Research Paper Geography

An Analytical Approach to the Changing Channel Characteristics : A Case Study on The Lower Manu River, North Tripura

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ABSTRACT

Channel morphology is the result of interactions of four variables namely, fluid dynamics, channel configuration, sediment load and bed and bank materials. Manu, the longest river of Tripura, is experiencing some changes in its form which leads to hazards like sedimentation, bank erosion, flood etc. In this paper an in-depth study has been carried out through intensive field work to identify the channel changes took place during a period of 4 years (from 2006-2009) with the help of some selected hydrological parameters like channel width, depth, velocity, suspended load and discharge in the River Manu at Kumarghat. It has been concluded that changes in these variables are closely related to discharge and are significant in different seasons. Such changes affect the environment of the study area.

Keywords : Channel characteristics, stream hydraulics, hydrological parameters, Environmental impact

INTRODUCTION

Channel character changes as a result of mutual interactions of velocity, discharge, roughness, width, depth, sediment load and bed and bank materials (Singh, 1998). The overall geometry of a river channel is controlled by the independent variables of discharge and load, i.e. the climate and geology of a watershed (Morisawa, 1985). Adjustment mechanisms include erosion and deposition in the channel to change its form, slope or pattern and creation and movement of bed forms. Erosion on the banks will increase the channel width and decrease velocity and depth with given discharge (Morisawa, 1985). On the other hand if the channel becomes sluggish and deposits sediments, the channel bed rises and hence channel depth decreases and channel gradient increases which results in increased velocity downstream.

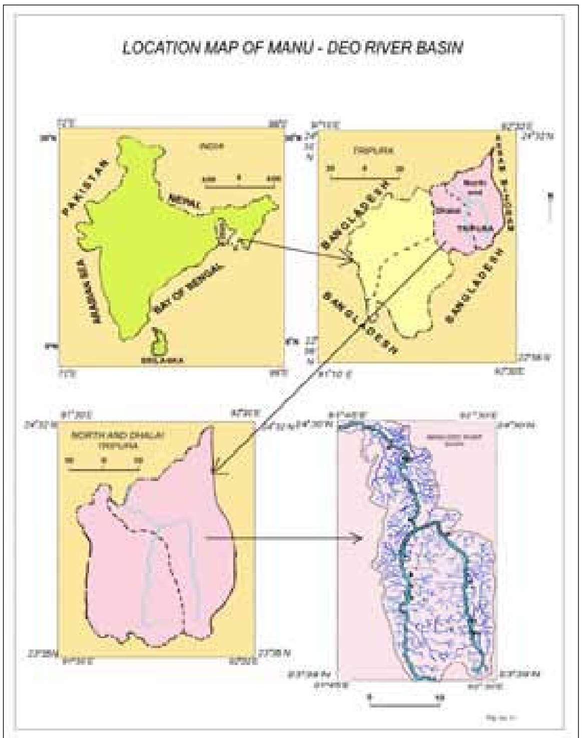


Fig.1: Location of the Manu-Deo River Basin within Tripura

Study Area: River Manu (167 km) originates at an altitude of 387m of Sakhantlang Hill Range of Dhalai District of Tripura and flows in a northward direction and finally joins with the River Meghna in Bangladesh. River Deo (132 km) is the main tributary to Manu within the Indian Territory. Its geographical extension is from 23° 39'N to 24° 30'N latitude and 91° 45'E to 92° 30'E longitude (Fig.1). It covers an area of 2,278 sq. km out of which 89% (2,023 sq. km.) lies in the hills and 11% (255 sq. km.) in the plains.

Geology: Geologically the Manu-Deo basin is occupied by the folded sedimentary formations varying in age from Lower Tertiary to Recent. The area is characterized by a series of tightly folded anticlines and broad synclines. These are parallel to the regional strike of N-S to NNW-SSE. The area is characterized by Recent alluvium, Dupitila, Tipam and Surma Group consisting of Bhuban and Bokabil sub-groups.

Climate: The basin enjoys a typical climate with variation ranging from sub-tropical to temperate conditions in hilly areas. Mean daily maximum and minimum temperatures are 29ºC and 6.4ºC respectively. January is the coldest month and July is the hottest month. Average annual rainfall received in the study area is 2210 mm and maximum amount is received during the monsoon months from June to October.

