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DYNAMIC CHANGES OF BAR FORMATION OF TEESTA RIVER BASED ON GIS APPLICATION

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ABSTRACT

Teesta River is one of the most important river of North Bengal and North- Western region of Bangladesh. In the late eighteenth century this used to be a tributary of Karatoya-Atrai-Jamuna-Saraswati river system. The starting point of this river is situated in the glaciers of Sikkim but climatic condition changed in the last 150 years. Temperature increased 3-4 degrees Celsius as a resent of global warming and other causes. In recent times river Teesta sediment gets its input mainly by rainfall due to the monsoon. So, during monsoon when rainfall increases, the amount of water flow through the channel increases. Thus erosion increases in river Teesta's lower part. The incoming sediment and water discharge make a big role for mid channel bar or side bar. So, result is that deposition also increases over this region. This form of river bars was found in that area. Every year, this continuous process is found in Teesta River. Sand bar data of every year will be able to describe the shifting of the river and it is also dependent on amount of monsoonal rainfall, flood or incoming sediment.

Key words: Channel shifting, Neo-tectonic, Scroll bar topography, Channel avulsion.

Introduction: A river has three main principle micro geomorphic features-bar, ripple and pothole. Bar is most important alluvial landform. Some types of bars are Mid-channel bars, Alternate bars and Point bars. The study area is mainly composed of Mid-channel bar and Point bar. Shifting of bar along with shifting of river channel is a natural process depending upon source of sediment, water velocity and sediment roughness. It is the new look and an ample scope for bar deposition and river shifting. Form late eighteenth century to now river Teesta shifted its channel. So, the sandbars are also shifted. River hydrology, subtropical monsoon and sediment production is correlated and main factor for bar shifting (Goodbred, 2003). Flood is the main factors for channel shafting and river bank erosion for any particular river basin (Schumm and Litchy, 1963).Subtropical monsoon affects rainfall which affects river velocity and discharge which further affects sediment production. Greater precipitation is main component for bar shifting (Cullen, 1981). Greater precipitation means high rainfall or high snowfall which affects the bar shifting directly. When the amount of rainfall increases in hilly region, then the rainfall pressure also increases in plain region like lower part of the river and as a result the river floods. Bed load sediment increase of the lower part of the river basin and flow pattern changes (Desai et.al. 2012). C limatic impact and tectonic process effects sediment production, thus causes bar shifting (Curray and Moore, 1971). Sometimes, regional climatic factors are more important than anthropogenic factors. Regional climatic changes and its variation are significant over the river water discharge (Dynesius and Nilsson, 1994). From late eighteenth century till date, the temperature has increased in Himalayan foothills, affecting the flow and bar shifting. Lithological attributes effects on alluvial deposits like bars (Moracke et al.2001).Temporal sediment variation directly effect on sand bar shifting (Prart-Sitaula et al.2003). The topography of the study area is also known as Scroll bar topography, as a series of bars present there. The channel form in the study area is braided. The main characteristics of the braided channel in this area are deposition, flashy discharge and flooding. As the river is mainly fed by rainfall, in monsoon the volume of water is much more than that in winter. The huge amount of water carries huge amount of sediment, which is now deposited to form bar. In every monsoon, a set of bar is deposited and the channel is shifted year by year. Thus the bar also changes from year to year.

Study Area: The study area is located in Teesta River near Jalpaiguri town. It is situated immediate after Teesta Barrage. The type area is located between 26° 28′ 30″ N-26° 3′ 31″ N latitude and 88° 44′ 4″E-88° 46′ 10″E (fig_1). Mainly fine sand bars are present in that area surrounded by flood plains. The area is 9 km in length and 4km in width. The study area is approximately 36sq.km (fig_2).

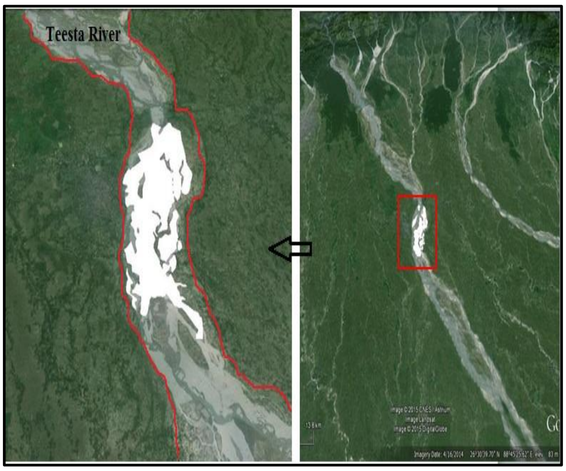

Fig_1. Location map of the study area from Google Earth, Sep, 2015.

