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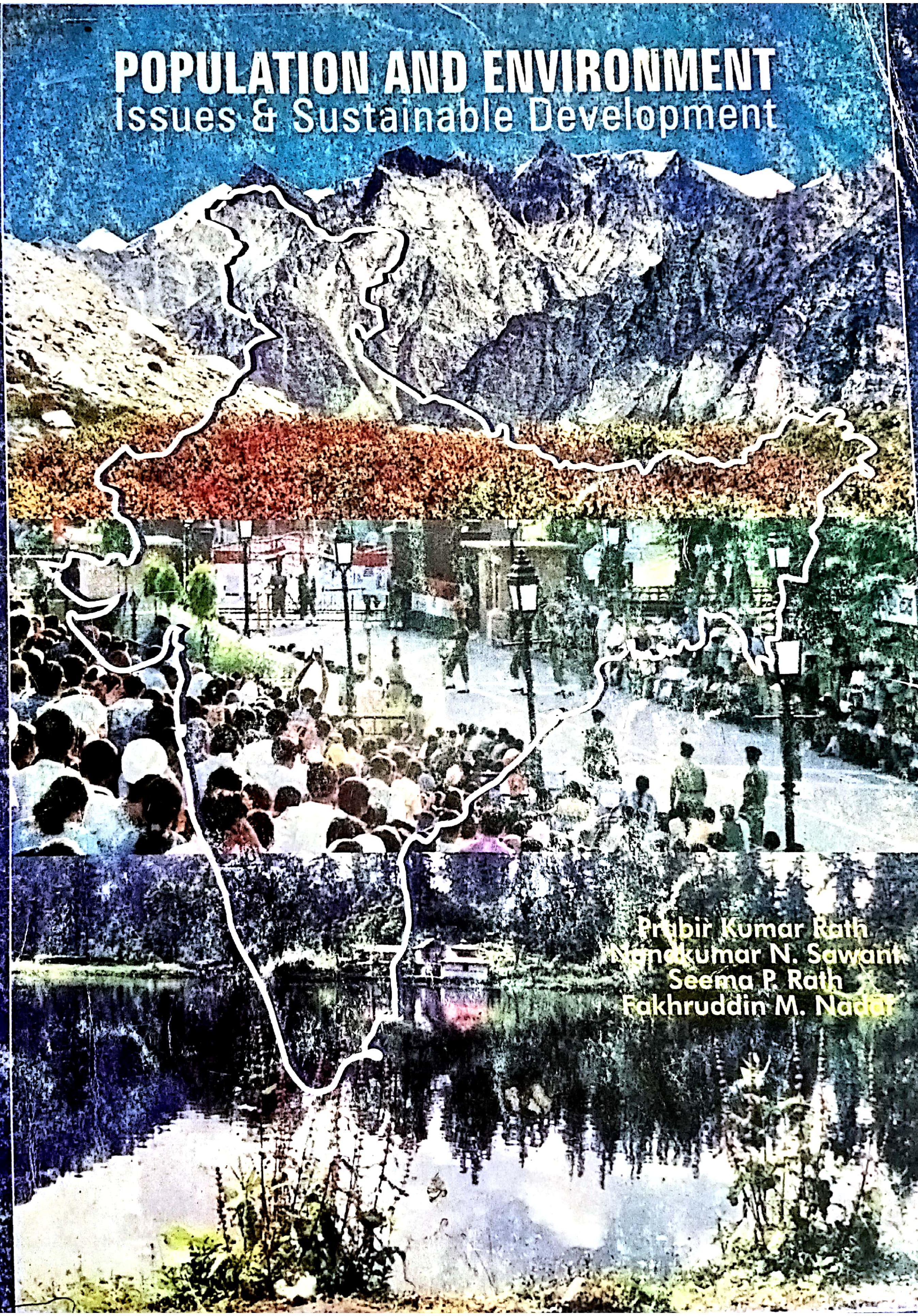

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RIVER AND FLOOD DYNAMICS IN THE MANGALDOI, ASSAM A STUDY OF DYNAMIC GEOMORPHOLOGY

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Abstract

Floods in some reverine areas, mostly in moist climatic areas, have been fast growing to have their impacts on a number of geomorphological forms and patterns. The Mangaldoi Sub-division, a part of reverine built-up plain composed of fine alluvial sediments, which has been washed by streams like Bega-nadi, Nanoi, Bar-nadi, Mangaldoi-nadi and Noa-nadi etc. has, of late, witnessed increasing floods causing sheet and river bank erosion and channel shifting. The alarming situation with rivers and floods as geomorphological agent in the sub-division has caused serious geomorphic, hydrologic and environmental conditions and implications to be investigated intricately.

