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Preliminary Investigations on Dhansiri (South) River Basin in NE India

S.R. Kumar[1] and D.S. Rathore[2]

[1]Centre for Flood Management Studies, National Institute of Hydrology, Guwahati
[2]National Institute of Hydrology, Roorkee

Abstract : Water resources management practice deals with occurrences, distribution, movement and properties of water on the earth and their environmental relations. Hydrological processes are quite complex in nature and show wide variation in space and time. A basic understanding of hydrology and characteristics of basin such as soil type, vegetation, land use, geology etc. are fundamental to the water resources programme of any region. Knowledge of basin hydrology essentially proceeds for planning and operation of any water resources development and watershed management program in the basin. North eastern region in India has the herculean task to efficiently plan for development or management of its huge water resources constituting about one third of the total potential of the country for want of sufficient data/information of the basins and sub-basins which are mostly ungauged as yet. In the present paper, an attempt has been made to provide the basic hydrological information of Dhansiri (south) river basin of NE region for efficient water resources management.

INTRODUCTION

The Dhansiri river system is one of the major sub-river systems of the river Brahmaputra and spreads over the States of Assam, Nagaland and small part in Manipur. Dhansiri is an 8th order tributary basin of the Brahmaputra river system. The river drains on an average of 6748.71 million cub.m of water annually to the Brahmaputra River. It has a catchment area of 10,305 km^2 upto Numaligarh GDS site. The origin of the Dhansiri river lies in the Laishang Peak on the south-west corner of Nagaland at an altitude of 1771 m. It flows in a north-westerly direction for about 37 km and then takes turn to the north-east and flows through the hilly terrains for about 75 km in the Nagaland upto Dimapur. Beyond Dimapur also the course of the river remains generally in the north-easterly direction upto Golaghat town. Near Golaghat it takes an abrupt turn to the North West and meets Brahmaputra River at Dhansirimukh after flowing through another 77 km in the plains of the Goalghat district. The principal tributaries of Dhansiri are Diyung, Diphu and Gelabil on the right bank and Deopani, Nambor, Doigurung and Kaliyani on the left bank (Fig. 1). The maximum discharge of the river observed at Numaligarh is 2092 cumec and minimum is 4 cumec. Only lower reaches of the Dhansiri is appears to be navigable. The existing width varies from 90 m to 200 m and depth varies from 0.8 m to 4.2 m. Study area is covered under SOI topo sheets (1:50,000) as below:

83F - 3, 7, 8, 10, 11, 12, 14, 15, 16
83G - 6, 7, 9, 10, 11, 13, 14
83J - 1, 2, 3, 4, 5, 6, 8, 11, 12
83K - 1, 2, 3, 5, 6, 7

GEOLOGY AND SOIL

The Dhansiri catchment is characterised by a large variety of rock types ranging in age from the Pre-Cambrian to Recent. The rock types include unclassified granites and gneisses, sedimentary rocks of Jaintia, Daisang, Barail and Tipam Group of the Tertiary group of rocks and pebble, gravel beds of Pleistocene and sand and silt of the Holocene to Recent period. Soil of the basin is dominated by Red Sandy laterite & Alluvial Red Loamy.

