

CHAPTER I

INTRODUCTION

1.1 Prelude

Dynamism is one of the characteristics of life. Life without dynamics signifies that interaction with environment is about to stop or has already been stopped. Same thing happens in the life of rivers. The term 'fluvial' is from the Latin word 'fluvius' a river (online, 'your dictionary'). Fluvial means whatever outcomes through the action of a river or pertaining to a river or stream. In boarder sense a fluvial system not only includes channel of a river but it includes whole drainage networks of a river (Schumm, 2005). And dynamics is a part of physical science and sub-part of mechanics. It deals with the moving materials and the factors affecting the movement. So fluvial dynamics deals with the water flow, sediment movement and also with bed-form features resulting from the interaction between flow and transporting materials within the channel (Robert, A. 2003). In another way, it is said that fluvial dynamics is the mechanism governing the relationships among the erosivity of river, transportation of bed materials and sedimentary processes occurring within the valleys, the alluvial plains and river beds (Cencetti & Tacconi, 2005).

The study of fluvial action and its dynamics of any channel especially foothill channels are related with the erosivity of the river, bed load character, entrainment of the load and processes that are operating within the valley. On the other hand, the alluvial channels show a wide variety of morphological forms in response to the complex interaction with the hydrological conditions (Ham, 2005).

1.2 The study area

The upper part of the Mahananda River is known as Mahanadi in the topographical map of SOI bearing no.78 B/5 and 78B/6 (Scale:1:50,000).The river has been originated from the summits of Mahaldhiram range near the locality of *Chimli* having the co-ordinates of latitude of 26° 55'40''N and longitude 88°14'04''E in the eastern part of Kurseong at an elevation 2200m (Sarkar, 1997) above the m.s.l. Traversing through the Mahananda Wild Life Sanctuary, it descends to the plains of the extensive Sub-Himalayan foothills in Siliguri and finally debouches into the Ganga. It covers a

length of 470 km in total. After the hills the river is taking more southerly direction in Siliguri