Introduction

Flood in almost all the countries, developed, developing or under-developed have, of late, been one of the most attractive and heart-rending features of news items because of their hazardous nature. This hazard has variously affected the natural landscape and the habitat, society, culture and economy of man in the flood-affected areas. Floods are dynamic entities causing differential erosion and hazards over space and time.

The study area

The Mangaldoi Sub-Division covering an area of 2024.76 Sq.Km. in the middle part of the Northern Bank of the Brahmaputra with a population of 849111 (as per 2001 census) distributed over as many as 815 revenue villages lies between the latitude 26° 0¢N to 27° 0¢N and longitude 91° 45¢E to 92° 0¢E (fig. 1). The area has been suffering from floods of high intensity and duration specially being more so after the 1950's great earthquake. During the months of May to September every year, floods of high to medium intensity and appreciably long duration inundate the river bank and basins causing hazards and problems. The floods and flood problems in the area have accelerated many times during the last two decades because of growing human interference with land, resource, water etc. The problems in the areas have become so prominent that there has been an utmost need of controlling and mitigating the same to protect land, people, society, environment and economy of the area. An investigation on such a volatile situation on the fluvio-geomorphic regime will definitely throw out light on the reality of the genesis, proliferation and impact of the problems in the area. With this rationale in mind the present problem under the title is undertaken.

Objectives

In order to follow the investigation some objectives are outlined as stated below:

- to examine the meteorological causes of floods in the area,
- to examine geomorphic bases and characteristics influencing the origin and development of floods,
- to identify the areas of floods in terms of their magnitudes, dynamics and duration,
- to examine the effect of floods on the river bank erosion, soil erosion, channel shifting, sedimentation an development of wetland, etc,
- to assess the damages caused by floods and their geomorphic, geo-ecologic, environmental, hydrologic an economic significance,
- to suggest measures for management of problems of floods & floodplains for economic sustainability.

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Assumptions

In order to substantiate the above-mentioned objectives some assumptions are also formulated as given below:

i) the high rainfall for days together at a stretch on the abruptly high hills and mountains of the Bhutan-Himalaya above the deadly flat plain of the Mangaldoi Sub-division causes floods of high magnitude and duration,
ii) the deadly flat alluvial-plain washed by a large number of shallow tributaries and sub-tributaries without any perceptible interfluves as bars between the streams creates easy on-rush of flood waters to result in sheet flood dynamics all over the plain,
iii) the loose alluvial soil over the recent deposits have been easily susceptible to soil and river bank erosion and channel shifting at the rapid rates,
iv) the shallowness of the streams and continuous sediments deposits on the bed of the river have rendered to reduce the carrying capacity of the streams causing lateral erosion on banks, and soil erosion on the flat-plain due to easy surface run-off,
v) the frequent shifting of the streams has caused to abandon some segments of the channel to result in numerous wetlands in the floodplains near the streams,
vi) the damage of lands, water, economy, environment has increased substantially during the last two decades because of increasing high magnitude floods.

Database and methodology

The logistic support for the work is derived partly from the field-through observation, data collection and interview with some elderly people of randomly selected flood-prone villages and points. On the other hand, the secondary information on different variables, such as water discharge and stage of flood peaks, damages caused and sedimentation etc. are collected from government and non-governmental offices and organizations. Topographical maps of 1:50,000 scales are also used to identify the riverbank erosion, channel shifting and some other geomorphic development. The data so collected are processed by using simple statistical, hydrological and geomorphic techniques and the processed data are represented by graph, diagrams and maps, etc. Finally the analysis on the maps, diagrams, graphs and tables are performed.