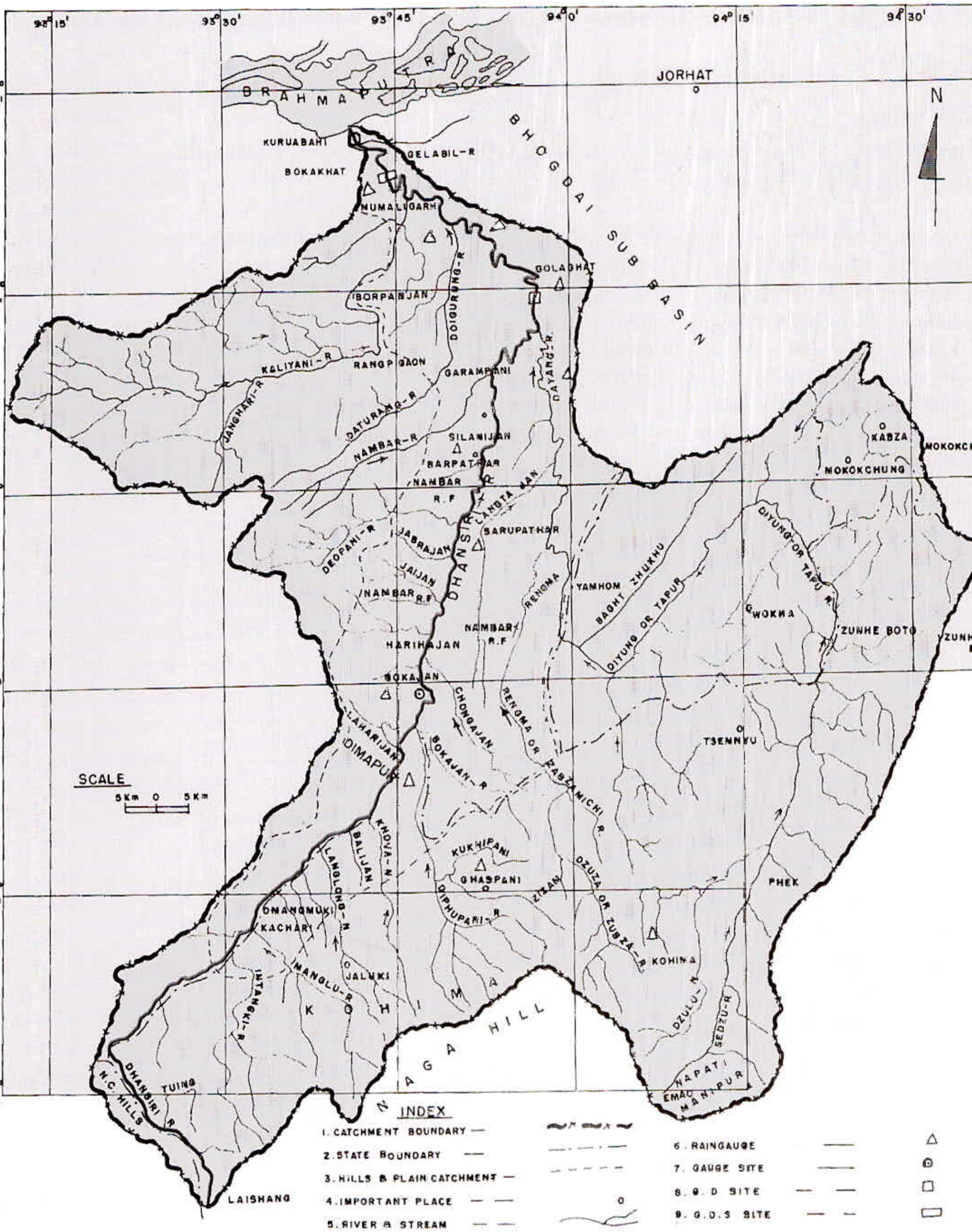


Fig. 1. Drainage Map of Dhansiri River

CLIMATIC CONDITION

The highest and lowest temperature recorded at Golaghat IMD Station was 39.6 °C, during Sep.'1969 and 1.1°C, during Feb.'1958, respectively. The mean daily maximum temperature remain in the range of 23.6 to 32.6°C, while mean daily minimum temperature remain in the range of 9.7 to 24.8 °C. Moisture content in the atmosphere changes the nature and characteristics of the pollutants. The suspended particulate matter provides surface area for fog to coalesce and grow in size to settle down and also enhances chemical reaction of the gaseous pollutants. The variation in the relative humidity recorded at Golaghat IMD station at 8.30 AM and 5.30 PM found as 75-85% and 54-77% respectively. The data for mean wind speed at Golaghat IMD station has been observed to be the maximum in the month of Oct. (17.5 kmph) and minimum in the month of Jan. (0.5 kmph). The calm period is generally highest in the month of December. The calm period is generally higher in the evening as compared to the morning hours. The rainy season in the region extends from June to September. The average annual rainfall over the basin is 1806 mm. The maximum annual rainfall received at Numaligarh raingauge station is 2431 mm. The rainfall data indicates that rainfall is well spread out throughout the year even though nearly 56 % of the total rainfall occurs during June – September (Fig. 2). ORGs are maintained by many Tea Estates. Information is available at Assam Branch of Indian Tea Association (ABITA). There are 13 Nos. of rainfall stations in the basin as listed in Table 1.