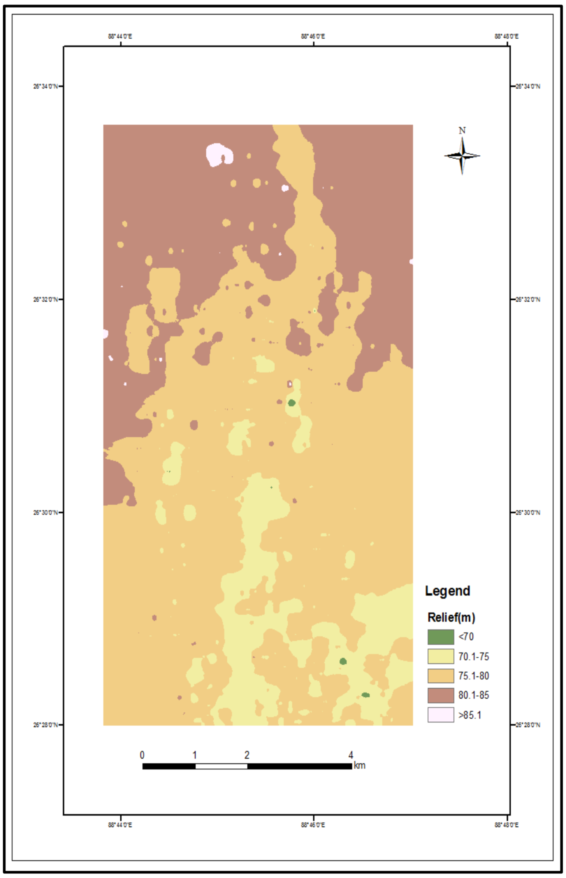

Fig_2. Relief of the study area.

Research Objectives:

1. Analysis of the scenario of dynamic shift of sandbars during last 12 years.
2. To understand the direction of shifting of active channel.

Methodology: This work mainly shows the bar shifting of part the Teesta River. In the initial stage this research mainly identifies the clear objective of the study. This work is totally based on GIS application in different ways. The methods used for the study is analysis of data and graphical representation of data. Software used in this research work is Arc GIS10.2.2. The study area is identified on Google Earth. KML file is created on the Google Earth. Then convert to KML on Arc GIs 10.2.2. Different bar formation provides different information of the study area. The present flow direction map creates by Arc GIs 10.2.2. It is the significant result for bar shifting in this place. When different bars are create in Arc GIs 10.2.2 than we are measurement of area and bar direction from Arc toolbar. At last here, the programs used in this work are Microsoft Word document and Microsoft Excel.

Responsible factors for dynamic changes of bar formation: From the given 12 years data of Teesta River, bar formation and corresponding diagrams provide the changing results of this particular area. Different year like 2014 and 2005 indicates the maximum area of bar formation and the other type of year of bar formation (area) the all-over same. Exceptionally year 2002 is a lower area out of total bar formation. On the other hand bar shifting and its directional changes provide new information. Stream velocity, sediment roughness, and nature of flow are also the responsible factors here. Sand and fine grain sediment make a big role in the deposition of bar formation. Large amount of floods and frequent nature of floods in lower part of Teesta River change their bar formation. From the google earth image observation along with previous data reports provide us with the scenario of flooding of the Teesta River. The nature of the drainage system of the Teesta River is an important factor for river channel shifting and bar shifting. Number of tributary carry large amount of sediment and provide deposition of alluvium. Local lithological factor, structural geology, and neo-tectonic activity are the other causative agents for the formation of bars. Himalayan mountain range is a young fold mountain; the instability is possible factor of this region. Tectonically this region is more active and it is responsible for source of sediment. Land slide and eroded material those are other factors for channel shifting and the result is dynamic changes of bar formation. Monsoon constitutes 80-90% rainfall out of the total rainfall in this area. So, during this time amount of water discharge, sediment load and flood is mainly responsible for bar formation.

Results: Based on various images and analysis of data thereafter we are provided with some important information regarding this region. From 2002 to 2014, during 12 years, the changes of bar formation indicate some fluvial dynamic characters and sediment character (fig_3-6).