Analysis

In the light of appropriate definition, Mangaldoi Sub-division is said to have frequent inundation by flood waters exercising impact on natural and cultural arena of the riverine region.

Bases of floods

Floods of the area represent a number of basic facts for their creation and enhancement. Of these, most pronounced is the geological base coupled with topographic and climatological situations.

Geological base: It is an alluvial plain formed of recent to sub-recent alluvium that rested on the Fore-deep (Krishnan, 1982) or the rift valley (Burrard, 1912) caused by tectonic forces on the pre-Cambrian rock base of the southern slope of the Bhutan-Himalaya. Since about 250 million years ago when Bhutan-Himalaya was formed, the geologically and tectonically significant forces have been acting to constitute the flat plain of the Brahmaputra Valley including the present study area.

Geomorphic base: The foothills zone composed of alluvial fan and cones, the built-up plain on the middle part constituted by recent fine-grained river-borne alluvium and the low-lying flood plains in the south signify the inherent fluvio-geomorphic basis for the ongoing geomorphic and hydrologic development. The endogenetic forces in the form of earthquake and isostatic balance of the very slowly rising Himalaya have also added something to the base and process of the geo-hydrology and floods in the area. The area has been signified by perceptible absolute relief differences with the counts of 450m, 100m and 50m respectively in the hilly, built-up and chronically flood affected areas. The relative relief is more than 50m in the hills, around 20m in the foothills,