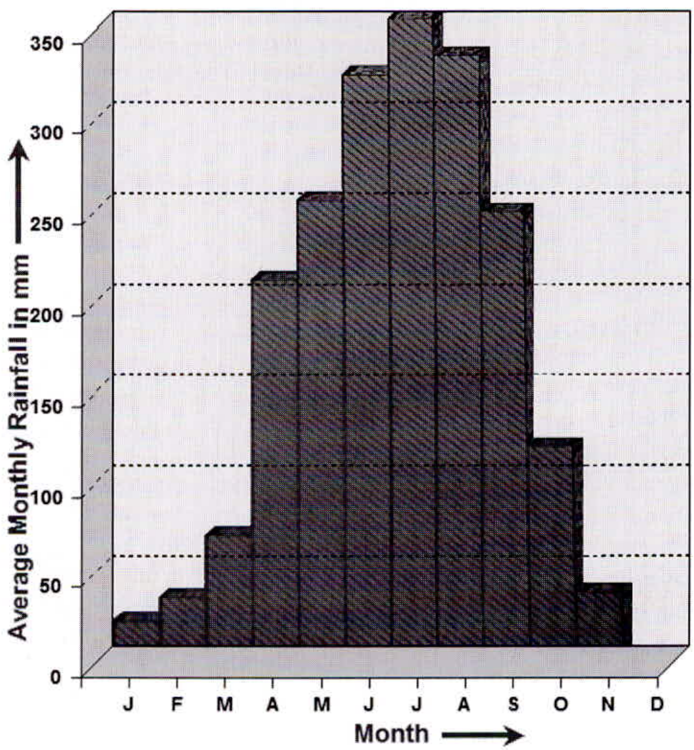


Fig. 2. Mean Monthly Rainfall in Dhansiri River Basin

Table 1. Raingauge sites in the basin

Raingauge Sites	Maintained by	Raingauge Sites	Maintained by
Numaligarh T.E.	Tea Estate	Khoomtai T.E.	Tea Estate
Bogidholla T.E.	Tea Estate	Kohima	Soil Conservation
Wokha T.E.	Tea Estate	Dimapur	Soil Conservation and NSPCB
Bokajan	Cement Corp. of India	Ghaspani	IMD
Sarupathar	BDO	Naharbari T.E.	Tea Estate
Barpathar T.E.	Tea Estate	Dolowjan T.E.	Tea Estate
Golaghat T.E.	Tea Estate		

G & D SITES

Gauge observations on the Dhansiri are being made at four sites. These are Bokajan, Golaghat, Numaligarh and Kuruabahi. The site at Numaligarh on the NH-37 bridge has the records since 1946, and the site at Golaghat RCC bridge has the records since July 1978. Both the sites have also the records of discharge observations. The Numaligarh site is just 15km upstream of the confluence of the Dhansiri (South) with the Brahmaputra and the Golaghat site is 77 km upstream of the confluence i.e. Dhansirimukh. The danger level at Numaligarh gauge site is 77.42m, 89.50 at Golaghat gauge site is 89.50m and at Bokajan gauge sites is 133.30m.

GROUND WATER REGIME

The study area has a very good aquifer source. Hydro geologically the study area can be divided into three units namely consolidated formation; semi consolidated formation and unconsolidated formations. More than 75% of the basin area is underlain by unconsolidated formations comprising of clay, silt, sand, gravel, pebble and boulders. The Bhabar belt is about 11 to 15 km wide with the tube wells yield between 27-59 m^3/hr. The Tarai zone follows immediately down slope of the Bhabar zone where the yield of the wells ranges between 80-240 m^3/hr. The flood plains follow the Tarai in Brahmaputra valley where the shallow tube wells yield between 20-50 m^3/hr and deep tube wells between 150-240 m^3/hr. In the semi consolidated formations of Cachar district, the yield of the tube well ranges between 50-100 m^3/hr.

RELATIVE RELIEF

The relative relief represents actual variation of altitude in a unit area with respect to its local base level. The relation between highest and lowest point in any particular area is very much important in relief analysis which is also related with basin length. The relative relief enumerates that vthe steeper the slope the higher is the surface above its base. In the present study the topographic maps of 1:250,000 scale covering the Dhansiri river basin are taken as the base map for relief characteristics. From the map eleven zones of relief provinces of 100m differences are recognized (Fig. 3). Relative relief map is an important need in the study of basinal area.

MORPHOMETRIC PARAMETERS

Morphometric analysis of river basins is also carried out to understand the relationships among different aspects of drainage parameters and resources distribution. The study of basin morphometry relates basin and stream network geometries to the transmission of water and sediment through the basin. The size of a drainage basin acts upon the amount of water yield; the length, shape and relief, affect the rate at which