AIMS AND OBJECTIVES

Main aim of this paper is to study the changing character of the River Manu in its lower reach during the period 2006-2009. It is achieved through the following objectives:

(i) To study the channel configuration during monsoon and non-monsoon seasons.
(ii) To analyse the correlations among discharge and channel width, depth, velocity and sediment load at Kumarghat area.
(iii) To highlight the impact of such changes.

MATERIALS AND METHODS

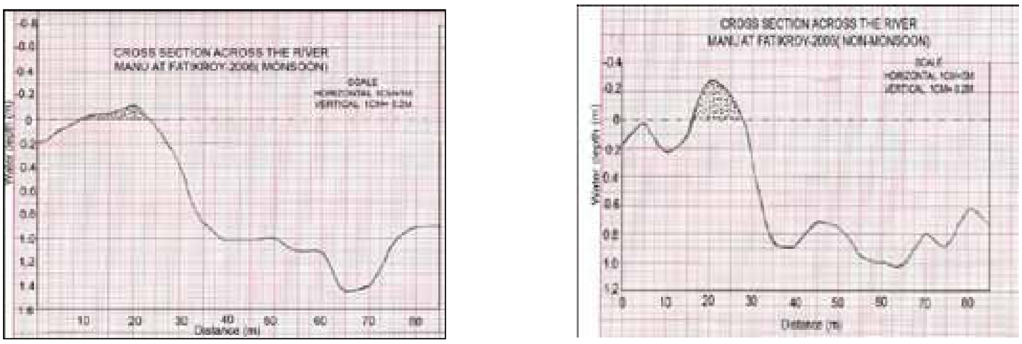
- In order to prepare this paper intensive fieldwork has been conducted during both monsoon and non-monsoon periods of 2006-09 in the lower course of the River Manu at Fatikroy – Kumarghat area.

- After measurement of different hydrological variables including width, depth, velocity, suspended load, related parameters like discharge (Q = A*V), Cross-sectional area (W*D), Wetted Perimeter (length of line of contact between bed and water) and hydraulic radius were calculated for both the seasons.
- Correlations among discharge and suspended solids, width, depth, velocity have been calculated.
- Then on the basis of acquired data cross-sections of the River for four years (2006-2009) for both the seasons were drawn.
- MS Excel software has been used for preparation of graphs in logarithmic scale and calculations for power equations between discharge-width, discharge-depth, discharge-velocity and discharge-sediment load.

Data Base: The paper has been prepared mainly on the basis of the hydrological data like discharge, channel width, depth, velocity, suspended solids etc, measured during field survey. Reports and Maps from different Central and State Govt. Offices like Geological Survey of India, PWD, CWC, Brahmaputra Board, Forest Department, Agriculture Department, Meteorological Division of ICAR etc were consulted to get a comprehensive geographical idea about the basin.

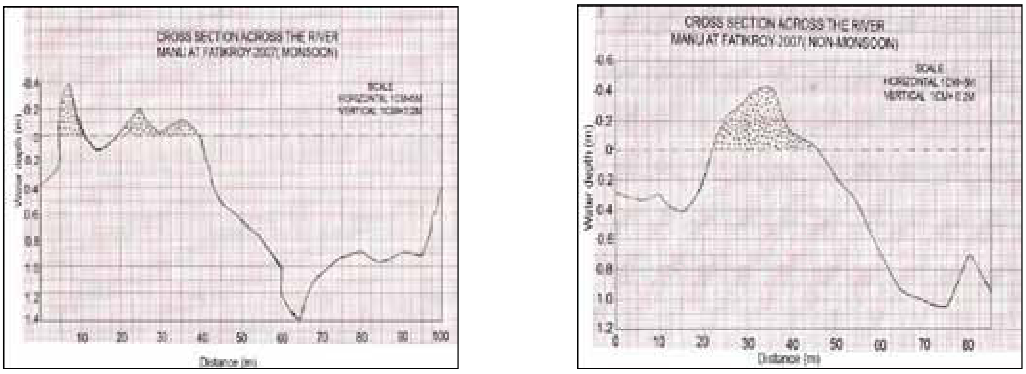
DISCUSSIONS AND RESULTS

In order to study the changing character of the River Manu at Kumarghat, cross sections for both monsoon and non-monsoon seasons for four consecutive years (2006 to 2009) have been drawn on the basis of field generated data (Fig.2-5).