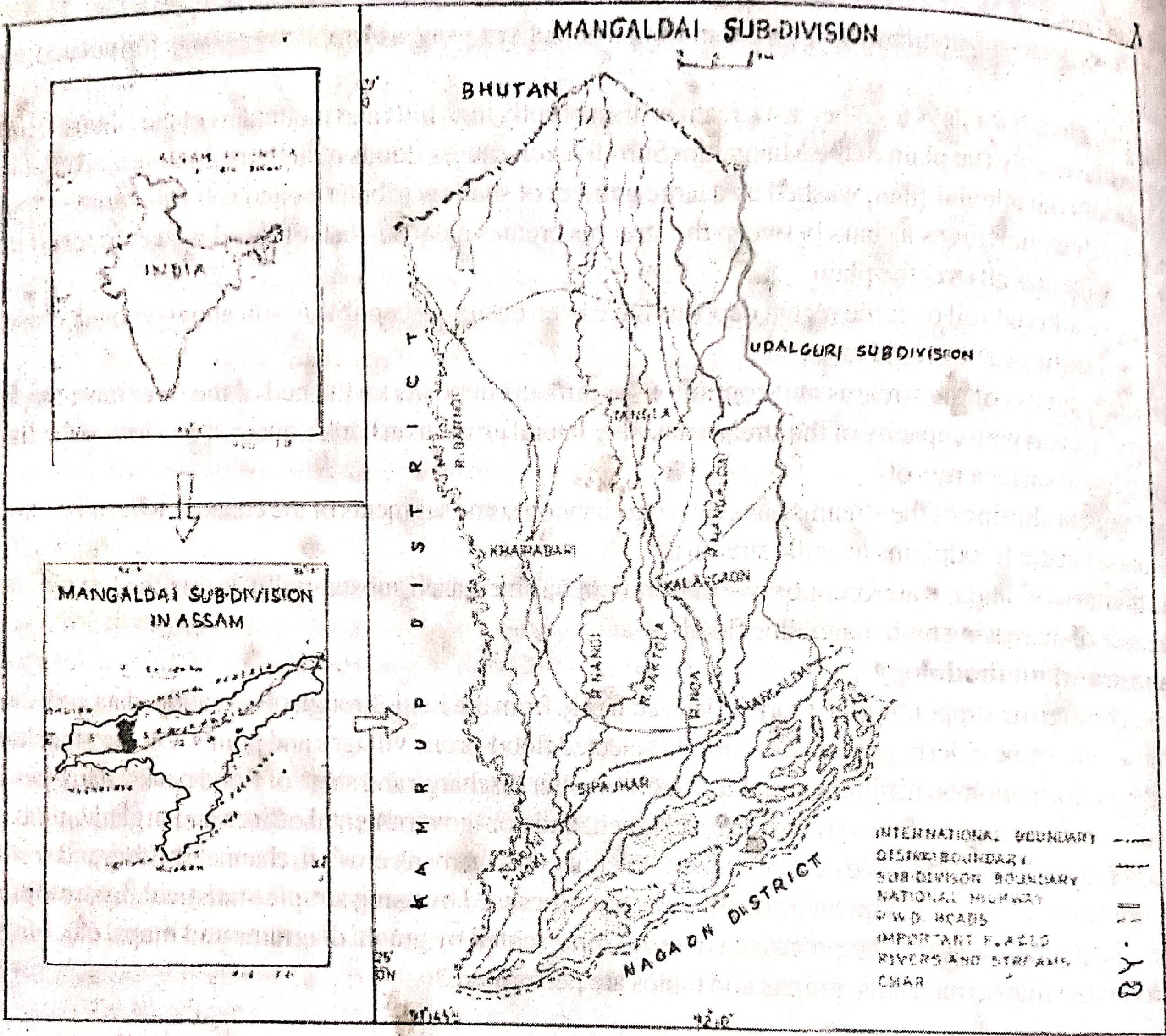


Fig-1

less than 10m in the built-up plain and less than 5m in the chronically flood affected areas. The overall slopes, o the other hand, are more than 3°, 1° to 3°, within 1° respectively on the foothills, built-up plain and chronicall flood affected plains. The peculiar natural arrangement of the streams are that they are mostly reticulated havin their density differences of 7 to 10 Km/Km^2 in the hilly and foothill areas, 1 to 2 in the built-up areas and less tha 1Km/Km^2 in the chronically flood affected areas. Similarly the frequency of drainages ranges from more than 1 to about 1 in the areas under study.

The Mangaldoi Sub-division lies under the active zone of earthquake occurrences. The area had expe rienced two most great earthquake viz. of 1897 (8.7) and 1950 (8.5) in addition to the historical occurrences c earthquakes (Gogoi and Barman, 1991). Most of the rives, specially the ones which are too volatile to floods an associated fluvio-geomorphic processes and were brought under control by embankments from 1952 onwarc have developed new bases for the present day artificial floods and geomorphic problems.

Edaphic base: The soils in the foothills zone are non-cohesive and mixed with boulders, pebbles, cobbles, gri sand and clay giving a suitable condition for easy and rapid percolation of surface rain and water underground t form underground flow. The soils of the built-up area are mostly loamy with varying proportions of silt, sand an clay. These soils in built-up area are comparatively cohesive permitting less percolation of water. This phenomenon in most of the river basins has resulted in wetlands of different dimensions. The soils of the chronically flood affected areas are having more sand proportions than the clay. But they remain saturated during rainy seasons.

Vegetation base: There is less vegetation cover in all the basin areas of the sub-division except in the Bhabar zone in the foothills portion of the sub-division. This has been effective on free passage of flood waters and associated erosion and sedimentation along and across the channels of the rivers.

Climatological and hydrological base: Climate is the basic factor of genesis and development of floods. The Mangaldoi Sub-division lies under the rhythm of weather marked by vagaries of annual rainfall ranging between 1400mm in the South and 2500mm in the foothill zone. During high storm period in summer the climatogenetic supply of water remains far more than carrying capacity of the streams. On the other hand, during the period of no rainfall in the winter as well as in summer the level of water or discharge go to a very low. During the heavy downpour the discharge as well as the water levels become high enough. On the other hand, the major rivers, viz. Mangaldoi, Noanoi, Saktola noi, Nanoi and Barnoi (Fig-1), owe their origins to the Bhutan-Himalaya and carry huge volume of water during the summer months and create flash flood in the lower region.

Flood scene and dynamics

General scene: It is observed that about 45per cent of the total area of the sub-division comprising the low-lying tract of the Brahmaputra and tributaries experience regularly high to very high floods. On the other hand, about 35per cent covering the built-up plains get occasional floods of low to moderate magnitude. The piedmont zone (about 20per cent of the sub-division's total area) in the north do experience very transitory floods.