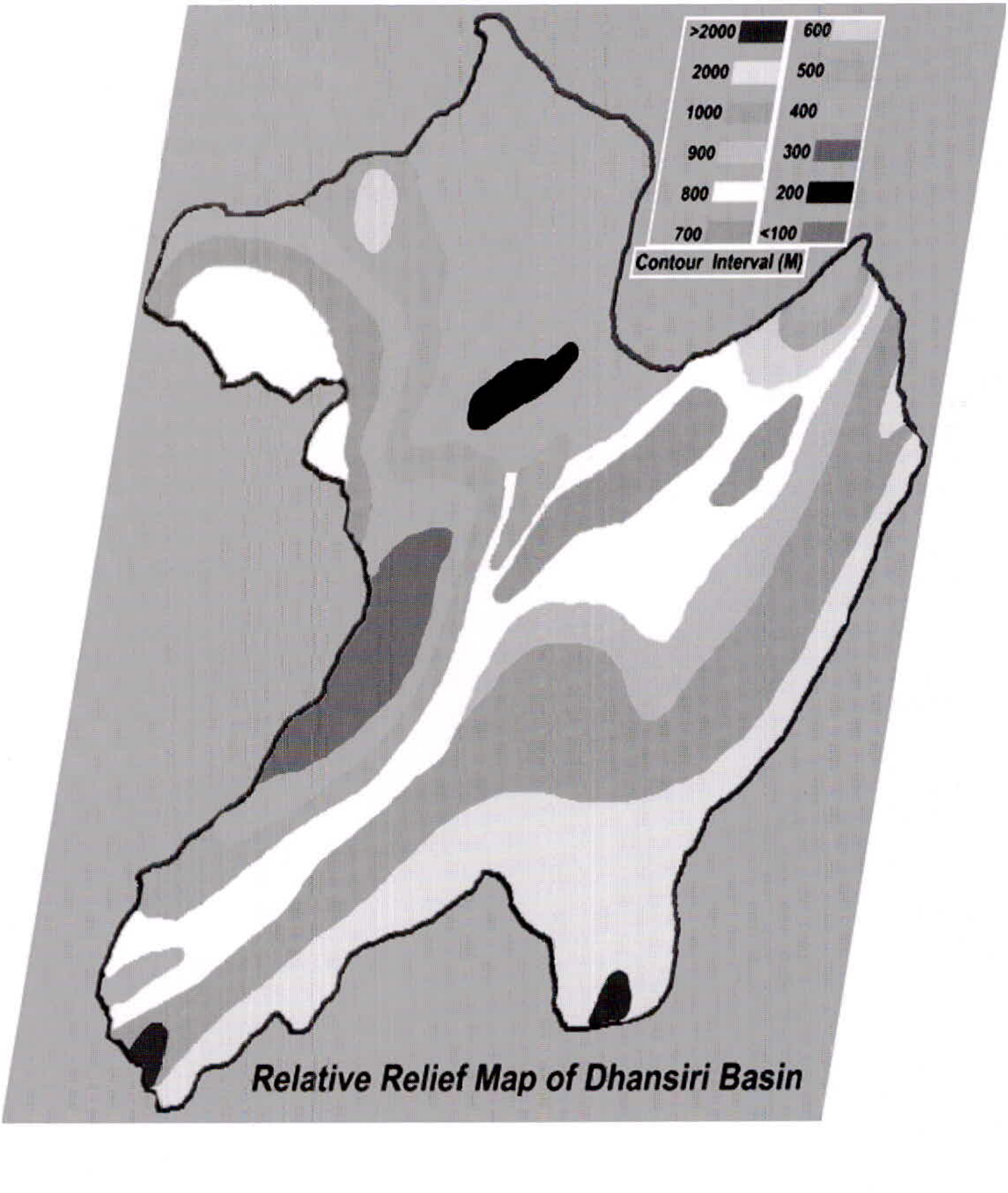


Fig. 3 . Relative Relief Map of Dhansiri Basin

Table 2. Results of Parameters of Morphometric Analysis
(a) Linear Aspect

Stream Order	Stream No.	Bifurcation ratio	Stream Length (km)	Stream Length ratio	Mean Stream Length (km)	Mean Stream Length Ratio	Max. basin Length (km)	Basin Perimeter (km)
I	37368	2.6	14195.9	1.44	0.37	1.83	450	1500
II	14372	8.18	9828.39	1.11	0.68	7.35		
III	1756	3.88	8787.53	5.82	5	0.6		
IV	452	4.75	1509.14	1.49	3.33	2.14		
V	95	4.31	677.76	1.22	7.13	2.88		
VI	22	5.5	452.65	1.38	20.57	3.96		
VII	4	4	326.65	2.71	81.6	1.47		
VIII	1	-	120	-	120	-		
Mean	6758.75	4.75	4487.25	2.17	29.84	2.89		

(b) Aerial Aspect

Drainage Area (km^2)	Elongation Ratio	Circulatory Ratio	Form Factor	Drainage Density (km/km^2)	Stream Frequency	Infiltration No.	length of Overland Flow (km)	Const. of Channel Maint.
10305	0.28	0.07	0.06	2.76	4.15	11.45	0.13	0.36

(c) Sinuosity Index / Braiding Parameter

Sinuosity Index	**Single Channel**	**Multiple Channel**
	BP<1	BP>1
Low(<1.5)	Straight	Braided
High(>1.5)	Meandering	Anastomosing

Sinuosity Index of Dhansiri is 2.3 (i.e. meandering in nature).

water is discharged from the basin and total yield of sediments. Systematic description of the geometry of a drainage basin and its stream channel requires measurement of linear aspects of the drainage network, areal aspects of the drainage basin, and relief (gradient) aspects of the channel network and contributing ground slopes (Strahler, 1964). In the present study, the morphometric analysis is carried out with respect to parameters like stream order, stream length, bifurcation ratio, stream length ratio, basin length, drainage density, stream frequency, elongation ratio, circularity ratio, form factor, infiltration number etc., using mathematical formulae and the results are summarized in Table 2. The properties of the stream networks are very important to study the landform making process. Morphometric parameters such as relief, shape and length also influence basin discharge pattern strongly through their varying effects on lagtime.

