Journal of North-East India Council for Social Science Research

NEICSSR, Shillong

Vol. 36:2
October 2012

ISSN 0970-7913

HYDRO-GEOMORPHIC CHARACTERISTICS AND THEIR IMPACT ON FLOOD HAZARD IN THE BARNADI RIVER BASIN, ASSAM USING GEO-INFORMATICS TOOLS

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Abstract : *River basin characteristics, morphometric behaviour and geological foundations have of late been found to help in a big way in the identification, evaluation, classification and management of riverine resourceful areas for the purpose of decision making and solving many of the rising problems related to the interface of man and environment, epecially floods. This paper attempts to investigate various aspects of morphometric behaviour caused by complex geologic, geomorphic and hydrologic processes operating in the Barnadi river basin of Assam.*

Introduction

A drainage basin being the best unit for hydrophysical studies among many (Horton, 1945, Chorley, 1969), bears a great significance in today's fluvio-geomorphological investigation of channel network and drainage morphology along with flood events and their relationship with land, water and man (Chorley,1969b). Not only that, the river water-borne threats and prospects have also come to the purview of geo-hydrological studies in drainage basin. Floods in recent times because of intense human pressure on the river regime have exercised many a time hazardous impact even as some of them act as a boon. The present paper, therefore, attempts to investigate the river basin morphometry and their impact on floods in the Barnadi basin of Assam. For this purpose, remote sensing and GIS techniques are used as the important tools for displaying the morphometric bases and properties along with their impact on floods.

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The Study Area

The Barnadi is a north bank tributary of the Brahmaputra river in the western margin of the mid Brahmaputra valley. The basin has geographical area of 496.62 Km^2 which extends latitudinally from 26° 14′ 30″N to 26° 49′N and longitudinally from 91° 45′E to 91° 53″E (Fig.1). It has been characterised by low relief both absolute and relative, and occupied by 3,00,319 persons (as per 2001census) over as many as 289 villages. The basin has been regularly washed by the Brahmaputra in the south and the Barnadi along with its tributaries like Kalpani, Dimila, Ranganadi, etc. in the basin itself. The basin is fed by monsoon rainfall during the summer which often creates flood havocs of low to very high intensities and durations.

The basin is facing topographic (geomorphic, soil, erosion etc.) and hydrologic (mainly floods, channel shifting, abandonment of channels, etc.) problems but it is least investigated. The authors have to investigated some of the vital determinants of geomorphology, hydrology and their impact on floods using remote sensing and GIS techniques.

Objectives

The main objectives of the study are as follows :

i) to find the morphometric determinants and examine the behaviour of the basin by using GIS and remote sensing techniques;

ii) to investigate the pattern of drainage network, wetlands distribution, vegetation cover, soil, geomrphologically significant micro characteristics in the basin;

iii) to identify the flood zone of the basin and analysis thereof; and

iv) to evaluate impact of morphometric and hydraulic/hydrologic determinants on floods,

Methodology and Database

The entire basin area is identified from Survey of India toposheets numbering 78N/10, 78N/11, 78N/12, 78N/13, 78N/14, 78N/15 and 78N/16. The whole basin area is digitize using Arc-view GIS software. To find out the basin area and the length of the channel NRSA IRS IC LISS-III digital data of 2000 were used. From modified map various types of parametric maps were drawn.