Floods of the disastrous to non-disastrous nature are known in this area since 1642 till 2004. Of these, those occurred in 1950, 1954, 1957, 1962, 1979, 1980, 1983, 1986, 1988, 1990, 1992, 1996, 1998, 2002 and 2004 are quite significant even as those of 1988, 1996 1998, 2002 and 2004 were of much disastrous nature.

Flood dynamics: Flood dynamics in the Mangaldoi subdivision reflects some changes in landform dynamics, river and hydrological regimes, cropland, ecosystem and the overall environment. It is seen that due to recurrent floods of high intensity many of areas under stream dynamics had in the recent past accelerated their fluvio-geomorphic processes to accentuate river metamorphosis (Schumm, 1977, a,b). Thus the river plan form has changed to a certain extent.

Flood duration: Floods in the sub-division have been observed to exist for days together, sometimes for more than 10 days at a stretch. The waters of the Brahmaputra heading back through the moths of its tributaries like Saktola, Nanoi and Mangaldoi noi in the southern part of the sub-division remain almost stagnant constantly as back water floods for 7 to 13 days. On the other hand, floods on the low-lying pockets of the tributary streams remain for 3 to 5 days. The occasionally occurred floods in the built-up plains run normally for 2 to 4 days. The floods which are too transitory to exist in the piedmont zone act only for 1 to 2 days. It is again observed that in the chronically flood-affected low-lying areas floods do occur 3 to 5 times a year during June to September. The small drainage basins in the sub-division are characterized by fluvial flash floods as well as long-rain floods amongst the four types of floods as identified by Colman (1953).

Flood intensity: The rivers of the Mangaldoi sub-division lack in even the adequate information and data o either discharge quanta or flood peaks and the run-off quanta as well. However, few hydrographs drawn fo Saktola, Nanoi, Barnoi, etc with available data show that there generally exist 3 to 4 peaks of flood water level within June to September during the years of high to very high intensity floods. It is observed that the variations c such peaks are very small. It is again observed that the lift of peak floods or flood stages above the danger leve of the above-mentioned rivers ranges between 1.5m (in case of the Barnoi) and 3m (in case of the Saktola). Tl

Table 1: Nature of Peak Flood Levels of the Rivers of Mangaldoi

River, Gauge site and year of event (N.T. Road crossing)	Average of peak floods and discharge of flood water	Standard deviation	Co-efficient of variation	Parameter
Mangaldoi 1989, 1992, 1995 & 2000.	53.37m -	1.48m -	2.77m -	Water level -
Noanoi 1980, 1991, 1999 & 2000.	54.86m 86.97 cumecs	1.82m 22.25cumecs	3.31m 25.62cumecs	Water level Discharge
Saktolanoi 1990, 1994, 1997 & 2000.	52.22m 82.26cumces	1.39m 68.54cumces	2.66m 83.32cumces	Water level Discharge
Nanoi Nanoi, 1983,1987,1991,1995, 1999	53.46m 121.60cumces	0.46m 63.30cumces	0.86m 52.06cumces	Water level Discharge
Barnoi 1976, 980, 1985, 1991, 1995, 2000	50.01m -	1.42m -	2.83m -	Water level -

Source: Calculated from the data of Water Resource Department, Govt. of Assam.

Fig-2

Table 2: Relative Frequencies of Flood Water Levels of Nanoi River

Year of event	Water level (meter)	Water level in descending order	Rank (m)	Relative frequency $P^{\wedge} = {}^{m}/_{n+1}$	% of relative frequency	Cumulative frequency of relative freq.
1979	53.62	54.01	1	0.125	3.75	3.75
1983	54.01	53.98	2	0.250	7.14	10.71
1987	53.20	53.62	3	0.375	10.71	21.42
1991	53.29	53.41	4	0.500	14.28	35.75
1995	53.98	53.29	5	0.625	17.85	53.55
1999	52.83	53.20	6	0.750	21.42	74.97
2000	53.41	52.83	7	0.875	25.00	99.97

Source: Calculated from the data of Water Resource Department, Govt. of Assam.

maximum flood discharge during 1976 to 2000 got varied amongst 66.41 cumecs, 221 cumecs and 239.10 cumecs as marked respectively for the rivers like Mangaldoi noi, Saktola and Nanoi, Table 1 shows peak flood flow variability of some rivers of the Mangaldoi sub-division.