SEISMICITY OF AREA

Many parts of the Indiar subcontinent have historically high Seismicity. Seven catastrophic earthquakes of magnitude greater than 8 (Richter scale) have occurred in the western, northern and eastern parts of India and adjacent countries in the past 100 years. Much of Assam lies in the Brahmaputra River Valley, except for a few southern districts. The northern and eastern parts of this valley area are bounded by the Himalayan Frontal Thrust (HFT). In the eastern parts along with the HFT, there are the Lohit and Naga Thrusts. Among the large earthquakes in this region were the events in 1869 and 1897. The 1897 earthquake is well known for the dramatic accounts of violent up throw during the shock. Active seismicity of the NE region has a very significant impact on the hydrologic regime and morphology of the Brahmaputra River including its host of tributaries and other water bodies (e.g. wetlands) strewn over the floodplains. Occurrence of these episodic events led to intensification of flood hazards, especially in the aftermath of the two great earthquakes of 1897 and 1950 (Goswami, 2002). As per the seismic zoning map of India, the entire study area falls in Zone V (most severe seismic intensity zone) (Fig. 4).

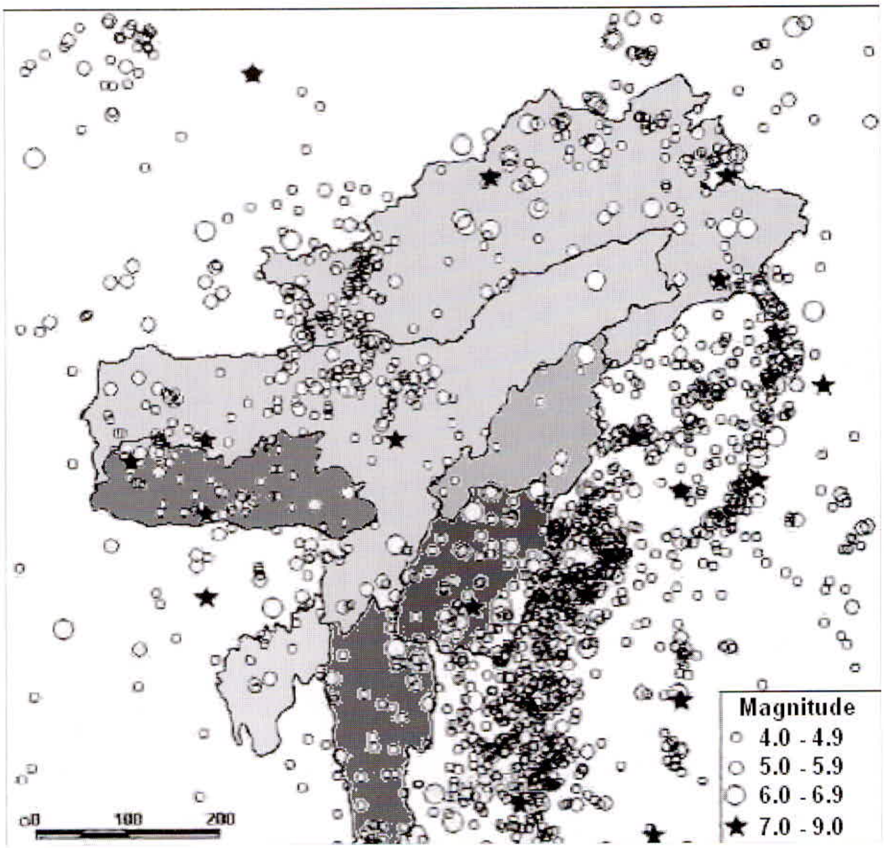


Fig. 4. Seismicity Map of Northeast India (1897 – 2002)

LONGITUDINAL PROFILE

The longitudinal profile of a river is an expression of the gradient of that river from its source to the end. Longitudinal profiles of stream channels are characteristically concave up due to the increase of discharge and the decrease of bed material grain size (due to sorting and abrasion during transportation) downstream. In the present study the longitudinal profile of Dhansiri main channel is constructed by a plot of altitude (ordinate) and horizontal distance (abscissa). The longitudinal profile of the Dhansiri main channel indicates a high gradient control from its source but slowly the gradient becomes decreases when the river emerges into the plains and ultimately to the vast alluvial plain of Brahmaputra (Fig. 5).

LAND USE PATTERN IN MIDDLE TO DOWNSTREAM AREA

The land use pattern indicates the manner in which different parts of land in an area is being utilized. It is an important indicator of environmental health; human activity and a degree of inter play between these two. Between Dimapur and Bokajan area of the Dhansiri basin, a mix-up of forestlands and agriculture dominant land is found. The land use data as per Census Data, 2001 for the Karbi Anglong District (middle to downstream area of Dhansiri basin) is given below :

SOIL PROFILE

Quality of the soil in the area is shown a marked diversity in nature depending upon the parent rock and climatic conditions prevailing in different parts

