 9.08 indicates the sinuous shape and it implies the hard structure of the basin (table.2).

Table.2 Arial aspect of Nanoi river basin

Basin area	Basin length	Form Ratio (F)	Shape ratio (S)	Lemniscates Ratio (k)	Sinuosity index SI
959.46 km^2	104.27km	0.0882	9.088	2.272	1.116

The basin has average stream frequency in the tune of 0.04 numbers per sq.km. however in the hilly areas including the foothill one the stream frequency ranges from 0.15 to 0.001 per sq km.. subsequently the drainage density in the basin (0.62 km/km^2) like other basin of the Brahmaputra valley or elsewhere has a good positive relation.

Table.3 Linear aspect of Nanoi river basin

Order of streams	Number of streams Nu	Bi Ratio Rb	Length of Streams Lu	Stream Frequency (Fs)	Drainage Density(Dd) km/km^2	Length ratio L_R
1st Order	143	-	316.13	0.15	0.62	0.31
2nd Order	38	3.76	100.47	0.04		0.66
3rd Order	3	12.66	66.88	0.003		0.84
4th Order	2	1.05	56.73	0.002		1.02
5th Order	1	2.00	58.28	0.001		-
		Mean Rb 4.86				Mean L_R- 0.71

Source: Calculated from The SOI topographical map, 1972 and IRS LISS-III image, 2008

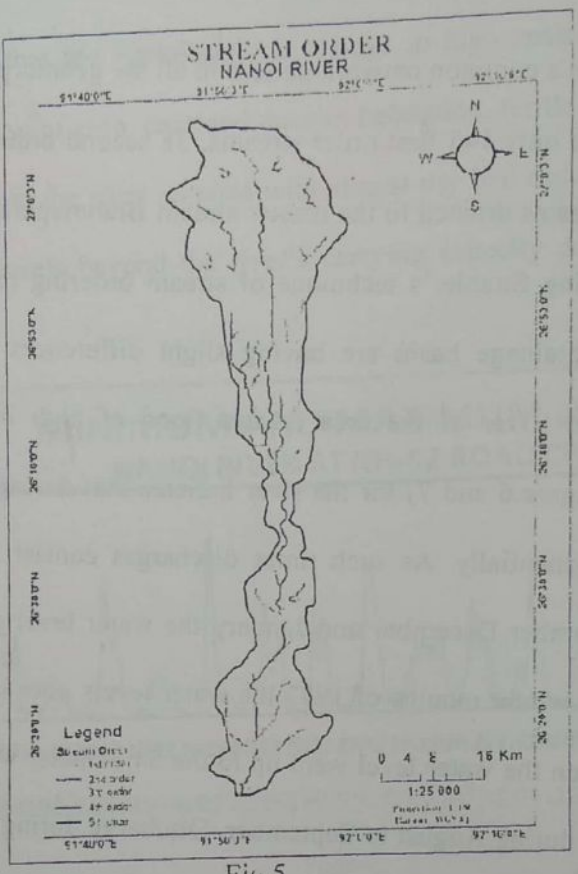

Fig.5

Bifurcation ratio of the 4th order Nanoi basin is 2.00, there are observable deviations from the average 4.86 among the bifurcation ratios of successive pairs of stream orders. The widely varying bifurcation ratios with the increasing orders of streams specially in case of lower reaches of the basin reveals the frequently recurring flash floods as well as the strong hydraulic action as compared that in the topographically controlled up stream areas. Elongated basin have low Rb value, where circular basin have high Rb value (Morisawa, 1985). The streams in the basin have been marked by differential length as per topographic, hydrologic. and hydraulic control (Horton. 1945). The length of the stream ranges length of the different orders of streams ranges shown in table.3 where in length ratios varies from 0.31 to 1.02 with an average of 0.71.