The Noanoi, Saktola and Nanoi having much supply of rains and run-off do create high discharge of water having maked pattern of variability in water discharge and flood lift or stage. All these rivers during the winter with of lean flows have only the base flow with less than one-meter depth of water.

Log Pearson Type III distribution and Log Normal Distribution are used to estimate the dimension of floods in the Nanoi river at the N.T. Road crossing gauge site, The relative frequencies of water levels are estimated by using Weibulls Plotting Position formula stated by $P^{\wedge}(X=x) = {}^{m}/_{n+1}$ where $P^{\wedge}(X=x)$ is the probability of exceedence of a given flood peak, 'm' is the rank of the flood peaks arranged in descending order, and 'n' is the number of flood events (Fig. 2). Table 2 shows such relative frequencies of the floods of the Nanoi river at the N.T. Road crossing gauge site.

Impact of floods: Like other areas of the Brahmaputra Valley...

Table 3: Flood levels recorded for the river Nanoi at N.T. Road crossing gauge site

Recurrent Interval (Years)	Water Level in Meter		Probabilities in Percentage
	Ø in Log Pearson Type III	Ø in Log Normal Distribution	
2	52.83	53.4749	50
5	53.20	53.4761	20
10	53.29	53.4767	10
25	53.41	53.4773	4
50	53.62	53.4777	2
100	53.98	53.4781	1
200	54.01	53.4789	0.5

Co-efficient of skewness – 0.28 by Log Pearson Method.

Source : Calculated from Table 2.

riencing various impacts of floods with spatio-temporal differences. Such impacts are quite evident with fluvio-geomorphic development, hydrologic and ecologic systems, human habitats, economic pursuits and the overall environmental characteristics of the region as explained in the following paragraphs.

River bank & valley erosion and channel migration: The flood dynamics along with the normal dynamics of the flood generating rivers has developed a characteristic fluvio-geomorphic environment of pattern, process and influence in the arenas of sheet erosion, siltation and sedimentation, river bank erosion and shifting of channels, development of wetlands, etc. The base material over which the streams use to flow being comparatively loose alluvial soil has always been susceptible to perceptible sheet erosion. Sheet erosion is found to be more than 1cm per year on the hill-slopes and margins of built-up plains and the low-lying plains due to development of gullies at the time of high rainfall period. It is observed that during the flood times the rivers, specially the Saktola, Nanoi and Noanoi develop in places linearly migrating vertical erosion for about 2 meters depth, more than 200 meters length and 10-20 meters breadth. For such a kind of regular bank erosion, the mostly flood generating rivers have shifted their bank and channel by about 500 meters during the last 5 or 6 decades.

Impact on drainage and hydrology: Due to repeated floods along the channel and across the basins the interfluves between the basins have gradually lost their existence. Again filling up the low-lying areas by sediment brought down by the floods has caused smoothness of the faces of the basins and the rising up of the riverbeds. All these have caused the unhindered flow of waters at the time of high rainfall. Thus erosion on the edges of the influves and sedimentation on the low-lying spots and areas have influenced water table and drainage network including the surface and channel flows. It is observed that the sub-tributaries like Dimla, Ghagra and Kalapani which previously used to flow by forming a dendrite pattern with the Barnoi river system, now use to flow almost parallel to the Nanoi river. Again, it is seen that all the streams in the sub-division are reticulated (Chorley, 1969) in nature thought they are broadly dendrite. The combined impact of sheet and river bank erosion, sedimentation and hydraulic flow of water has been found to be solely responsible for such a deviation in the drainage plan form of the region. Thus metamorphosis of channels (Schumm, 1977, a,b) and Gregory, 1985) have been the most significant characteristic in the hydrological and fluvio-geomorphic regime of the region.