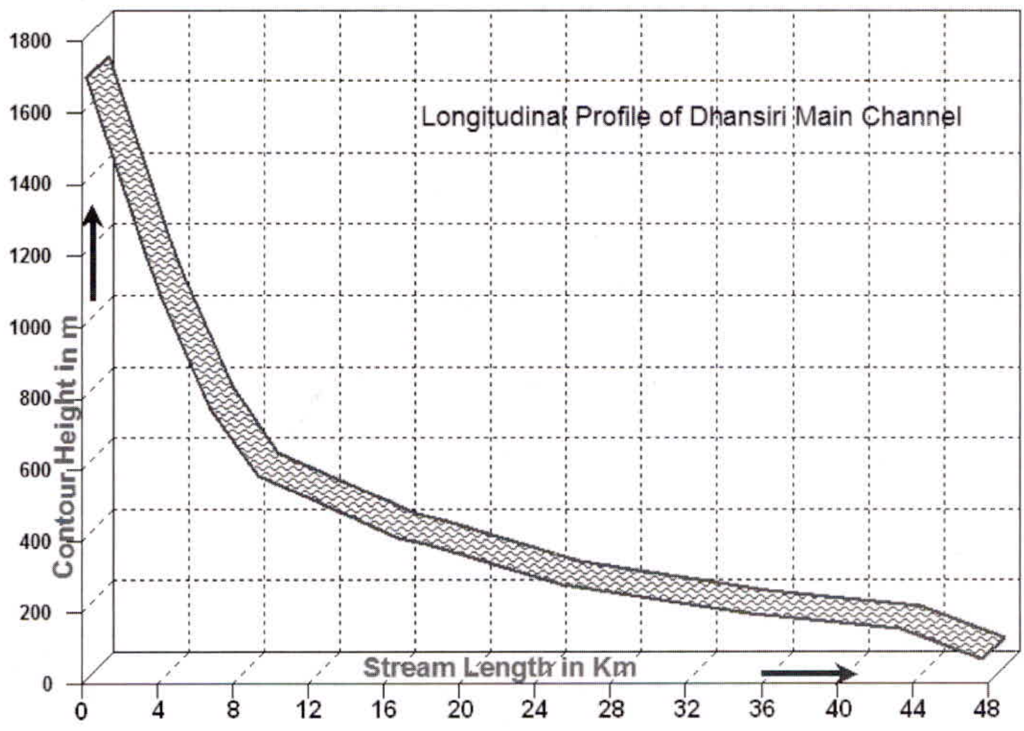
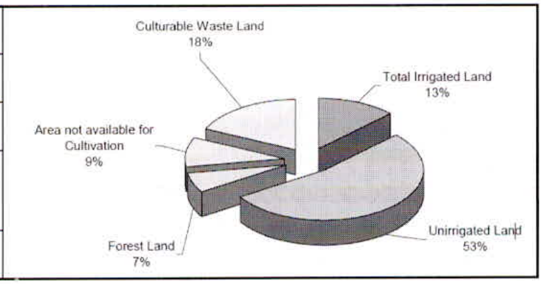


Fig. 5. Longitudinal Profiles of Dhansiri River

Total Irrigated Land (ha.)	23052.47
Total Unirrigated Land (ha.)	96373.79
Forest Land (ha.)	12036.82
Area not available for Cultivation (ha.)	16635.62
Culturable Waste Land (ha.)	32906.18



of the district. Composite sampling of soil up to root depth (15 cm) was carried out at each location. Location of the representative soil samples from 6 different sites within the study area is shown in Fig. 6 and results are presented in Table 3.

WATER QUALITY

To know the nature and extent of present water quality of groundwater and surface water, analysis results (concentrations of physical and chemical parameters) of 6 ground water samples and 2 surface water samples have been shown in Table 4 and 5 respectively. The river water can be best used for Irrigation and domestic purposes. Location of water quality sampling sites is shown in Fig. 6.

FLOOD PROBLEM

Flood in the Dhansiri basin occurs in the middle and lower reaches of Dhansiri and Dayang, the problem is more pronounced in the downstream of NH-37 crossing at Numaligarh. Floods of high magnitude occurred in the basin in the years 1954, 55, 59, 60, 70, 76, 86, 87, 89, 91, 98, 2004, 2008 and

Table 3. Soil Analysis Results

Parameter	Unit	Location					
		Village Khatkhati	Vill. Goutam Basti	Bokajan	Vill. Hathighara	Vill. Sarthe Timung	Dimapur
1. Soil Texture	-	Sandy Loam	Sandy Loam	Loam	Sandy Loam	Clay Loam	Sandy Loam
2. Water Holding Capacity	%	75.20	65.40	72.50	80.10	66.30	75.00
3. Permeability	cm. / hr.	0.62	0.76	0.68	0.56	0.70	0.65
4. Porosity	%	28.00	21.00	25.00	21.00	30.00	24.00
5. Conductivity	μmhos/cm.	272.00	252.60	298.10	365.40	281.10	270.00
6. pH	--	8.00	7.20	7.40	7.00	7.10	7.60
7. Calcium as Ca^{++}	mg/100g	22.50	21.80	25.00	20.10	21.40	23.20
8. Magnesium as Mg^{++}	mg/100g	12.10	13.20	10.40	13.60	11.80	12.00
9. Sodium as Na^{+}	mg/100g	0.79	0.81	0.72	0.88	0.77	0.80
10. Potassium as K_2O	Kg/Hec.	7.10	6.30	6.10	7.20	6.00	7.20
11. Available Phosphorus as P_2O_5	Kg/Hec.	125.30	110.40	115.10	124.50	123.30	111.80
12. Cation Exchange Capacity	meq/100g.	1.48	1.36	1.35	1.46	1.62	1.55