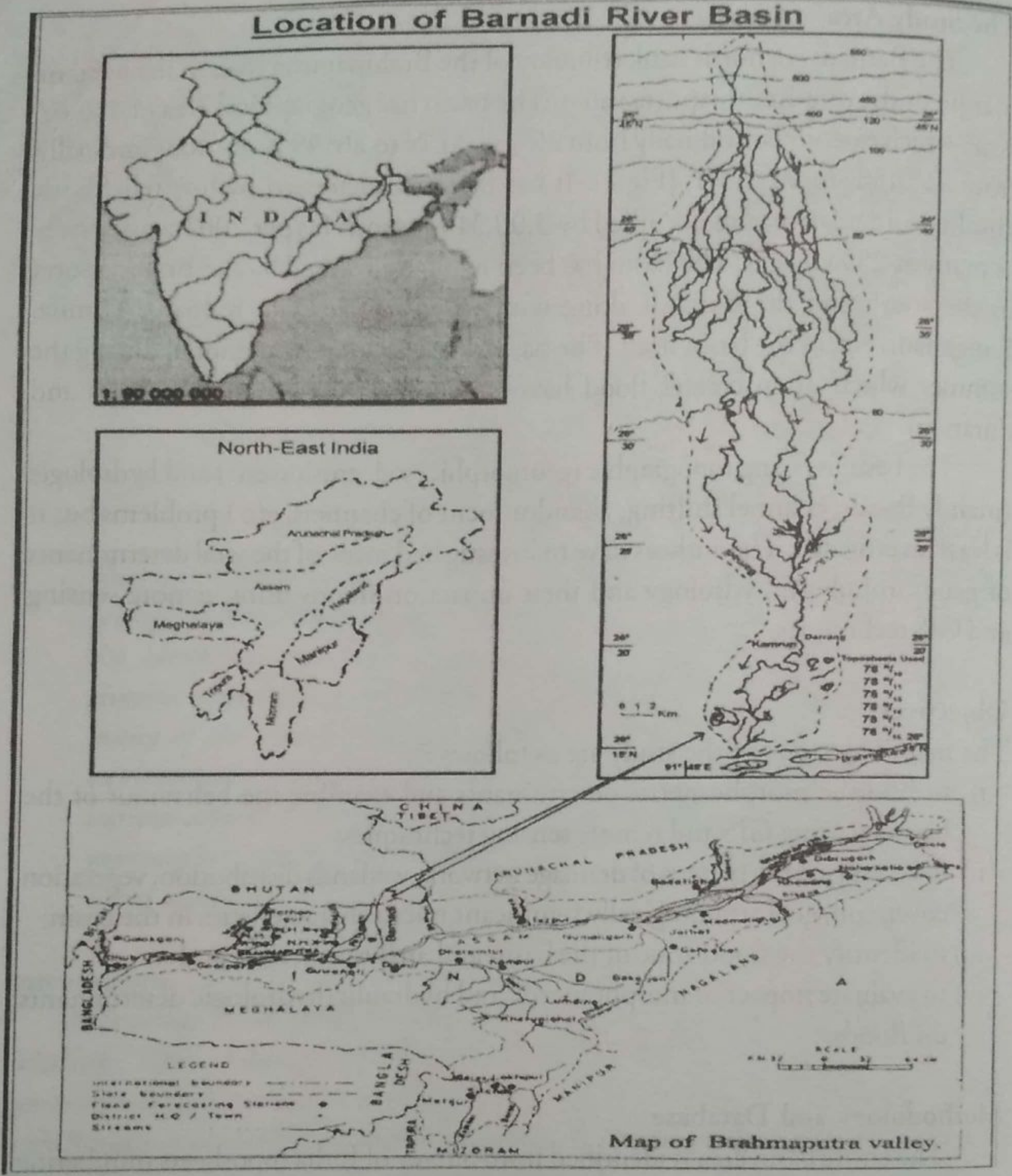


Fig. 1

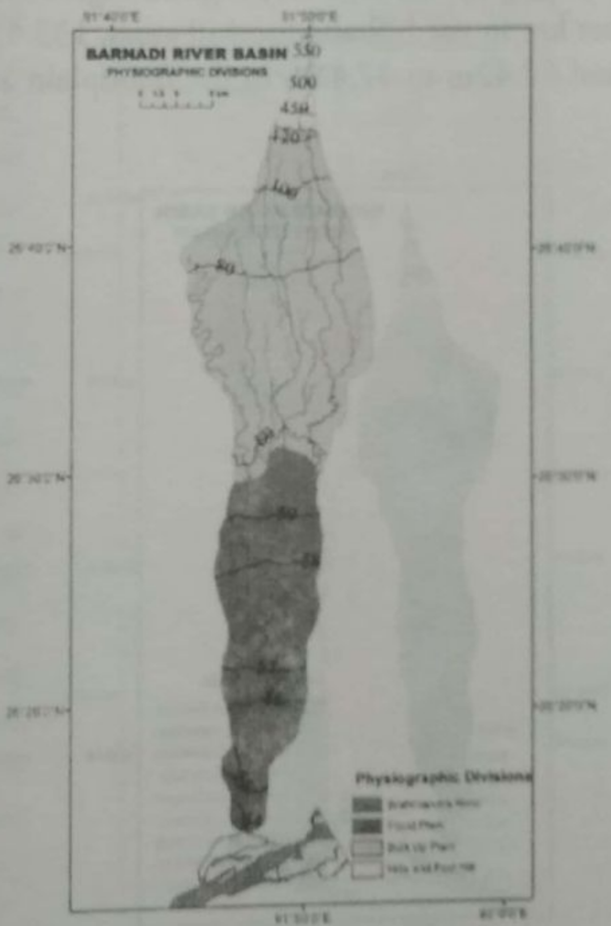
Analysis

While the material basis expressed by geological structure, rock composition vegetation cover and hydrological energy play significant role in morphometric determinants influening floods.