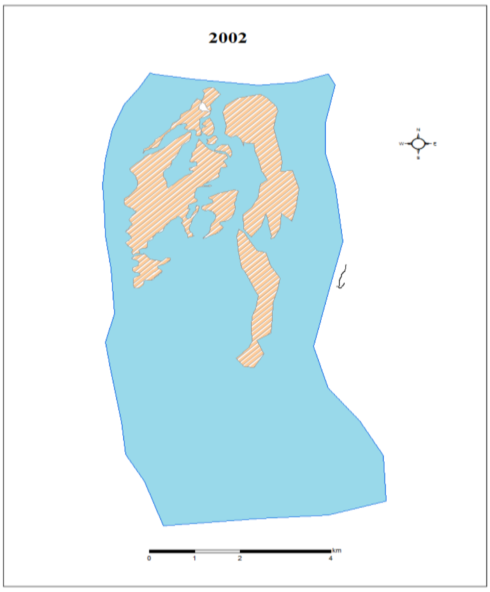

Fig_3. Bar formation of year 2002.

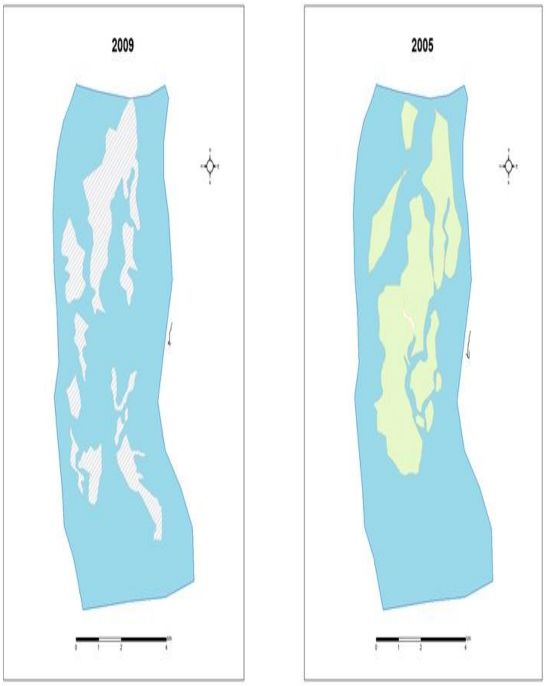

Fig_4. Bar formation of year 2005 & 2009.

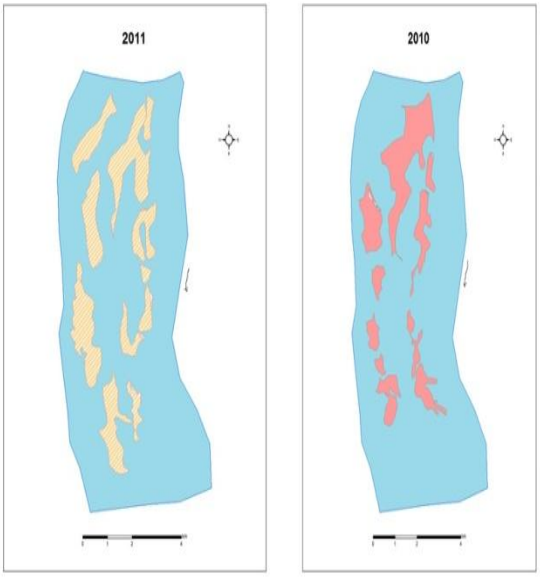

Fig_5. Bar formation of year 2010 & 2011.

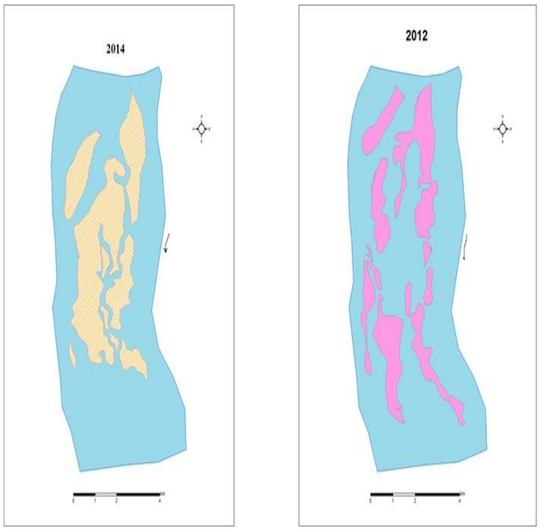

Fig_6. Bar formation of year 2012 & 2014.