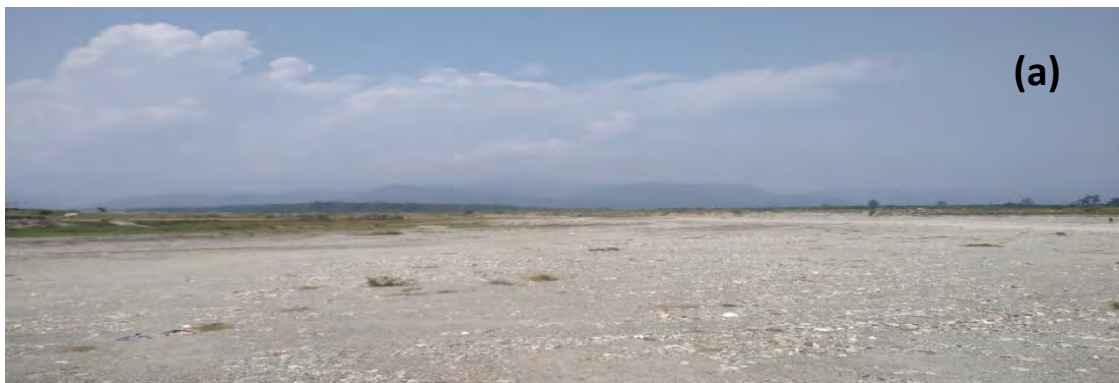
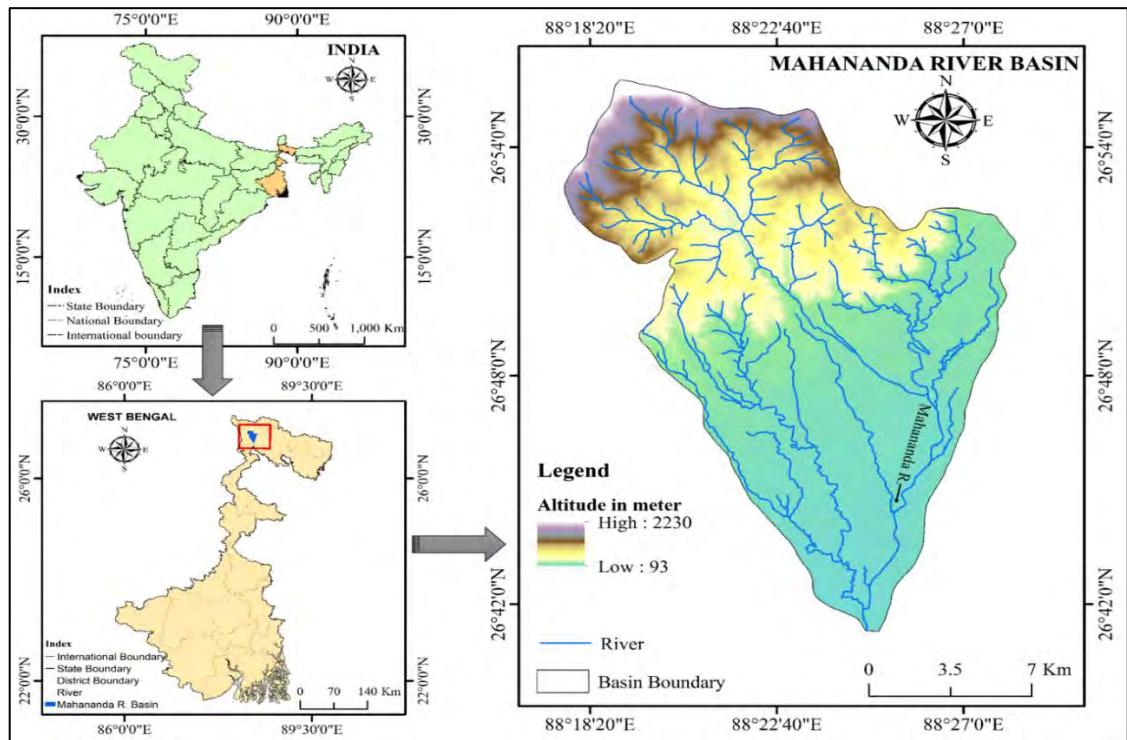


Figure 1.1 Location of the Study Area (a) River Mahananda descending down the Sub-Himalayan region near Lincon School, (b) Mahananda River at Gulma railway crossing in the lean season of 2022

and turns west to form the boundary line between the Terai and Jalpaiguri as far as Phansidewa in the extreme south-east of the district (O'Malley, 1907; Darjeeling District Gazetteer). Further it passes through Uttar Dinajpur district of West Bengal, Kishanganj of Bihar, and Malda district of West Bengal. Below Malda it enters to Bangladesh. The present study has been confined to the upper Mahananda course denoting the reach between its source and confluence of Mahananda – Balason River at Naukaghat area of Siliguri. The basin is falling within the latitudinal extension of $26^{\circ}40'00''\text{N}$ to $26^{\circ}55'59''\text{N}$ and within the longitudinal extension of $88^{\circ}17'00''\text{E}$ to $88^{\circ}30'05''\text{E}$. The part area under study is receiving 242.5sq. Km.(approx.). The important rivers forming the Mahananda system are the Babu Khola, the Mana Khola, the Jyoti Khola, the Jogi Khola, the Gulma Khola, the Balason, the Panchanai etc. All these rivers are having sinuous courses infested by braiding and bed deposition. The river regime shows seasonal variations of discharge associated with the quantum of huge load. Bed filling characters have strong impetus on occasional floods and inability to water holding in the channel. The river Mahananda has also been seen with human interferences likely to say the architectural works like roads, bridges, embankments etc. causing obstructions to the natural fluvio-dynamic action of the river. One cross-sectional survey is further south of the study area, i.e., after coinciding with the river Balason. This is for studying the fluvial dynamics change of river Mahananda after coincide the river Balason and compare with others survey stations.