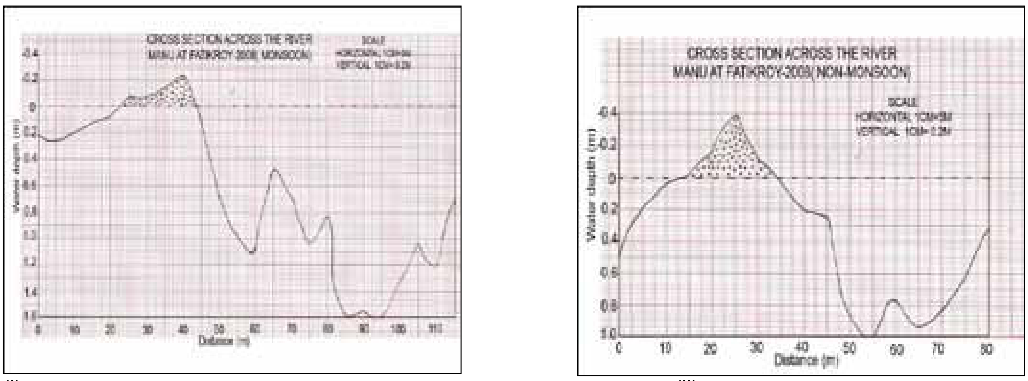
(i) (ii)

Fig. 2: (i) Cross-section across the channel on 14th October, 2006. (ii) Cross-section across the channel on 23rd December, 2006. Difference in maximum depth between two seasons is 0.45 m.



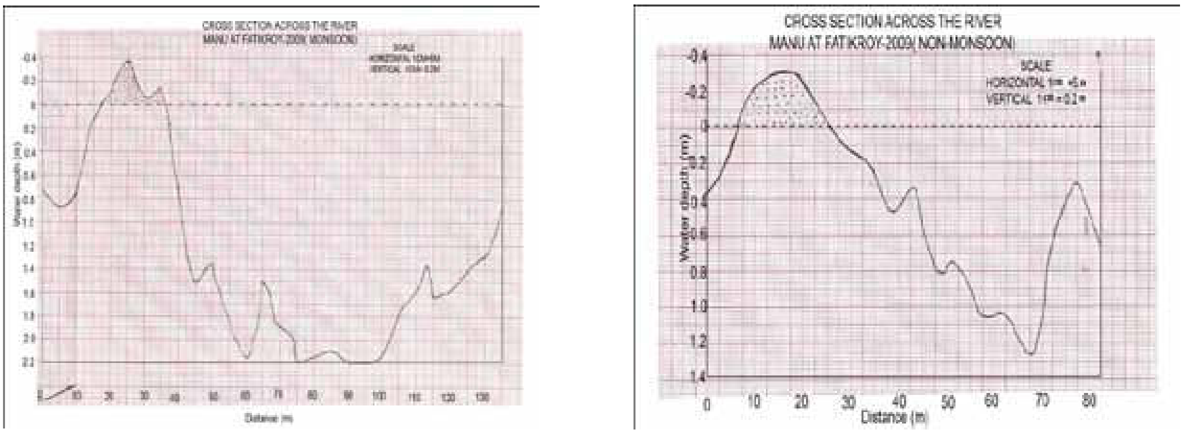
(i) (ii)

Fig. 3: (i) Cross-section across the channel on 25th May, 2007. (ii) Cross-section across the channel on 22nd November, 2007. Difference in maximum depth between two seasons is 0.35 m.



(i) (ii)

Fig.4: (i) Cross-section across the channel on 24th August, 2008. (ii) Cross-section across the channel on 27th December, 2008. Difference in maximum depth between two seasons is 0.60 m.



(i) (ii)

Fig.5: (i) Cross-section across the channel on 31st May, 2009. (ii) Cross-section across the channel on 26th December, 2009. Difference in maximum depth between two seasons is 0.95 m.