Table 4. Ground Water Quality Results

Parameter	Unit	Limit (Desirable) as per IS 10500	Village Khatkhati	Vill. Goutam Basti	Bokajan	Vill. Hathighara	Vill. Sarthe Timung	Dimapur
1. Colour	Hazen unit	5.0 hazen limit	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
2. Odour	---	Unobjectionable	Unobjectionable					
3. Temp.	^0C	---	16.8	18.0	18.4	16.2	16.0	18.2
4. pH	---	6.5 – 8.5	7.24	6.72	7.16	6.42	7.24	6.86
5. Electrical Conductivity	m-mhos/ cm.	---	0.13	0.26	0.08	0.12	0.20	0.18
6. Total Dissolved Solids	mg/l.	500.00	82.6	170.8	50.6	72.0	146.2	126.4
7. Total hardness as $CaCO_3$	mg/l.	300.00	56.2	58.4	20.4	24.8	105.0	58.2
8. Calcium as Ca^{++}	mg/l.	75.00	15.4	18.2	4.8	6.6	24.2	12.8
9. Magnesium as Mg^{++}	mg/l.	30.00	4.3	3.2	2.0	2.0	10.8	6.4
10. Total Alkalinity as $CaCO_3$	mg/l.	200.00	48.2	40.6	46.2	34.8	64.8	32.0
11. Chloride as Cl^-	mg/l.	250.00	14.0	20.5	8.2	10.6	20.4	14.2
12. Sulphate as SO^{--}_4	mg/l.	200.00	5.4	8.6	2.0	3.8	8.2	5.8
13. Fluoride as F^-	mg/l.	1.00	0.14	0.10	BDL	BDL	0.14	0.10
14. Sodium as Na^+	mg/l.	---	5.4	4.5	5.0	4.6	4.0	4.8
15. Potassium as K^+	mg/l.	---	3.2	3.5	3.8	3.0	3.2	3.2
16. Boron as B^{+++}	mg/l.	1.00	BDL	BDL	BDL	BDL	BDL	BDL
17. Total Phosphate	mg/l.	---	BDL	BDL	BDL	BDL	BDL	BDL
18. COD	mg/l.	---	BDL	BDL	BDL	BDL	BDL	BDL
19. Total Kjeldahl Nitrogen	mg/l.	---	BDL	BDL	BDL	BDL	BDL	BDL
20. Sodium Absorption Ratio	%	---	0.31	0.26	0.48	0.40	0.17	0.27

2010. The major portion of the river course of Dhansiri is within the originating state Nagaland and termination state Assam. In Nagaland, the river passes through hilly areas of Kohima district, around Dimapur town. Normally inundation occurs due to spilling of its bank and it stays for a day or two at the most. In its course in Assam also, same nature is found upto Bokajan. The problem of flooding in the lower reach downstream of NH-37 becomes more complicated when the Brahmaputra remains in high stages. Sarupathar, Golaghat, Khoomtai and Bokakhat divisions of Assam state are affected by the flood of Dhansiri river. The main causes of flood in the basin are :

- High intensity of rainfall with average annual monsoon period rainfall of 1158 mm.
- Steep slopes of the river in the upstream hills.
- Deforestation and landslide proneness in the upper catchment.
- Highly meandering nature of the river in the plain.

EROSION PROBLEM

The basin falls in a highly seismic zone and experiences several earthquakes in a year alongwith heavy downpour in the hill catchments. This factor coupled with heavy deforestation in the hill catchment leads to considerable soil erosion on the steep slopes of the hills. The eroded topsoil and the debris from the landslides pour

Table 5. Surface Water Quality Results

Parameter	Unit	River Dhansiri Upstream	River Dhansiri Downstream	Drinking Water Acceptable Limit as per IS:10500:2009
1. Colour	Hazen unit	0.0	0.0	5
2. Odour	---	Unobjectionable	Unobjectionable	Agreeable
3. Temp.	^0C	20.50	20.10	-
4. pH	---	6.70	7.10	6.5-8.5
5. Electrical Conductivity	m-mhos/cm.	0.22	0.28	-
6. Dissolved Oxygen	mg/l.	3.50	3.80	-
7. Turbidity on NTU	---	1.00	1.60	5
8. Total Dissolved Solids	mg/l.	230.40	260.50	500
9. Total hardness as $CaCO_3$	mg/l.	110.50	126.10	200
10. Calcium as Ca^{++}	mg/l.	28.30	30.50	75
11. Magnesium as Mg^{++}	mg/l.	9.70	12.10	30
12. Total Alkalinity as $CaCO_3$	mg/l.	160.20	178.00	200
13. Chloride as Cl^-	mg/l.	14.10	9.00	250
14. Sulphate as SO^{--}_4	mg/l.	6.20	5.50	200
15. Fluoride as F^-	mg/l.	BDL	BDL	1.0
16. Sodium as Na^+	mg/l.	7.10	11.50	-
17. Potassium as K^+	mg/l.	2.60	2.00	-
18. Boron as B^{+++}	mg/l.	BDL	BDL	0.5
19. Total Phosphate	mg/l.	BDL	BDL	-
20. BOD	mg/l.	4.10	4.80	-
21. COD	mg/l.	11.30	15.40	-
22. Ammonical Nitrogen	mg/l.	BDL	BDL	-
23. Total Kjeldahl Nitrogen	mg/l.	BDL	BDL	-
24. Total Coliform (MPN value)	---	90	120	Must not be detectable in any 100ml sample