1.3 Statement of problem

Economically and politically Darjeeling district and part of Jalpaiguri district adjacent to Siliguri city play vital role. It connects Nepal, China through Sikkim, Bhutan through Jalpaiguri district or Kalimpong district, Bangladesh and also with the seven sisters of north-east India. So, it can be easily understood the potential importance of this district in terms of international relation and business, and also plays a connection between seven sisters of N-E India and others parts of India. Among all other cities and towns of Darjeeling district, Siliguri city has great importance. Most of the part of the city is situated within Mahananda river basin. So, most part of the developmental process of the region depends on watershed management, i.e., Mahananda watershed management. As the days' progresses, population of Siliguri city as well as whole river Mahananda basin will be increased. Keeping in mind needs of future generation, we need water management.

Change of land use and land cover of the upper Mahananda basin especially in hilly part came through the hand of British East India Company. From that time to now natural forest area is converted to tea plantation and urbanized area, which accelerate river force minimizing ground water, increasing soil erosion as well as bed load of the hilly part of the upper Mahananda River. Deposition of bed load is high in monsoonal months at the foot hills plain of Terai due abrupt slope change and human interventions.

The channel form has seriously been affected and has been modifying during the last hundred years as viewed through the comparison of SOI topographical maps and available satellite images. The variations in the channel dynamics and its behavior are connected with the increasing population pressure and modification of the channel course which directs to analyze the governing processes behind the channel behavior and hydraulic factors responsible to the morphological outcomes. The catchment area under study has been witnessed with temporal deforestation and load deposition downslope the landslide scar sites. The rainstorms of 1993, 1998, 2000, 2002, 2005, 2010 (local information) have generated high discharge over the foothills carrying excessive load to the bed of the channel. The channel is experiencing the problems of siltation, bank failure, braiding and channel diversion at sites. To minimize the human suffering from the above said problems, we urgently need proper scientific management.

1.4 Objectives

The present study has been undertaken to fulfil the following objectives-

- i. To study the basin Morphometry for understanding the geo-physical character of the basin
- ii. To assess the hydraulic parameters for studying the forms i.e., cross-sectional area, wetted perimeter, hydraulic mean depth, channel width-depth ratio, velocity, discharge, bank height etc. from cross-sections at selected sites
- iii. To assess the nature and degree of channel diversion, braiding and transformation
- iv. To assess the type and size of river load in the downstream direction and variation of their distribution

- v. To assess the nature and extent of avulsion, bank line shift, flood etc. and their impact on the channel form and process
- vi. To assess the nature and extent of anthropogenic activities on the river Mahananda

1.5 Hypothesis

The following hypotheses have been selected to be tested:

- a. Bank failure materials and bed materials have impact on the channel form and consequently on the hydraulic parameters.
- b. Anthropogenic activities have affected the channel form.
- c. Occasional floods have impact on the channel form and bed characters.

1.6 Methodology

Conventional and modified indices on morphometric study (Doornkamp and King, 1971) will be carried out and pair-wise relationships among morphometric variables will be performed by correlation and Regression analysis.

Conventional survey techniques are the prime methods to measure the hydraulic parameters from the field at selected sites. The important hydraulic parameters to be taken up are cross-sectional area, wetted perimeter, hydraulic mean depth, channel width-depth ratio, velocity, discharge, bank height of the river during the pre and post monsoon periods to analyse their variations. For preparing longitudinal profile of the river based on SOI topographical maps (1: 50,000) field work is the prime method. For calculation of Discharge 'Area-Velocity' method (Chow, 1959 & Mutreja, 1986) based on field works has been selected. For Water level data same time frame has been selected as specified above through field work. The following sites have been selected for carrying out the field study:

Site 1: 250 m Upstream and Downstream of Gulma Khola and Mahananda confluence

Site 2: 50 m north of the NH 31 Bridge at Champasari, near Siliguri

Site 3: 200 m north of the Station Gauge

Site 4: 250 m south of the Station Gauge

Site 5: 200 m Upstream and Downstream of Balason and Mahananda confluence

To analyse the modification of channel forms during the past 50 years based on SOI topographical maps, cadastral maps, tea garden maps and satellite images under GIS platform are the prime methods. To study the nature and extent of channel diversion and resultant braiding the technique of Brice (1964) is to be carried out in the braiding infested sites. Suspended sediment load measurement is to be carried out along the sample sites in pre and post monsoon months with 1 litre sample bottle (Chow, 1959) whereas size distribution are to be determined by sieving techniques in laboratory. Measurements on bed material size and their distribution pattern are to be done by using slide calliper at the field sites and judging them with standards. GPS survey techniques are to be followed to map the bank lines along the vulnerable sites and will be drawn in the post field work. Rate of bank line shifting will be measured by superimposing the temporal bank lines under GIS environment. Impact of flood will be studied by identifying the flood imprints in the basin during field. Questionnaire survey will be carried out to evaluate the social perception and the nature and extent of the anthropogenic activities behind the variations of channel dynamics and modification of geomorphological outcomes.

1.7 Review of literatures

The paper of S. Sarkar (1997) is directly related to my subject matter i.e., fluvial dynamics of the river Mahananda. It is concentrated in particular at and around Champasari Bridge. His study will help me a lot to compare what was the situation of that period with the present one and give me a clear dynamism tendency of the river Mahananda. Moreover, Sarkar has also pointed out the watershed degradation and resulted environmental crisis in Sub-Himalayan West Bengal. According to him, most of the Sub-Himalayan watersheds of North Bengal are of decaying state due to change in land-use pattern. To get rid of that change of present land-use pattern is one of the most effective ways. The work may be helpful to shape up the conceptual framework of the present study to assess the nature of foothill rivers of Sub-Himalayan North Bengal.

As per Sarkar, 1998 use the monsoonal water for the benefit of the local people is also needful. Madani, K. and Marino, M.A. (2009) said about the system dynamics of channel taking the case of Zayandeh-Rud River basin. Rosa, R.N., et al (2004) showed how and what are the processes responsible for the shaping out of the landscapes.

According to him, earth's crust dynamic & fluid dynamic are the main responsible aspects for shaping the earth crust.

In another work he (Sarkar, 1987) has tried to quantify the soil erosion of the upper Mahananda Basin which may have impact on the changing of the morphology of the river channel. Bank erosion not only changes the shape of a channel, also the huge source of river load. It is mainly found in plain and deltaic part of a river.

Sharma et al., (2007) showed change of river channel through bank erosion by comparing the data collected from topographical map and digital satellite data using GIS and this literature is helpful to frame out the methodological aspects of the present work to assess the degree of bank erosion in the present study area,

Tamang, L. and Mandal D.K., (2010) showed how bed materials extraction for the constructional purpose & human encroachment changes fluvial characteristics of lower course of river Balason. Same human interferences are going on in case of the river Mahananda and thus this article will help the author a lot. Tamang (2015) also has elaborated on the effect of bed material extraction of lower Balason River and related changes in river bed form and processes and the work is really helpful for chapter VIII to study implications of human interferences on fluvial dynamics.

De, S.K. (1998) studied on fluvial dynamics of River Balason. In the same way the work of Tamang (2014) about the effects of boulder lifting on the fluvial characteristics will be helpful to assess the nature and extent of load characteristics of the river in the study area Mahananda.

Cancetti, C. and Tacconi, P. (2005) worked is on the fluvial dynamic of the Arno River basin in Italy to emphasize the impact of construction of dam and dredging that causes the disequilibrium of the channel associated with temporal sedimentation and human interference of the Arno River and the work may be helpful to define channel dynamics for a channel highly influenced by human action as also found in case of River Mahananda.

Strahler, A. N, 1957 stressed on quantitative geomorphic methods to measure size and form properties of drainage basins. He divided the measures into two namely, linear scale measurements and dimensionless properties of a river basins. This method will

help the worker to represent the morphometry of the Upper Mahananda basin quantitatively as well as diagrammatically.