All the above sections show channel variations between two distinct seasons i.e., monsoon and non-monsoon seasons, particularly in the years 2008 and 2009. During these two years channel width and depth have decreased significantly from monsoon to non-monsoon season and discharge has also been decreased by 31.38 cumec and 22.64 cumec respectively (Fig.4 and 5). But in 2006 and 2007 discharge was increased by 5.65 cumec on 23rd December and 27.16 cumec on 22nd November (Fig. 2 and 3). This is due to the release of water from Nalkata Barrage, located upstream of Kumarghat, on that particular day and heavy rainfall too in November. In order to know the changes in hydraulic geometry, cross-sectional area and wetted perimeter have been calculated.

Table I: Changes in Hydrological Parameters during Monsoon and Non-Monsoon Seasons

Days	Width (m)	Mean depth(m)	Discharge (m3/s)	C.A. (m2)	W.P. (m)	HR(m)
10/14/2006	70	0.85	17.82	59.50	45	1.32
12/23/2006	75	0.63	23.47	47.25	95	0.50
Change	+ 05	-0.22	+5.65	-12.25	+50	-0.82
05/25/2007	80	0.71	42.87	56.40	115	0.49
11/22/2007	65	0.57	70.03	37.05	80	0.46
Change	-15	-0.14	+27.16	-19.35	-35	-0.03
08/24/2008	100	0.75	58.00	75.20	155	0.49
12/27/2008	65	0.50	26.62	32.55	85	0.38
Change	-35	-0.25	-31.38	-42.60	-70	-0.11
05/31/2009	115	1.38	49.54	158.20	215	0.74
12/26/2009	70	0.61	26.90	42.70	105	0.41
Change	-45	-0.77	-22.64	-115.50	-110	-0.33

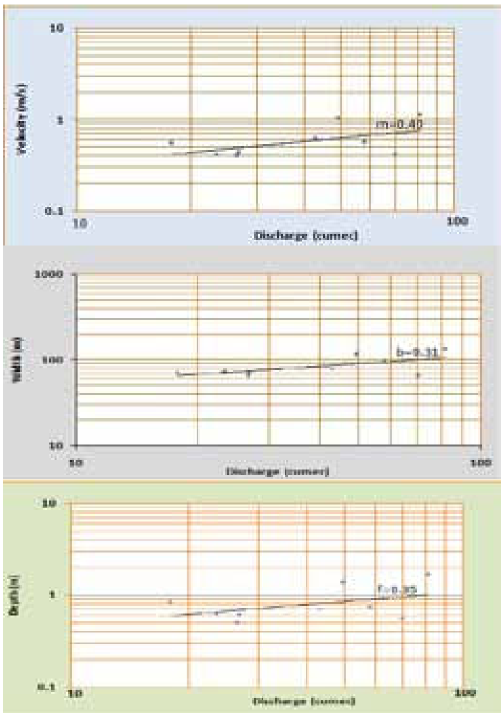
In the year 2006 on the particular non-monsoon day, though width was increased by 5 m but depth was decreased by 0.22 m, therefore the cross-sectional area was decreased (by 12.25 m2) but wetted perimeter increased by 50 m. In rest of the observations from 2007-09, the width and depth of the channel were less on the particular non-monsoon days than the monsoon days and accordingly cross-sectional area and wetted perimeter were also less (Table I).

These changes means from 2007 onwards, less water is in contact with the channel, so friction from the bed and banks have decreased and the river is more aggrading in character in the non-monsoon months than the monsoon months. Moreover, during monsoon, channel width has increased from 2006 to 2009 from 70m to 115m whereas channel depth has decreased from 2006 to 2007 from 0.85m to 0.71m, but increased from 2008 to 2009 from 0.75m to 1.35m. Accordingly cross-sectional area, wetted perimeter and hydraulic radius have changed which indicate the changing character of the river.

Leopold and Maddock (1953) proposed hydraulic geometry to reveal the relationships between discharge and width, depth and velocity at a particular point on channel reach. They described hydraulic geometry i.e. variations in channel forms as power function of discharge as follows;

$\mathbf{w = aQ^b, d = cQ^f, v = kQ^m}$,
where w is width, d is mean depth, v is mean velocity, Q is discharge and a, c, k, b, f and m are numerical coefficients.

