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Anthropogenic Impact on Morphology of Teesta River in Northern Bangladesh: An Exploratory Study

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Abstract The present study deal with the anthropogenic impact on morphology of Teesta river in Northern Bangladesh includes bridge and barrage, bank stabilization, artificial levees, human settlement on side of river bank, intensive agriculture, sand mining which poses various negative impact. Extensive field work was conducted from December 18 to December 27 in 2013 to observe environmental impact of anthropogenic activities in the study. In addition, water discharge data (1979 to 2008) were analyzed to show the recent situation of Teesta River. The result reveals that water discharge quantity has been significantly reduced at Dalia point of Teesta River. The study also shows that excessive control of water discharge of Teesta River by man-made structure makes this river useless for the study area people. Average water discharge of monsoon season and dry season is 994.73 and 71.20 cusecs respectively. Therefore it is not conclusive but the study suggests that Govt. should be taken initiative to reduce the anthropogenic impact on morphology of Teesta River in northern Bangladesh.

Keywords: *river morphology, anthropogenic activities, water discharge, water flow condition, Teesta River*

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1. Introduction

River has its own emotion. River is capable to manage its own activities without human interference. Bangladesh is intersected by more than 600 rivers, which make the fertile land of the country. Teesta is the fourth main river in terms of discharge in Bangladesh [1]. Human activities such as dam, barrage, bridge, artificial levees have substantially changed river morphology. Various bridge, barrage and artificial levees have been built across by the side of Teesta River of Bangladesh. Though these activities are important for development and welfare of human being but they have adverse impact on river morphology and on its natural characteristics. Human environment interaction explains how people adapt to the prevailing environment and also the modification in the environment to suite their demand [2]. From the late 20th century, river play a vital role in modern civilization and also raise the environmental concern due to construction of dam and barrage [3]. Northern part of Bangladesh is a plain land area and 90% of its population rely on agricultural production, depending on nature [4]. Teesta River is a blessing for human settlement and agricultural activities of the study area. Various developmental works have been done by Teesta River as construction of irrigation, multi-purpose water resource projects, transportation, flood embankment, channel improvement, anti-erosion work, bridge and barrage etc. These anthropogenic activities also reduce the river stability and river morphology. Direct consequences of anthropogenic activity where human activity affects river channels through engineering works including channelization, dam construction, diversion and culver- ting have been long recognized [5]. Effects of alterations of land use such as deforestation, intensive agriculture and frequency of fire with the most extreme effects produced by building activity and urbanization are the accompaniment of above these. Various researchers have made significant contribution about human interferences like dam building, channelization, channel modification, river diversion, water extraction, water diversification on river morphology (Table 1).

Drought and poverty were occurred by the consequence of reduced water flow of Teesta River. Water scarcity in a geographic region is not only a natural problem but also man made phenomenon [6]. Groundwater level depends on volume of seasonal rainfall partly irrigated water during monsoon season [7]. Ground water levels are falling 1.2 m/year in many parts of study are due to excessive withdrawal by tube-wells together with low recharge, poor management and land use change [8]. The morphological characteristics of Teesta River need to be properly documented and analyzed and the unique characteristics of the river should be understood. Recently, Islam et al. [9] conducted the study of the geomorphology and land use mapping of Northern part of Teesta river of Rangpur district, Bangladesh. Protective and development work have an impact and change the morphological characteristics of Teesta River. In this regards, an attempt was made to show the anthropogenic impact of Teesta

River in the study area. This river plays an important role for socio-economic development in Rangpur division. Artificial activities have done by human which creating the interferences between river environment and human being as well. The main objective of the study is to show the anthropogenic impact on morphology of Teesta River and current water discharge situation in the study area.

Table 1. Examples of human impacts related to change in river channels

Impact types	Examples	Sources
Dams	At least 45,000 large dams (N 15 m high or 5– 15 m high if reservoir volume N 3 million m3)	World Commission on Dams [10]
	More than 400,000 km2 inundated behind the world's large dams	McCully [11]
	Fragmentation of nearly all rivers in North America due to presence of dams, with 80,000 dams N 6ft (1.83 m) and including all structures may be 2.5 million in the USA	Dynesius and Nilsson [12]
	More than 1500 large- and medium-sized dams in India and 100 barrages on all major river systems	Gopal [13]
	Australia has 447 large dams and several million farm dams which modify river flows	Schofield et al. [14]
Channelization	In the USA 26,550 km of major works gives a channelized density of 0.003 km/km2	Leopold [15]
	In England and Wales 8504 km of major or capital works gives a density of 0.06 km/km 2 , and there is also a further 35,500 km of river which is maintained	Brookes and Dawson [16]
Channel modification	Average of ,<10% of length of Alpine rivers is in a semi-natural condition ranging from 2.5% in Germany, 4.9% in Switzerland, 9% in Italy and 18% in France	Ward et al. [17]
River diversions	By the end of the 13th Century the 1780 km Beijing – Hangzhou Grand canal built to link 5 river basins and transfer water from Yangtze to North China Plain	Li and Mou [18]
Water extraction	Approximately 11% of freshwater runoff in USA and Canada withdrawn for human use.	Karr et al. [19]
	Water abstraction of about one fifth of total water resources with 87% for irrigation agriculture in China	Li and Mou [18]