Chopra et al., (2005) updated the Bhagra-Phungotri and Hara Majha sub-watersheds of Punjab by remote sensing and GIS techniques for study of basin morphometry. Another GIS based morphometric analysis has been done by Vijith, H. and Satheesh, R. (2006) on Meenachil River in Kerala. Another paper of Ahmed, S.A. and others (2010) evaluated the morphometry of Bandihole sub-watershed in Karnataka by using ASTER and SRTM DEM.

Biswas, S. S. (2016) evaluated the hydrological changes through the morphometric parameters of Parbati River basin using GIS techniques. And the work may be useful for study of hydrological changes of Upper Mahananda basin.

Aher, S.P. and others (2012) showed the changes of Pravara River basin mainly river shifting due to bank erosion with the help of remote sensing and GIS. Jain, V. and Sinha, R. (2004) have also showed shifting tendency of anabranching river, taking the case of Bhaghmati river in North Bihar.

According to Ham (2005), the channel morpho-dynamics is connected to the downstream variability of sediment transfer and this study is associated with the relationship between sediment transfer and channel deformation. As well as bank erosion types and associate results on poor lithology of sand-silt composition has been discussed by Saha, S. (2012) and the works may be helpful to study the channel behaviour and pattern of channel in chapter IV.

Karmakar M. (2016) emphasized on bank erosion as a natural process that impacts human loss and other damages are the impetus behind structural preventive measures. The work may be helpful to point out the conclusive statement of the thesis in chapter IX.

Kumar D. (2018), stressed on the significance of topography and drainage characteristics as parameters to take up comprehensive watershed development plans. For this purpose, they evaluated the morphometric parameters of Kalyani river basin by using RS and GIS and this work will be significant for studying channel behaviour in chapter IV for the present study.

River basin management or watershed management is not only concentrated with the morphological dynamics of a river channel but also with the political and socio-economic aspects of the river basin which determines the strategies of basin development and the work is helpful for chapter IX.

In the case of international rivers as showed in the Himalayan-Ganges region by Kattelman, R. (1990), there should be a mutual co-operation between the countries for reducing flood hazards as well as the better management of a river basin.

Saha, S. & Chakraborty, K. (2017) has done detailed study of the Upper Karatoya basin and showed the channel hydraulics and morphometry of the basin for understanding the present situation in comparison to the past to study the geomorphology of the basin.

Talukdar, R. (2012) studied the linear morphometric parameters of Jia Bhareli River basin in N-E India for drainage development and landform evolution. Waikar, M.L. and Nilawar, A.P. (2014) has evaluated the morphometric parameters of Charthana basin, Maharashtra, for better utilization of the resources especially water for the sustainable development of the basin area. Bharadwaj, A.K. and others (2014) have used SRTM data for the morphometric analysis of Adyar watershed for scientific utilization of the available resources and for the overall development of the watershed. Saha, A. et al., (2017) and Oyedotun, (2022) also evaluated morphological characteristics of Krishni River using RS and GIS for watershed management and Rosca, S. et al (2012) have used GIS tools for evaluating the fluvial morpho-dynamics of Niraj River.

Pisal, P.A. and others (2013) also studied the morphometric parameters of the Bhogavati River basin for the sustainable development of the basin. Same type of study has done by Nigam, G.K. et al, (2017) and Sharma, M. et al. (2016) on Vaishali river basin and Karun watershed respectively by using RS and GIS. Rao, N. K. et al. (2010),

Rai, S. et al., and Dubey, S.K. et al. (2015), have carried out the morphometric analysis of Gostani River basin, Nar River basin and Banas River basin respectively for the available resource management of the respective river basins.

In another work Pal, S.C. and Shit, M. (2012) has studied various geo-hydrological aspects of the Gandheshwari sub-watershed for the better use of water resources by rainwater harvesting and artificial recharge methods etc. All these works will be

supportive to analyse basin morphometry in view of geomorphological study of the basin.