Morphometric Determinants and Functions

The morphometric developments and assemblages of basin landforms (F) in the Barnadi basin have been caused by the dynamic process (P) on the characteristic material composition (M) of the basin since its inception and coming under geomorphic actions till date (dT). As such the whole geomorphic phenomenon can be contained in the Gregorian geomorphic process model of F=f(M.P)dT (Gregory, 1983). While going to examine the morphometric determinants it is observed that in the hill and foothill portion in north of the basin for a very restricted area there lie the geological structure and rock composition akin to Himalayan origin. In the plains below the hills alluvial deposits carried from the Himalayan region by fluvial agents have formed material base. In the upper part of the plain there is the dominance of old alluvium in the Bhabar and Tarai zone while in the built up and floodplain areas recent alluvium composed of fine sand, silt, and clay dominate. The micro physiographic disposition having impact on continuation of morphometrically significant landform development indicates that three zones, viz. foothills, built-up plains and floodplains act differently in deciphering landform entities of fluvio-geomorphic nature thereon(Fig.2).

The entire basin as revealed by the GIS based map and ground truths has been characterised by differential geomorphic slopes between 41.04 and 47.94 degrees in the hill slopes, 3.68 to 8.08 degrees in the foothills, 0.37 to 0.56 and 0.19 to 0.56 respectively in upper built up and lower built-up areas. The floodplains which is still in the process of alluviation in the neighbourhood of the river Brahmaputra has slopes ranging between 0.19 and 0.56 degrees as indicated by table.1and fig.3. The relief of the basin is such that it ranges within more than 550m in the hill top to about 50m in the floodplain areas.



(Fig.2).

Table 1 : Morphometic Characteristics of Barnadi Basin

Physiographic Unit	Contour Limit (m)	Slope (Degree)	Area (km2)	Percentage of basin's total area	Slope Gradient (m/km)
Hills and Foothill	>550 to <400 400 to 120	41.04 - 47.94	18.20	3.66	133.43 - 604.50
Builtup plain upper built up	120 to about 80	0.56 - 0.37	279.56	56.29	133.43 – 62.42
Lower built up	80 - 60	0.19 – 0.56			
Floodplain	60 - 52	Do	198.86	40.05	47.41 – 62.42

The Fig. 3 indicates that there is quite anomalous absolute as well as relative relief disposition within the micro geomorphic units. Thus the absolute relief in the hill ranges from more than 530m to 400m, foothills area has 400m to 120m, upper built up areas marked by 120 to 80m, lower built up plain by 80 to 60m and floodplain areas by 60 to about 50m. Such a dispositional pattern of topography contains very high to high slope gradient of 604.51m to 133.43m per km in the hill and foothill areas, 133.43m to 62.42m in the built up areas and 62.42m to 47.41m in the floodplain areas (Table.1, Fig.4). It is thus best