Development of wetlands: River Channels adjust themselves with the change of hydraulic and fluvio-geomorphic elements (Schumm, 1977, a,b). The channel shifts and consequent development of new channels definitely cause to abandon the old channels. The flood-generating persisting rivers Saktola, Barnoi, Nanoi, Noanoi, Mangaldoi noi have developed a number of such abandoned channels to give birth to wetlands. The Batha... Naoputa and Badiasisha amongst many others are some of the examples of such wetlands. It is examined on the map and field as well that the Batha river was a direct tributary to the Brahmaputra up to 1912. But due to repeated floods and surface run-off the river changed its course and developed the wetlands mentioned above.

Sediments yield and deposits: The sediments that are yielded on the agricultural land due to on-rush of flood waters across the breaches of river embankments cause to rise sand deposits by about 1m to 1.5m on both sides of the new channels. The heavily changed sediments carried down by the river from its upper part add more to the menacing sand deposits such a pattern of sand deposits (20 cm to 150 cm thick) was observed during the floods of 2000 along the river Nanoi. Table 4 shows the dimension of sediment yield of some rivers of the Mangaldoi Sub-division.

Table 4: Sediment yield of rivers in Mangaldoi Sub-division

River	Sediment yield (Tons/Km^2 /Year)
Noanoi	323
Nanoi	166
Barnoi	228

Source: Water Resource Department, Govt. of Assam.

Hazard impact of floods: Floods in the Mangaldoi Sub-division like other areas of Assam do develop natural a...

Table 5: Flood affected areas and damage

Category of damage	Quantity	Approximate value (Rs. in Lakh)
Area affected	131.47 Km^2	Not available
No. of villages damaged	343	Not available
Crop area damaged	500 hectare	Not available
No. of families fully affected	3240	129.00
No. of families partially affected	17121	256.82
No. of people affected	333051	-
No. of human life lost (Reported)	1	-
Area eroded	262.50 hectare	Not available
No. of Institution affected	196	9.80

Source: Deputy Commissioners Office, Mangaldoi, Darrang (Assam).

Table 6: Damage of Crops/Cropland and Loss of amount during flood of 2000

Crops damage	Area under Crops (in Hectare)	Approximate value (Rs. in Crores)
Jute	388	0.10
Sugarcane	81	0.06
Paddy (Sali & Ahu)	23715	15.74
Others	-	[illegible]

Source: Revenue and Relief Branch, Darrang District, Govt...

man-induced hazard of environmental and developmental significances. The sudden on-rush of thick floodwaters affect villages, agricultural lands and crops, etc. The floods of 2000, for example, took the dimension of a disaster, which had affected or damaged human environment as shown in Table 5. The hazard impact of flood 2000 on agricultural land is tremendous (table 6.). During the last two or three decades, the floods have repeatedly affected the surface roads and made disruption to transport and communication system of the whole of the Sub-division.

Human response to floods: The continued floods in the Mangaldoi Sub-division have developed a changed sentiment of the floodplain dwellers. While the Muslim peasants (of erstwhile East Pakistani origin) living in the chronically flood affected low-lying areas have developed more positive nature than before to adjust with the floods and flood plain in the way of growing more crops to raising their economic base, the aboriginal Hindu peasants have developed mostly a pessimistic attitude to floods and their resource qualities. Thus there has developed a tendency of human immigration from these areas. The help and co-operation of the government, as reported during the field study towards the mitigation of flood problems or rendering, relief, etc. is also poor. A survey on the field just after 2000 flood shown that 60.1 per cent of respondents replied that nothing of the assistance was given by the government. But in this case 22.3 per cent of the respondents replied with the "yes" of the assistance. It is also observed that most of the respondents expressed their dissatisfaction on the measures taken so far for protection them from floods.