Land use and land cover of upper Mahananda River have changed considerably since British period. This LULC changes affect the river morphometry. In this regard the work of Prokop, P. and Sarkar, S. (2012) in the piedmont of Sikkimese – Bhutanese Himalayas in between river Tista and river Kaljani about the transformation of LULC (land-use and land-cover) both by natural and man induced will be helpful for the chapter VIII.

The work of Noorazuan, M. H. et al (2003) and Pfister, L. et al (2004) were also on the similar topic evaluating the land use and land cover changes of Langkat basin, Malaysia by using GIS techniques and land use and runoff relation of the Rhine-Meuse basins respectively. In another paper Junior, J.L.S. and others (2015) have shown the change of flow regime of river Madeira basin due to climate change and conversion of forest area to pasture land i.e., land cover change.

Bandyopadhyay, S. et al (2014) showed availability of water resources for human use in West Bengal and the most water stressed parts of the state. This paper and the paper of Alford, D. (1992) will also be helpful for management of available water resources.

Rudra, K. (2010) and Momin et al., (2020) studied the channel dynamics of river Ganga in between the Rajmahal and Farakka since historical past. He showed the effects of Farakka barrage on fluvial dynamics of this part of Ganga creating national and international problems. Another work on channel dynamics carried out by Ghosh, D. and Saha, S. (2014) in Jainti River. They showed that the different channel gradient and bed materials of various part of Jainti River change the channel behaviour differently.

In the work of Das and others (2012) evaluated the present status of bank line, bank erosion tendency with comparison with past data and thus they have projected the shifting tendency of bank line of river Ganga. This paper is closely related with chapter VII.

Quader et al., (2009) have shown the relation between hydrological characteristics with sedimentary characteristics and especially how modify the channel and flood plain

formation and Guha, A. and others (2017) have analysed the alluvial fan regime in Mahananda and Tista by using various GIS techniques.

Ghosh, S. (2015) has studied the erosion of Padma River of Murshidabad district. He has given the detailed information of bank erosion and their protective measures and also the human adjustment to this problem. Same way Baishya, S.J. (2013), Kusimi, J.M. (2014) and Rahman, M.M. and Islam, N.M. (2017) have done detailed study of bank erosion of Baralia River near Bhairatola, Assam. Iva et al, (2017) have also concentrated on the effects or human responses to bank erosion. And Das, R. and Talukdar, B. (2017) tried to show erosion prone areas of the Subansiri River, Assam for the purpose of proper planning by using RS and GIS. In other paper, Balamurugan et al (2015) and Guite, L.T.S. and Bora, A. (2016) also showed the bank erosion of the Bhagirathi River in the part of Koil Bhatwari village and the lower Subansiri River respectively with the help of topographical map, RS and GIS data of various years.

Rabbi, H. et al (2013) have studied the amount of bank erosion by using GIS and human sufferings in Sirajgonj riverine area of Bangladesh. There was no or little governmental/institutional help or any plan to mitigate the suffering of the people till the date when the study has conducted. So, the authors have conducted this study to get it noticeable to the govt. and for proper planning.

From the study of Sarma, J.N. and Acharjee, S. (2012), it is found that neotectonic activity can accelerate the rate and direction of bank erosion of a river as found in the river Brahmaputra around Rohmoria area in Assam. On the same river Sarma, J.N. and Acharjee, S. (2012) evaluated bank erosion trend along Kaziranga national park.

According to the view of Toriman, et al (2013), the gradient and height factors are more effective among the others causing side erosion of the Chini River bank and major supplier of bed load to the river. So, bank slope protection will be the major protective measure to get rid of this problem.

A river works programme (2017) has been done by Australian Govt., for the Murray-Darling Basin under the supervision of Murray-Darling Basin Authority (MDBA). This programme has been taken to mainly study the flow regulations in between Hume dam and the Ovens junction for the Murray River especially.

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