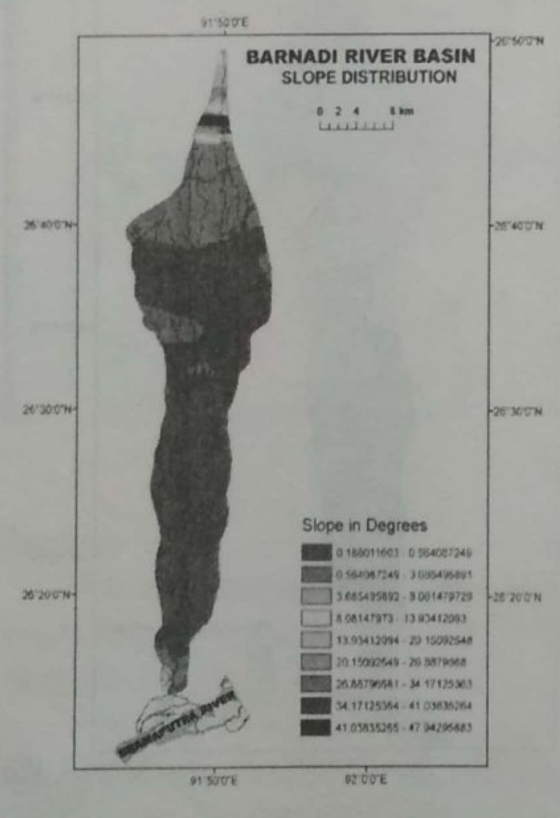


Fig.3

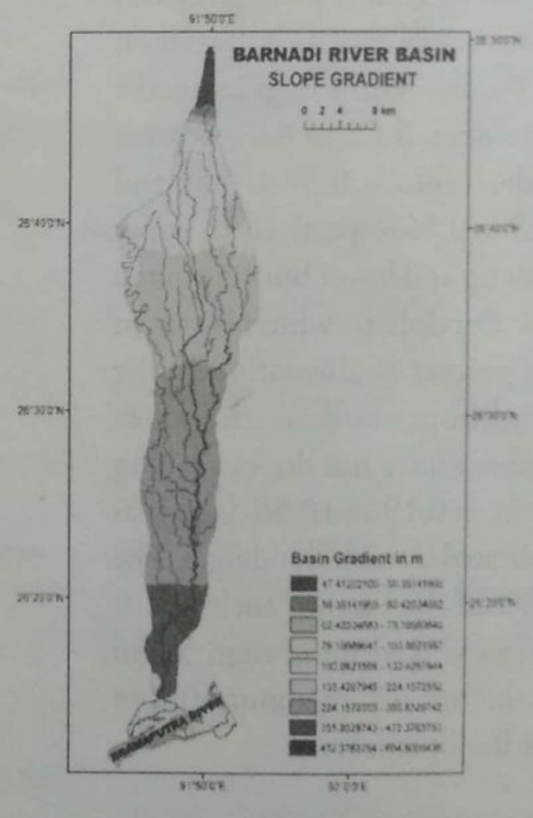


Fig.4

observed that the anomalous rather the stressed geomorphic situations in respects of rocks and topographic bases have developed dominantly fluvio-geomorphic processes of more hydraulic influences to smoothen the geomorphic surface and development of differential morphometric behaviour.

Hydrologic Determinants and Functions

The drainage basin contains a coarse network pattern in all the geomorphic units except the hills (Fig. 5) as there are only 29 first order streams, 8 second order streams and 2 third order streams drained to the master stream Barnadi (4^{th} order stream) totalling altogether to 40 streams identified by using Strahler's technique of stream ordering (Strahler, 1952). The bifurcation ratios are 3.62, 4.00 and 2.00 having the average of 3.2 for the whole basin. At the same time the length ratios among the drainages of different orders range between 8.83 and 3.69(Table 2). The density and frequency in the drainage basin are 0.78km/km2 and 0.08 km/km2 having slight differences among the various physiographic units. Such a hydrologic pattern of stream networks and related values indicate that the basin is quite reliefless having far more hydraulic control than the topographic one. Accordingly various morphometric details and fluvio-geomorphic landforms are developed. The bifurcation ratios reveal a very significant point of hydraulic and fluvio-geomorphic development in the sense that the streams abruptly fall from hill top to the plains through the alluvial fan and cone. Such a phenomenon is providing congenial condition for rushing out of huge amount of water and causing accumulation of flood water in the flat plain areas especially more so in the active floodplain areas of the basin.