HYDROLOGIC DETERMINANTS AND FUNCTIONS

The drainage basin restrain a common network pattern in all the geomorphic units except the hills top area (Fig. 2) as there are only 143 first order streams, 38 second order streams, 3 third, 2 fourth order and 1 fifth order streams drained to the master stream Brahmaputra totaling altogether to 187 streams identified by using Strahler's technique of stream ordering (Strahler, 1952). The density and frequency in the drainage basin are having slight differences among the various physiographic units. The Nanoi River of the area creates flood of high intensity and serious devastation. The hydrograph (figure.6 and 7) for the river indicate that during dry period (winter) the stream flow decreases exponentially. As such times discharges consist solely of base flow. During winter months of November December and January the water level goes down to that of base flow. For example during winter months of 1987 the water levels goes down to the extent of 49 meter but during rainy season the water level went up to the 54.01meter where the danger level is 52.74 meter. This happened during August to September. Discharge during winter season was of the under of base flow measured at 1.02 cumecs, which rise to 239.10 cumecs during the summer season's. From the hydrograph it is clear that the month of May is the starting month of abrupt increase of water level as well as discharge as because rainfall starts falling from May. A number of maximum above the normal discharge or water level occurs during the month of May onward to September. Of course there are minimum either of discharge or water levels during these months also. Base flow occur also during the month when there exist periods of no rainfall.

Table.4 Hydrological Characteristics of Nanoi River

Rivers at NH 52 site	Avg. maximum water level and discharge (yearly)	Avg. minimum water level and discharge (yearly)	St.dev. maximum water level and discharge	St.dev. minimum water level and discharge	CV of maximum water level and discharge	CV of maximum water level and discharge
Nanoi (1988-2008)	53.50m	50.08m	0.60	0.042	1.13	0.84
	138.1cumecs	3.04cumecs	59.02	1.41	42.72	46.38

This also bear out that the Nanoi river is always in high spate of flood and consequent problems associated with loss of crop, cropland, human habitation, fertile soil along with shifting of river channel. It is found that the river remains with almost dry bed during the rainless period and with high spate of water levels beyond the river's carrying capacity during the period of heavy rainfall.