The field data of these three variables against discharge on logerithmic graph paper have been plotted and found straight linear relationships as power function of discharge (Fig.6).



w = 26.597 $Q^{0.3115}$, d = 0.2181 $Q^{0.3497}$, v = 0.134 $Q^{0.396}$.

Here exponents are b = 0.31, f = 0.35 and m = 0.40.

Fig. 6: Changes of width, mean depth and mean velocity with discharge at a particular cross-section, Lower Manu River at Fatikroy during 2006-2010.

The study on the basis of the field data shows that on the particular time of measurement at a particular point of Kumarghat, channel width (mean value 80.80 m) was approximately double of discharge (mean value 39.41 cumec); depth (mean value 0.77) and velocity (mean value 0.56) were also increased with discharge.

Moreover, The ratio m/f can be related to the transportation of load through the interdependence of the various channel factors. The ratio may be defined as

m = rate of increase of velocity with discharge
f rate of increase of depth with discharge

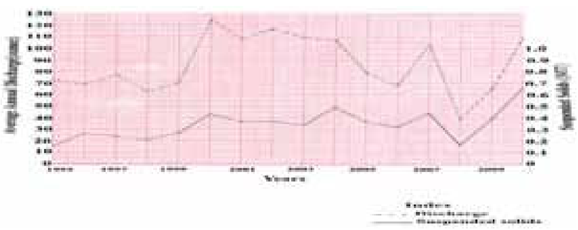


Fig.7 shows the amount of average annual discharge and average suspended solids carried yearly by the Manu River at the Kailasahar gaging station located in the lower Manu River from 1995 up to 2010. Superimposition of two graphs shows that from the year 1999 onwards, the amount of suspended solid had increased with increase in the flow discharge, though at variable percentage. Prior to that period, sediment load had decreased with increase in discharge and the total amount of suspended solid was also less (0.15 -- 0.26 MT). This may be due to the fact that, then vegetal cover was more extensive in the catchment of the River Manu than the later period. This kind of regular relationship permits the determination of a sediment-discharge rating curve for the River Manu. This curve forms a straight line when plotted on logarithmic scales (Fig.8).

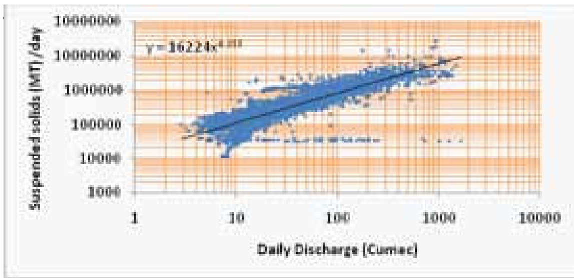


Fig.8: Rating Curve showing relation between daily discharge and suspended solids at Kailasahar, Lower Manu River, North Tripura.

$G = pQ^{j}$

Where G is sediment load in metric ton per day and p and j are numerical constants.

In the River Manu at Kumarghat $G=162224Q^{0.86}$ i.e., the exponent is 0.86. Therefore increase in discharge leads to high concentration of suspended load in the lower reach of the Manu.

Impact of changing character of the river Manu:

(i). Now a days bank erosion and sedimentation are common phenomena in the lower Manu River which has adversely affected the navigation of the channel.

(ii). Due to bank shifting State Highway has come under the grip of the channel at Sonaimuri, Tarapur etc. Some villages like Asrampalli, Teghari etc are partially demolished.

(iii). Land use pattern, location of settlements, occupational structure, culture etc have also been changed and at large scale total socio- cultural environment has been affected. e.g., fishermen and boatmen are now rare in this area, though once upon a time Manu was an important inland waterway in this part of Tripura.

(vi). Due to change in channel character the riverine ecosystem has also been affected. Different varieties of flora and fauna are now become extinct.

CONCLUSION

The above study reveals that when discharge at Kumarghat increased, width, depth, velocity and sediment load of channel were also increased in monsoon seasons. Again during non-monsoon months with decrease in discharge, except the period of the release of barrage water, the suspended solids get deposited in the channel bed, reduces the depth and chances of different hazards increases. During the study period the field observation showed huge increase in sedimentation within the channel which leads to the formation and enlargement of channel bars and thereby leads to various adverse effects on the socio-cultural environment of the study area. Therefore discharge plays the key role in modifying the channel character

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