The position of channel and the bar avulsion are related to the monsoonal water. Channel geometry, departure of channel and bar shifting in this area is also significant. The channel is braided and this micro landform deposition change from year to year. The year 2005 indicate the maximum deposition (35.56%) and the year 2002 provide the minimum deposition (20.83%) of bar. In year 2009, 2010, 2011and 2012 are almost same. The total area of the bar in 2014 represents 34.81% of the total area (Table_1).

Year	Bar area(sq.km)	Percentage of Bar
2014	12.53	34.81
2012	10.28	28.58
2011	8.73	24.56
2010	7.34	20.39
2009	9.01	25.03
2005	12.80	35.56
2002	7.50	20.83

Table_1. Showing percentage of bar in different years.

Main cause of variation of bars in this area is maximum rainfall due to monsoon and flooding. The possible results are heavy discharge and large amount of sediment supply. On the other side, year 2002, 2011, 2009 also indicates the lower area of bars out of total area (fig_7).

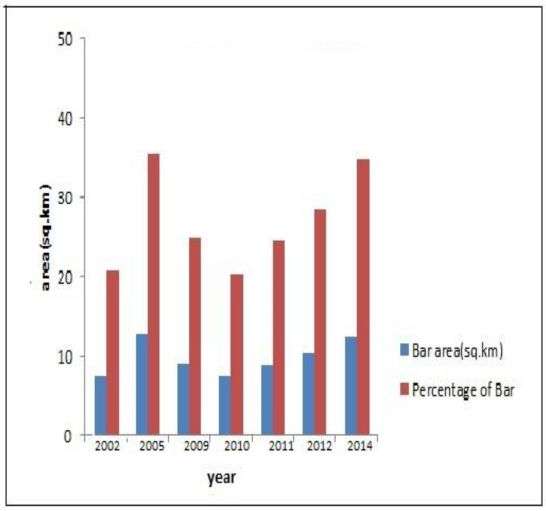

Fig_7. Distribution of bar formation in different years.

Primarily, Bar formation has changed year by year and the elevation of particular point of a bar is also different. Seasonally, incoming sediment and water velocity are affected over the bar and sometime sediment deposition is removed from one place to another. So, bar elevation profile have changes. On the other side, the directional change of bar provide the flow of water discharge. The mean bar direction are mainly south-east direction and south-southeast direction (Table_2), (Fig_8).

Year	Bar mean direction	Bar mean angle
2002	SSE	162° 30′
2005	SSE	168° 30′
2009	SE	142° 00′
2010	SE	148° 30′
2011	SSE	172° 00′
2012	SSE	156° 30′
2014	SSE	176° 30′

Table_2. Bar shifting on different angle in different years.

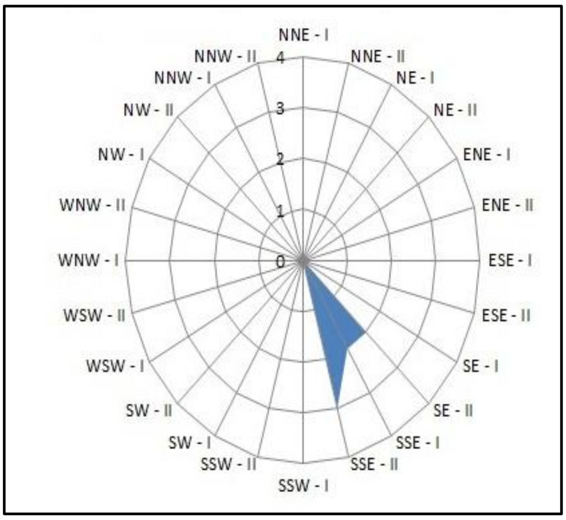

Fig_8. Mean directional changes of bars in different years.

The overall flow velocity nature indicates north to south-east direction. The flow direction indicates the overall regularity of flow and seasonal flow velocity depends on flashy water discharge and heavy rainfall (fig_9).