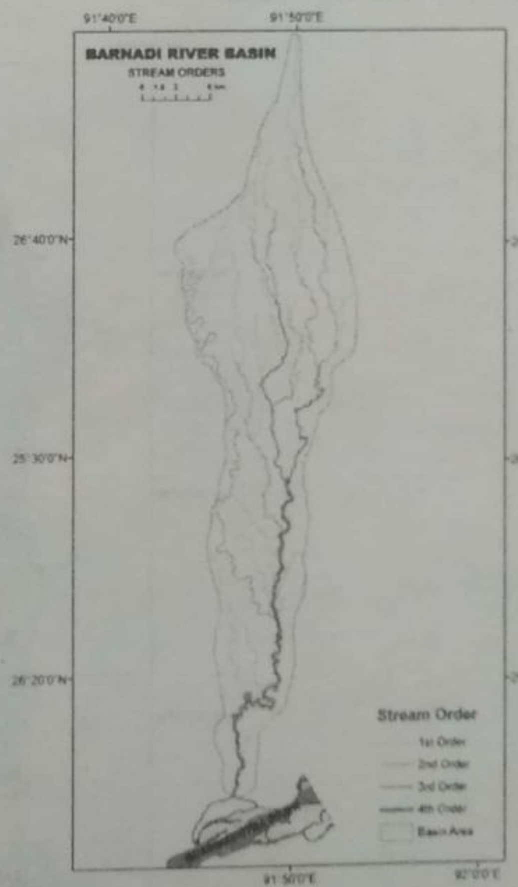


Fig.5

Table 2: Stream Network Pattern

Order of Stream	Number of Stream	Bifurcation Ratio	Length	Length Ratio	Density
1st order	29	3.62	175.99	-	Foothill slope >12
2nd Order	8	4.00	133.30	1.32	Built up around 1.5
3rd Order	2	2.00	36.05	3.69	Flood plain >1
4th Order	1		43.14	0.83	

Source: Based on maps drawn

Land Cover and Land use Determinants and Functions

Table 3 and Fig. 6 reveal that the vegetation cover exists in a very small area (only 2.59% of the basin area) scattered all over the basin. Such a dispositional characteristics of the forest cover has only a very limited impact on the infiltration of water in the basin resulting in more surface flow of water and sediment in the basin. As the other parts of the forest cover are being degraded (41.34% of the basin's area), they have tendencies to encourage more erosion due to flood waters. The wetlands have only 11.11 percent of the basin's total area which has piculiar hydraulic and topographic influences on landform development and fluvial processes including floods.

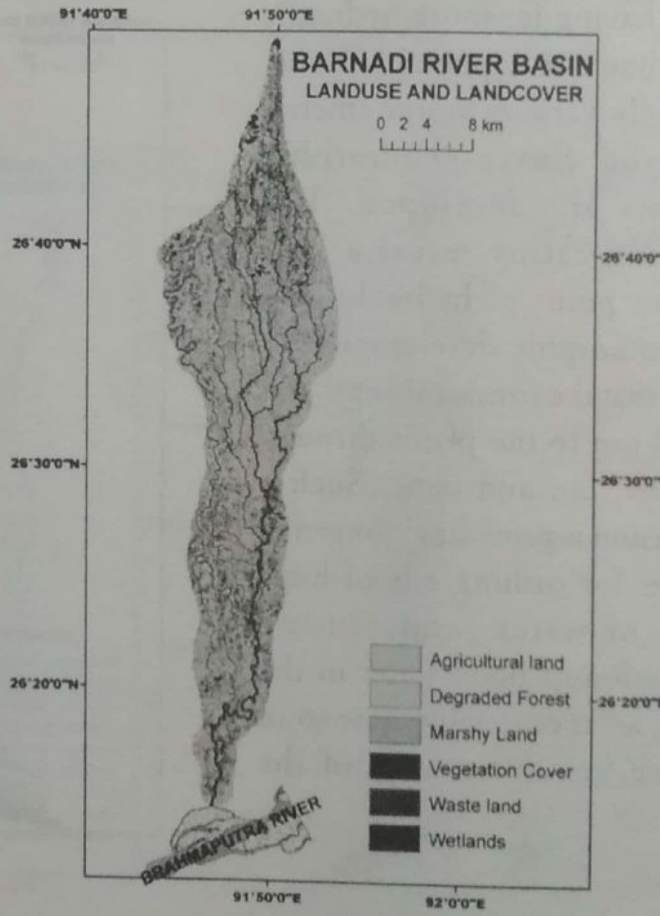


Fig.6

Scanned with CamScanner

Table 3: Landuse and Land Cover Distribution

Landuse and land Cover	Area Km2	Percentage	Physiographic Unit
Vegetation	12.89	2.59	Scattered over Upper built up and foothill areas
Degraded Forest	205.31	41.34	Scattered various in all the basin
wetlands	1.05	0.22	Scattered mainly over the flood areas in the neighbourhood of the river channel
Marshy land	54.08	10.89	
Agricultural land	128.12	25.79	Scattered mainly in the built up and partly in the floodplain areas
Wasteland	95.17	19.17	Mainly in the upper built up and floodplain areas