2. Materials and Methods

In the present study, anthropogenic impact on Teesta River has been divided into two parts on the basis of human interferences and activities. The first part deals with the collection of basic information of the study area and the second part which deals with the extensive field survey in the Teesta River at Dalia point and observe the human activity.

2.1. Study Area

The study area comprises Teesta River catchment in Northern part of Bangladesh. The present study focus mainly on Northern part of Bangladesh at Dalia barrage point. It is situated in 26º10'43"N latitude and 89º3'6"E longitude at Dalia point (Figure 1). Of the total area of Teesta river catchment 8051 sq. km is covered by hilly region in Sikkim state West Bengle in India and 4108 sq.km is plane land in West Bengle and Bangladesh (Table 2). Total target area for irrigation is about 750000 ha at Dalia project, however only about 111000 ha are under irrigation due to lack of water during dry season. This barrage includes link cannels for water distribution over the irrigation project in the downstream which is three times higher than upstream is about 21 million people depend on it.

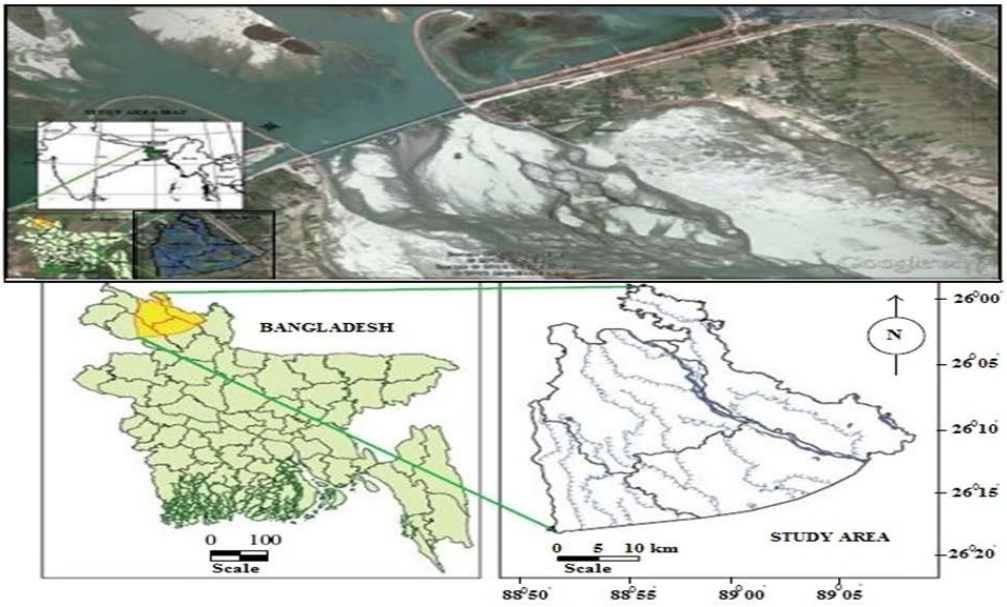

Figure 1. Map show the location of the study area

Table 2. Catchment area of Teesta River (in sq, km)

Type of landscape	State or region cover	Sq. km	Total area
Hilly Region	1)Sikkim	6930	8051
	2)West Bengal	1121	
Plain Land	1)West Bengal	2104	4108
	2) Northern Bangladesh	2004	
Total in India			10155
Total in Bangladesh			2004
Total			12159

2.2. Data Collection and Analysis

Primary data were collected from south eastern point of Dalia Barrage on the basis of their personal experience for the study. All these data provide basic information to understand and to show an outline of the anthropogenic activities on Teesta River. Water discharge data from 1997-2009 at Dalia barrage point of Teesta River was collected from Bangladesh Water Development Board (BWDB). The flow characteristics are analyzed by simple statistical techniques using MS-excel sheet. Monsoon season of the study area indicates June to September and dry season indicates October to February.