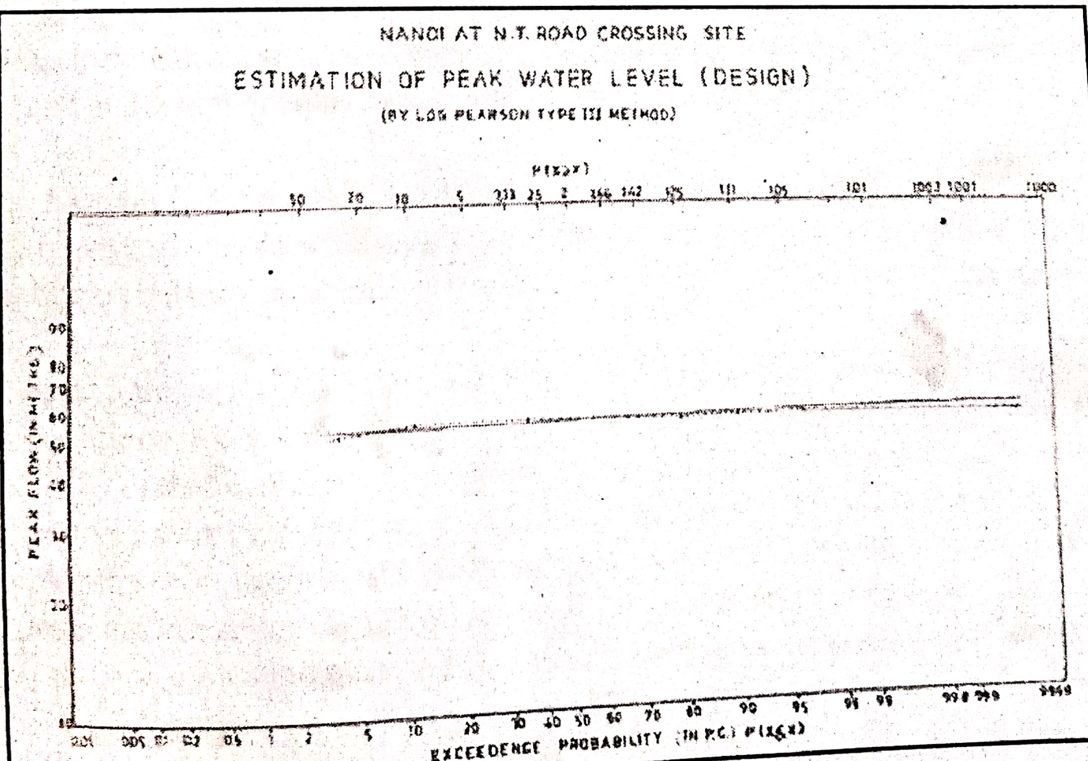
Measures for flood mitigation: In order to mitigate the flood problems and geomorphic disorder in the Mangaldoi sub-division, most of the rivers need flow regulation in the way of training the river on the reticulated channel planfrom. Further more the most flood-prone areas are to be monitored an effective structural as well non-structural measures are to be adopted.

Conclusion

Floods, riverbank and soil erosion, agricultural land and crop damage are always with the riverine ecology. Floods have both their resource and curse qualities, while controlling floods one should see both the positive and negative impact of the floods.

References

- Burrard (1912), "*Origin of the Gangetic Trough Commonly call the Himalayan Fore-deep*" Royal Soci-



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ety, London.
- Chorley, R.J. (1969), *Water, Earth and Man*, Mathuen London.
- Chow, V.T. (1956), *Hydrologic studies of floods*, the US International Association of Science Publication
- Colman, J.M (1969), *Brahmaputra River Channel:* Processed Sedimentation, Sedimentary Geology, Vol.
- Krishnan, M.S. (1982), *Geology of India & Burma.*
- Leopold, et.al. (1964), *Fluvial processes in Geomorphology*, Eurasia, New Delhi
- Petts, G.E. (1983), *Rivers (Source and Methods in Geography Series)*, Butterworth, UK London.
- Rost Vedt, et al. (1968) *Summery of floods in the US during 1963*, US Geol. Surv. Wat. Sup. Paper, 183
- Schumm, S.A. (1977a) *The Fluvial System*, A Wiley Publication.
- Schumm, S.A. (1977b), *River Metamorphosis.* In Gregory River Channel Changes, IASH/UNESCO WMO.
- Ward, R.C. (1978), *Floods- A Geographical Perspective*, McMillan, London.
- Wisler & Brater (1959), *Hydrology (2nd edition)*, John Wiley Sons.