Source: Based on maps drawn and field observation

Flood Scene and Zonation

Floods in response to climatic, topographic and hydraulic controls occur differently in different physiographic units. The differential flood zones identified on the GIS based maps taking the consideration of ground truths (i.e. based on field observation) clearly show that the hill slopes and foothill zone are considered almost flood free one even as there are very transitory floods in this part during the days of storm rainfall (Table.4, Fig.7). The upper built up areas are having very low floods due to slope and gradient of lands leading to free pass of accumulated waters within a very short duration of time. The lower built up zone having river meandering, ox-bow lakes, marshes etc. has been marked by occasional floods of low to medium intensity. On the other hand, because of morphometric and hydraulic situation, the vicinity of the river Brahmaputra (forming the active floodplain) has been marked by back water effect and flood havocs of medium to very high intensity and duration, sometimes the floods of 1 to 2m occur for about 10 to 15 days at sretch.

Table 4 : Flood Zonation

Flood Zone	Physiographic Unit	Area Km2	Percentage
Flood free	Dominantly hill slope and foothill slope	38.67	7.80
Low flood	Dominantly upper part of the built up zone	111.47	22.44
Occasional flood	Dominantly lower part of the built up zone	215.04	43.30
High or frequently occurred flood	Floodplain zone	131.44	26.46

Since the early times floods have been of major aspects of man's interactions (Ward, 1978). The occurrences of floods in floodprone river basins have been a rule rather than an exception. Because of the steepness (especially in the hill tops and foothill areas) of the river bed from north to south the river Barnadi has been creating flash floods during the season of high rainfall over the catchment. From the slope and physiograhic analysis it is found that the river slopes down very steeply from more than 500m of altitude to the 120m altitude followed by a very gently sloping ground in the built up and low lying areas towards the Brahmaputra river (Table 1). The channelized waters as well as the surface runoff being accumulated in the low lying parts of the basin cause flood havocs of low to high magnitude, intensity and duration. The heavy siltation caused after the great earthquake of 1897(Gait, 1905) and especially after another disastrous earthquake of 1950(Barman, 1986) has resulted in the continuous siltation processes and lateral erosion along the river banks enhancing the flood menace and damage of land and crops in the basin.

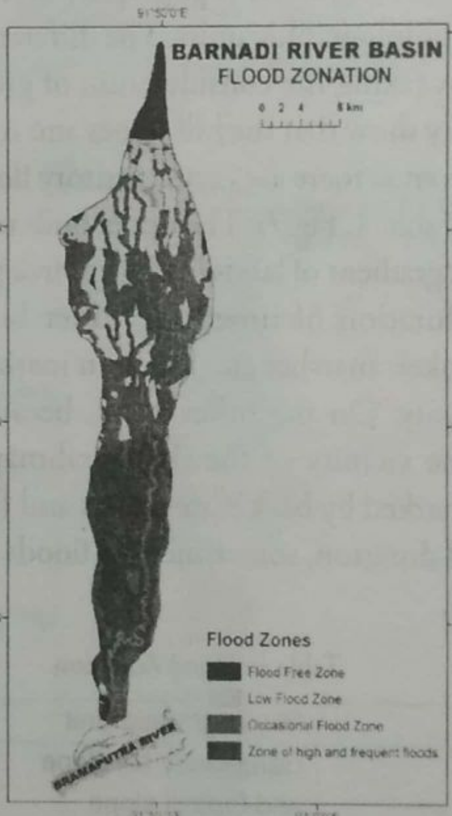


Fig. 7

Two hydrographs drawn each for stage(Fig.8) and discharge (Fig.9) of waters of the river Barnadi following the argument of Chow (1964) clearly indicate that the average level of water during a period of 16 years from 1988 to 2003 stands at 52m above the mean sea level against the average discharge 85.72 cumecs during the same time period. It is further observed that there occurred the highest flood in

2002 (July)at the level of 196.20 cumecs of discharge of water against the maximum water level of 52.90m in the same year measured at the 52 National Highway Crossing gauge site. Such a height of flood level of 2002 has a flood lift of 1.90m over the danger level, which is considered as a very high flood damaging human habitat, agricultural land etc. It is again observed that out of the 16 years of flood peaks during 1988 to 2003, as many as 15 years have been marked by floods water lift over the danger level of 51 m.