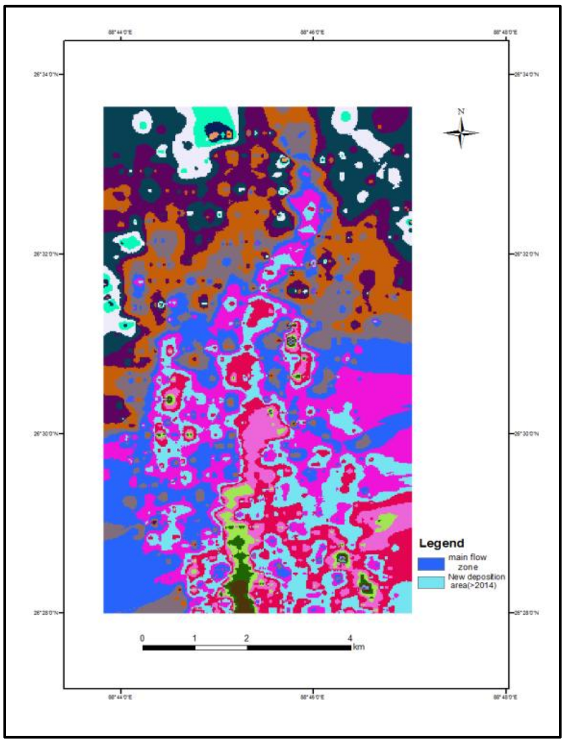

Fig_9. Present flow direction and new bar formation area (Feb, 2015).

But the bar stability of those years provide a new information of this area. Mainly less than 5% (approximate) area indicates the stable bar formation and other 95% bar area is shifted year by year .So, the overall bar instability provide strong relation between deposition of sediment and water velocity. From previous scenario and data provide the flood information and very strong water flow. The erosional power of the flow is most responsible factor for shifting of the bars. Here the zone of intersection is a common zone for stable bar. On the other side, zone of union provide the bar area, those area is an overlapping area but not common area or stable bar. Less than 27% (approximate) area was zone of union. The shadow zone of bar stability isn't too large. So, the union zone and the intersection zone are also related to each other in this area. However, the bar formation of this area was also instable (fig_10).

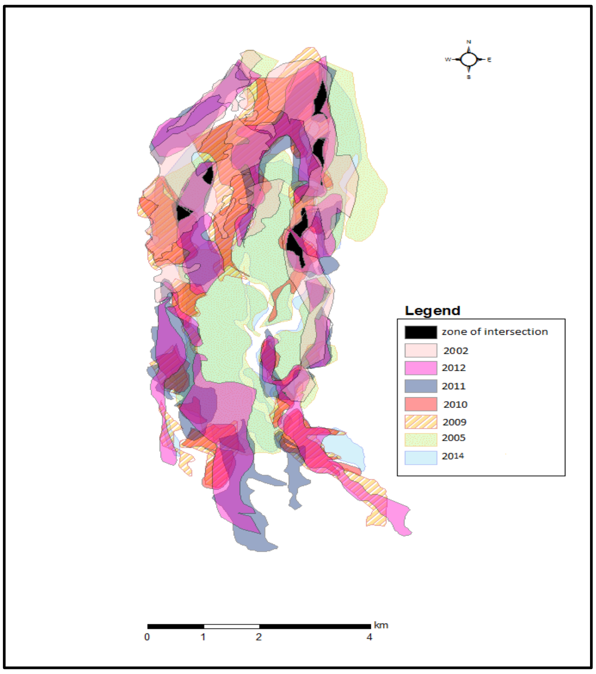

Fig_10. Stable bar area during last 12 years.

Conclusion: Detailed analysis of the bar formation and shifting of bars from 2002 to 2014 gives very important information. Flood in monsoon is the main factor for dynamic changes of the bar formation. The incoming sediment has an important role for the changes of bar. Sometime landslide due to cloud burst influence the source of sediment. The result shows, year 2002 and 2005 provide the maximum bar deposits and year 2014 represent minimum bar area. The incoming rain water of previous monsoon is the main factor for these changes. The sediment character of this area is mainly fine grained, coarse sediment and sand. The water flow and discharge are also dependent on incoming rainfall. The tectonic instability of this region is the other source of sediment. The hydraulic factor (water velocity, discharge) is also responsible for bar shifting. The temporal variation of sediment has a big role for bar shifting in this area The bar intersection and union method aids to understands the dynamic (shifting) nature of the bars. Changing and shifting of channel bars are not a new scenario of this region. It is a frequent observation amongst most of the rivers in the alluvial plain and Teesta being one of them.

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