2.3. Field Work

Two field works were conducted to collect data and relevant photographs of the Teesta River sites where the anthropogenic activities are more pronounced. Field work was carried out from December 19 to December 27 in 2013 to observe the human impact on Teesta River. Throughout the channel, construction of artificial levee and bank stabilization were observed during the field survey. During the field work, several bridge and barrage were also observed and keep on record it.

3. Result and Discussion

Human are mostly responsible for changing river morphology which includes water flow, water quantity, water current and river environment etc. Various anthropogenic activities mostly build in bridge and barrage on river are the main cause for changing river environment.

3.1. Bridge and Barrage

The bridge and barrage play a significantly important role in the river environment and river morphological feature. River water flow, sediment distribution and wave regulation largely rely on bridge on the river. Figure 2a is showing a bridge on Teesta River in the study area which is adjacent with the barrage. The barrages are built for better use of river water in various purposes. The purposes like irrigation, balance in soil moisture in adjacent area, maintain a sustainable water table is mostly rely on water quantity but various negative impact pose on that area. This creates downstream water scarcity, creates char lands, river bed siltation by rain water upstream sediment load, water logging, and floods etc. Due to stopping of the natural current of the Teesta in the dry season, the river bed has been filled up with sands and the river has lost its natural motion [20]. Imbalance water in upstream and downstream water condition of Teesta River (Figure 2b and Figure 2c).

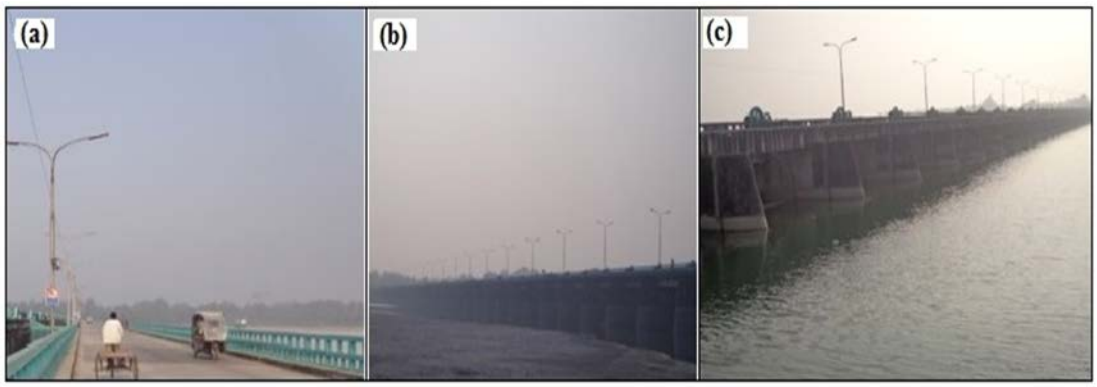

Figure 2. Photographs represents the Teesta River barrage at Dalia point, (a) Bridge on Teesta River; (b) Barrage showing upstream and (c) downstream water flow condition

3.2. Bank Stabilization

Teesta River forms meandering channel in study area. Rivers flow in its own meandering way and its own system. in a meandering stream, erosion takes place on the bank and deposits on the other site. This fluvial process is governed by running water velocity during monsoon season [21].When this situation become stream, a lot of problem like bank erosion, human settlement, agricultural land degradation take place. To overcome from this extreme phenomenon and minimize the hazard risk, some engineering structure like bank stabilization on the side of river takes place (Figure 3a). Bank stabilization is provide the stability by the construction [22]. This bank adversely affecting present prospect and will affect the future prospect of the Tista River on its water flow amount, flow direction and also in river natural motion.

3.3. Artificial levee

Natural levee are formed naturally by accumulating particle on river bed, along the bank near the active channel. Artificial levee constructed artificially by human being to regulate river morphology. Artificial levee not only modifies the fluvial environment, but also possess an alteration or disturbance active fluvial processes of the river [2].This artificial levee is constructed to protect the river from human settlement on the side of flood plain area. Though artificial levee have some positive side, it modifies fluvial morphology of river environment and water flow direction. This artificial levee stores water and

sediments, which cannot flow downstream. As a result downstream river environment become rude by losing its sediment contamination and sufficient water quantity and flow. Artificial levee on the eastern side of Teesta River near Dalia barrage point (Figure 3b).