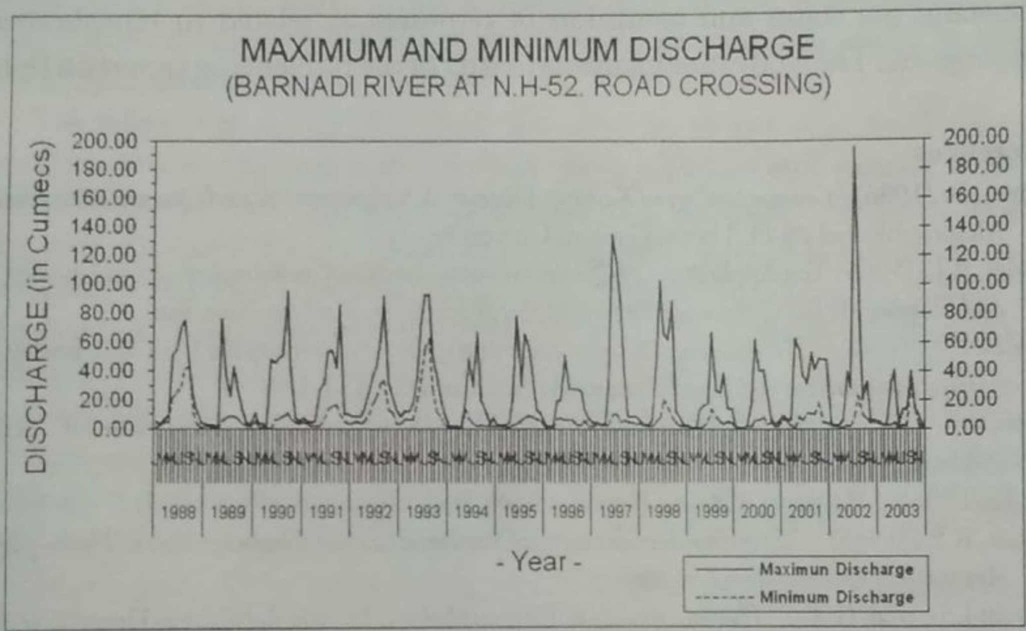


Fig.8

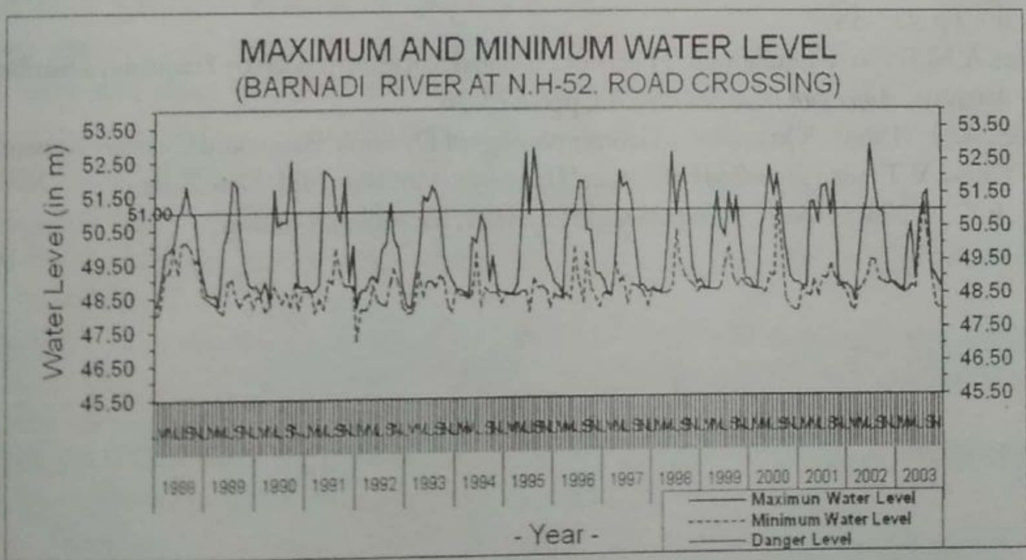


Fig.9

Conclusion

It is observed that as the drainage basin has been identified as one of the most resourceful areas for new order of production and sustainable development of land, water and man, the basin needs serious investigation in physiographic economic ecologic environmental and even the social aspects of that exist in the face of the drainage basin. The Barnadi basin even though a small one has been the source of potential resources yet to be tapped. The above work is actually a very preliminary step to understand a number of basin parameters and details that can help to further understand the status and condition of resources as related to morphometry, hydrology, etc. The study thus focuses on many of the influencing factors on floods.

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