into the river and transported by the monsoon discharge all along its hill reach where the river bed slope is very steep. On reaching the plain the transported materials get deposited at the river bed due to sudden change of the river grade from a very steep to a mild one leading to meander which ultimately results in bank erosion.

River bank erosion is a perennial problem in Dhansiri basin, causing loss of lands and livelihood along river. Structural and non-structural interventions are needed to prevent potential loss of land and livelihoods. Several towns and villages are threatened by river bank erosion. River bank erosions near Dimapur town (in Nagaland) and Bokajan town (in Assam) are of more concern. Every year a considerable area of the Dhansiri catchment is engulfed by river erosion. The erosive action of the river causing great panic particularly after it was feed by river Doyang, Nambor, Rengma, Doigrung etc. The people residing near the bank of the river had to shift their houses considering the changing action of the river. The economy of the people residing near the river mainly depends on the agriculture therefore loosing of these highly fertile land causes multiple problems to the local people.

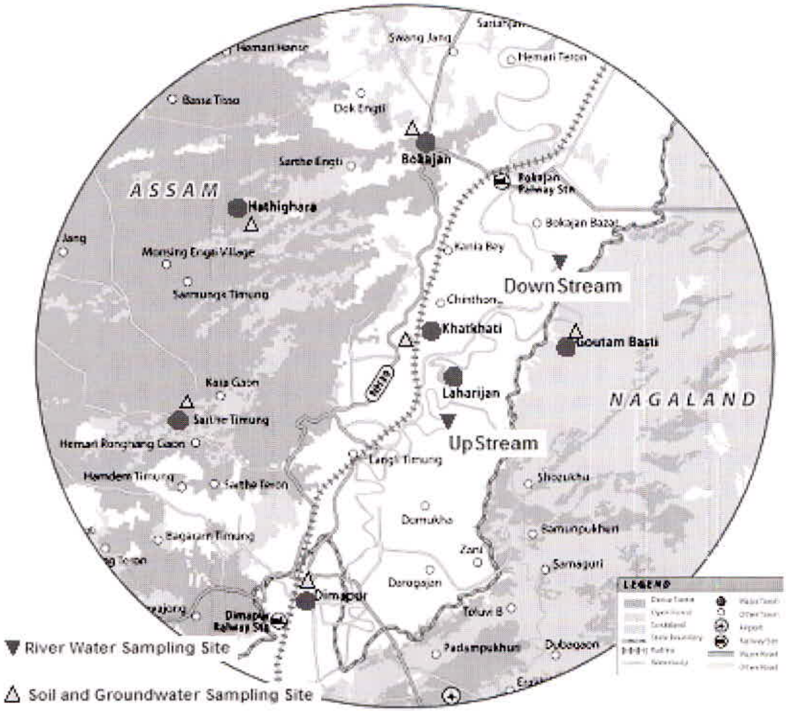


Fig. 6. Part of the study area showing sampling sites for soil with ground and surface water

CONCLUSIONS

Flooding and river erosion have devastating impacts each year in Dhansiri basin. The floods are caused by the runoff of extremely heavy rainfall during the monsoon and high sediment loads from upper watersheds that are geologically unstable and degraded because of deforestation and changing land use. River bank erosion is a perennial problem in Dhansiri valley, causing loss of lands and livelihood along river banks. Erosion also caused damages to flora and fauna. Structural and non-structural interventions are needed to prevent potential loss of land and livelihoods. Observations of year wise changes in the river configuration are essential. The multi date satellite data are one of the important tool to record and understand river configuration changes with respect to time for a meandering river like the Dhansiri. A combination of structural and non-structural measures in a phased manner is the most accepted strategy for flood and erosion management.Hydrological investigation of river is very important to study the behaviour of a river, its aggradation/degradation, shifting of the river course, erosion of river bank etc. and to plan remedial measure for erosion and other related problems. The interrelationship of various morphometric parameters is important for understanding the basin geometry, role of bedrocks of the streams, infiltration capacity, surface runoff, role of sediments carried by the stream channels and formation of soil. For the evaluation of river basins, study of watersheds and water conservation, the quantitative analysis of morphometric parameters are also essential. Information provided in this paper may be quite useful for future planning of river management works.

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