Figure 3. Photographs shows anthropogenic impact of the study area, (a) River bank on the south eastern side of study area; (b) Artificial levee on the south eastern side of Dalia barrage; (c) Human settlement on side of Teesta River on the south eastern side of Dalia barrage; (d) Crop yielding on the bed of Teesta River

3.4. Human Settlement on Side of River

Human settlement adversely affects almost all parts of river environment. Various wastes like, household waste, relinquished vegetable rubbish, human tools and urines, animal pests, settlement construction waste material, unnecessary things, even polythene, wood, paper are thrown in to the river, that reduces the river water quality. On the other hand settlement settlements on flood plain area are more vulnerable at the time of flooding. The river water cannot accumulate its water due to human settlement. Intensive uses of river water in various purposes of human needs and environmental unfavorable trees like Ukaliptus plantation around the settlement also responsible for reducing water quality as such kinds of tree consume more water than other tree and their leaves do not compose easily. Figure 3c indicates human settlement on flood plain area and environmental unfavorable tree plantation. To use this flood plain area as playground or as fellow land, can be environmental sustainable and by this way the vulnerability of human and damaging phenomenon of flood can be reduce.

3.5. Intensive Agriculture and Grazing

Floodplains have been traditional grazing and under cultivation from millions of years. These area are being use as beneficial practice as domestic animal rearing, crop production and agricultural practices. But in the recent years intensive human interferences make the river useless. Intensive agricultural practices require huge quantities of water and most of the water is extracted from the river. A few amount of water extracted from ground water table where as river water is not available and costly to carry that means the area is either far from the river or shortage of water make the distance. So the farmers have to pull more water to yield their require amount of crop. This extensive uses of water in intensive irrigation purposes which is lowering the water quantities of Teesta River day by day. Intensive grazing sometime become the cause of soil moisture decrease due to their nocturnal and boring activities. Agricultural activities on the floodplains of Teesta River at Dalia point. These agricultural practices lower water quality as well by spreading various chemicals and pesticides (Figure 3d).

3.6. Water Flow Condition

Dalia barrage is the largest irrigation project among others project in Bangladesh. The radial gates of the barrage have 12750 cusecs of water discharge capacity [23]. Gradually dry season water in Bangladesh becomes decreased ended up in getting only 176 cusecs of water in January 1999. Average discharge of water was about only 376.15 cusecs of water that is extremely low flow of water at study area. The range of water flow at study area of Teesta River is 0.18 to 5294.21 cusecs. Table 3 showing maximum and minimum water discharge in monsoon season (Jun-Sep) and in dry season (Dec-Feb) which defines water flow fluctuation at that point. Minimum discharge in monsoon season was 71.73 cusecs in 1979 and maximum water discharge was 1825.86 cusecs in 1999. These discharge quantity is not sufficient to go on river natural emotion and agricultural production. This lowest amount of water is gradually leading the river dry up and making unusable for the local people. This continuous situation creating unfertile, lowest moisture content, decrease ground water table that is ultimate cause for drought. In dry season the maximum water discharge was 158.49 cusecs and 5.36 cusecs in 1997 and in 1988 respectively. These two seasons are the main time for dater discharge fluctuation.

Table 3. Statistics of water discharge in study area

Season	Average	Maximum	Minimum
Monsoon season	994.73	1685.12	71.73
Dry season	71.20	111.57	19.22
Year counting	376.15	5294.21	0.18

The Dalia barrage becomes useless by exclusive control of Teesta's water in the dry season by Gajoldoba Barrage (India) and sudden release of excessive water in rainy season causes flood and river bank erosion that leads to serious sufferings by the people. Lower water flow conditions leading gradually death of the river by sand deposition and river bed silt up. According to the IPCC [24], annual rainfall trend over the Teesta catchment in dry season is reducing as a result of global and regional climate change. As a result of low rainfall ground water recharge rate is decreasing and at the same time ground water extraction rate is abruptly increasing at the study area. As for example, in downstream Teesta region the proportion of ground groundwater extraction for irrigation in dry season has changed significantly during last two decades, it was about 40% of total irrigation in 1982-1983, 70% in 1996-1997 and over 70% during 2001 [7]. Change in climate is noticed in surrounding Teesta River barrage project area has some positive and negative impacts on the ecosystem [4].

Figure 4 shows water discharge fluctuation, where highest water discharge in the year of 1999-2003 and lowest discharge in 1979-1983. Water discharge fluctuations noticeable in monsoon season because lowest water discharges about 71.73 cusecs, where highest water discharge about 1454 cusecs. Average water discharge in monsoon, dry season and year counting where year counting representing average water discharges of 30 years showing in figure: 8.68.98% of total water discharge happened in monsoon season and 4.94% in dry season. But year counting average water discharge is too low compared to the required water discharge amount.