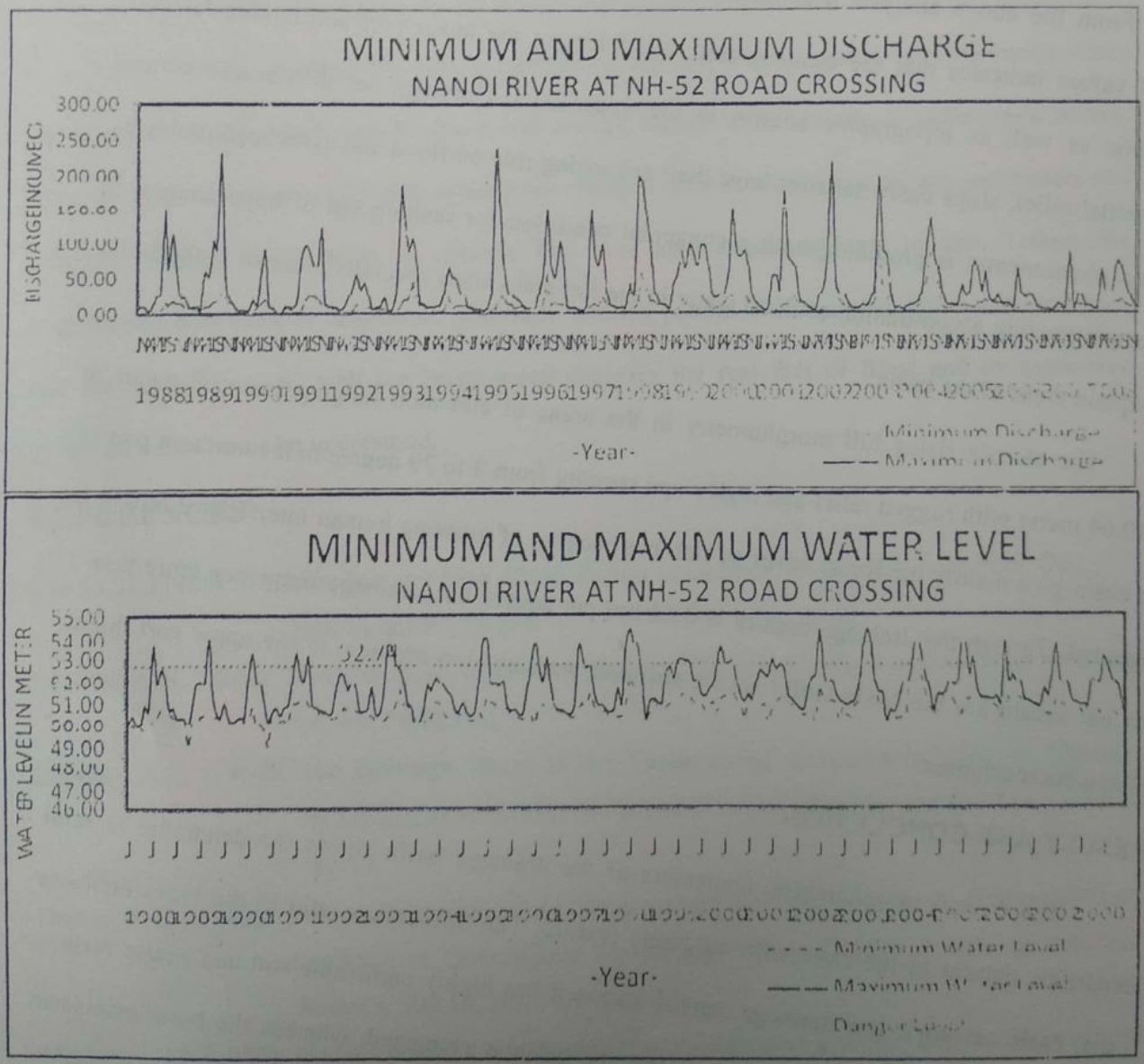

Fig.6 and 7 Hydrograph

A comparison of stage and discharge hydrographs reveals that the high discharge of water had a great parity with the high water stage in the river. It is observed in the hydrograph

representing stages of peak floods during 1988 to 2008, that majority of the peaks lie between 52.74m and 54.38m above the mean sea level. It thus observed from the hydrograph that the high flood peaks during the period cover 87.5 percent of all the occurrences.

HYDRO-GEOMORPHIC IMPACT

From the above analysis it is found that the hydrologic pattern of stream networks and related values indicates that the basin is quite relief less in the lower part and having far more hydraulic as well as topographic control in the upper part. Drainage net distribution pattern, differential relief, slope characteristics have their enhancing role on flood and associated problems. Such a phenomenon is providing with a congenial condition for rushing out of huge amount of water and causing accumulation of flood water in the flat plain areas specially more so in the active floodplain areas of the basin.

The steeply rising hill morphometry in the areas of elevation ranging from 60 meter to 1310.64 meter with rugged relief and high slope ranging from 8 to 79 degree in the northern part of the basin give mainly the forest cover of rich but because of growing human interference now it is degraded. Though the drainage density is 0.62 km per square km, drainage frequency more than 1 nos per square km the basin suffer severe soil and bank erosion problem in the upper part due to human encroachment.

RESULT AND CONCLUSION

The overall morphometric characters of the drainage basin shows the dendraitic to semi dendraitic pattern of the river with moderate texture. The bifurcation ratio in the basin indicates usual basin category, low drainage density shows it has highly permeable soil and coarse texture. The value of form and shape ratio indicates the basin is elongated, whereas the basin associated with moderate to high relief and flat ground slope.

River systems are dynamic. Restoration projects that do not acknowledge and plan for expected variability in habitat-forming processes associated with the hydrologic, geomorphic, and vegetation regimes are unlikely to be successful in the long term. In the study areas enhancement of morphological problems and spatio-temporal changes has also been noticed. The changing pattern of hydrological components of the river, augmentation and controlling of flood and its associated problems in the lower catchment area are mainly caused due to the hydro-geomorphic nature of the river basin. The basin being fed with a number of big and small streams carrying much water including the flood waters creates flood and erosion havocs differentially at different locations. Thus the study shows that GIS techniques have efficient tools to understand terrain parameters and drainage pattern which helps to manage the river associated problems in situ. Unless the multifaceted behaviors of landforms, landscape, and the pattern of human habitation and activities, and the human need as well are investigated properly the real fact of flood and its associated problems could never be understood.

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