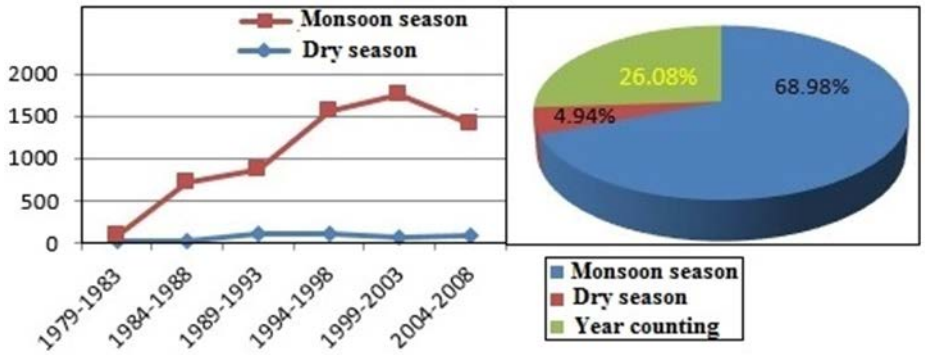

Figure 4. (a) Water discharge in mons0on and dry season of the study area; (b) Pie diagram shows average water discharge (%) in different season & years

Teesta River water flow condition till 1994 was in a balance condition compared to the water flow condition of 1979 (Fig. 5). After the year of 1994 conspicuous decrease of water flow condition at Dalia point was noticed. This gradual decrease water flow trends became worst in the year of 2010 when it was near 1.5%. As the water flow condition is going down day by day, so it will be dry in most recent years. Proper water share agreement between Bangladesh and Indian government only can solve situation.

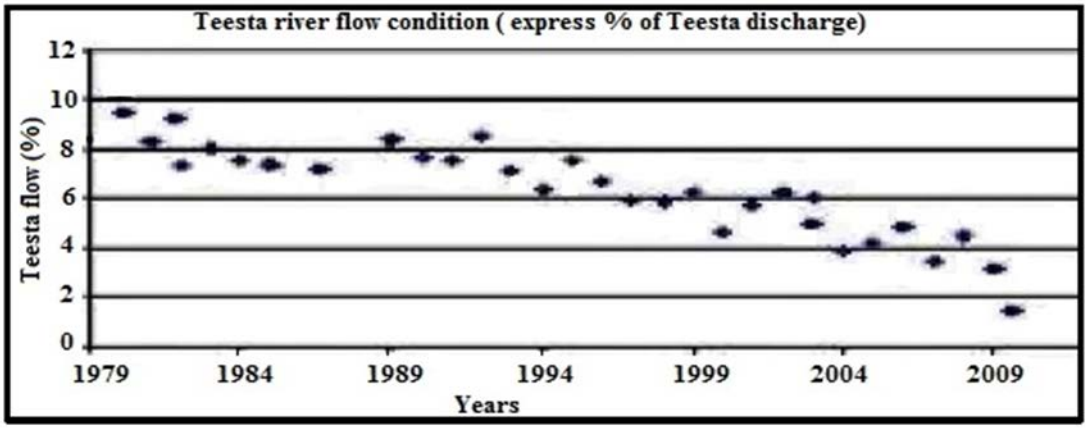

Figure 5. Teesta River flow condition in the study area

4. Conclusion

Teesta River is the vital source of water in northern region of Bangladesh. This river water is being used in various sector of human life including livelihood, irrigation, fisheries and household uses. The present study depicts that water demand increases day by day but significance decrease of water quantity make the river useless. The study also indicates that various anthropogenic activities and human interferences are responsible for water quantity decrease at the study area. Most noticeable anthropogenic activity is building dams and barrage that interfere on the regulation of water flow. Average water discharge in monsoon season is 994.73 and the range of water discharge is from 71.73 to 1685.12 cusecs. This finding reveals that Teesta River is gradually dry up. Therefore, it can be concluded that public awareness of various sector of water use can reduce the scarcity of water and Govt. should take initiatives to overcome the situation.

The following recommendation should be considered for regarding anthropogenic impact of Teesta River morphology

- Proper planning of water use & sharing and modernization of policy implement.
- Establish Indo-Bangladesh joint river commission in suitable water sharing trend model.
- Optimal use of Teesta River water.
- Implement integrated flood management program.
- Reduce water sharing conflict and ensuring real justice.
- Supply water considering on numbers of beneficiaries and dependency on river water.

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