Investigation on Spatio-temporal Changes in River Morphology of Lower Damodar between Durgapur barrage to Bardhhaman town over a time Period of 1990- 2015

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Abstract: Natural and anthropogenic activities in a river system affect the morphology of the river by influencing various factors like rate of sedimentation, compositions of the bed materials, vegetation etc. Damodar river has undergone morphological adjustment due to the human intervention in the form of construction of dams which controlled the river flow and also by other anthropogenic actions by the people settled nearby the river. This study presents the quantitative assessment of spatio-temporal changes in river morphology of lower Damodar between Durgapur barrage to Bardhhaman town over a time period of 1990 to 2015 by extracting the required information from digital satellite images in the GIS platform. Outcomes of the study indicate that due to aggradation of riverbed, the average cross-sectional area of the river in selected reach is reduced upto 50% and also on the basis of Geomatic techniques it is observed that approximately 16.5 km^2 area encroaches for agricultural purpose from the selected reach where sedimentation takes place within or nearby the river.

Keyword: Damodar river, River morphology, GIS, Erosion

1. Introduction

The river is the broad term for a watercourse in which numerous landforms develop through channel processes. The key fluvial developments are erosion, sediment transport and siltation. Erosion prevails in the upper catchments of a river basin (Brasington et al. 2000). The constituents transported to the downstream reaches in a waterway are sediment load. Weathering of rocks constituting slopes is the key source of the generation of sediment load and it is deposited in the form of alluvial plains. River morphology is a domain of science which deals with the variation of river hydraulic features and cross-sections due to erosion of river bank and deposition of sediments (Brasington et al. 2000). The study related to river morphology gives the idea about the shapes of the river and its spatial and temporal changes. Flow dynamics and transport of sediment load play key role in the in changing the morphology of river and morphology of river is described by channel shapes and channel systems (Akhtar et al. 2011). It helps us to address the various river problems in technical and logical perspective and for implementation of various water resources planning project. Therefore knowledge of morphological Studies is important in planning, designing and maintaining river engineering structures. River bank erosion can be measured by direct or indirect method. Field measurement in terms of linear rate of erosion, volume of sediment erosion and change in cross-sectional area comes under direct measurement. Analysis of satellite imagery and other conventional survey map with sediment record of different time period is the part of the indirect method (Richards 1988, Brasington et al. 2000). Natural or human interventions in a river will affect river morphology. In present times, Remote Sensing and GIS technology have been proven as a well-informed geospatial database producer for carrying out river morphological investigation. Mapping of river bank shifting, formation of new channel, bank erosion and sediments deposition at different scale can be done using multi-temporal satellite data. The objective of this paper is to examine the Spatio-temporal shifting of bankline in Damodar river over 25 years from Durgapur barrage to Bardhhaman town. In the present study sediment deposition and bank erosion area were calculated by comparing multi-date Landsat satellite imagery of 1990 and 2015 using GIS.

2. Study area

Damodar river is an important river flowing through the Jharkhand and West Bengal. Palamu hills of Chotanagpur plateau in Jharkhand is the starting point of Damodar river. It joins with the Barakar River near Dishergrah before falling into the rivers of Hooghly (Bhattacharyya 2011; Ghosh and Guchhait 2014). Stretch downstream to the meeting point of the Damodar River and Barakar river termed as lower Damodar (P.K.Sen 1991). In the present study, 75 km reach of Damodar river from Durgapur barrage to Bardhhaman town was selected. The average annual of the selected reach is 1313 mm. In the study area, 10 cross-sectional points were selected for calculating the change in the cross-sectional area. Surveyed cross-sections data were obtained from DVC for the years 1990 and 2015. River stretch from Durgapur barrage to Bardhhaman town of the Damodar river is selected for study purposes. The location map of the study area is shown in Fig.1.

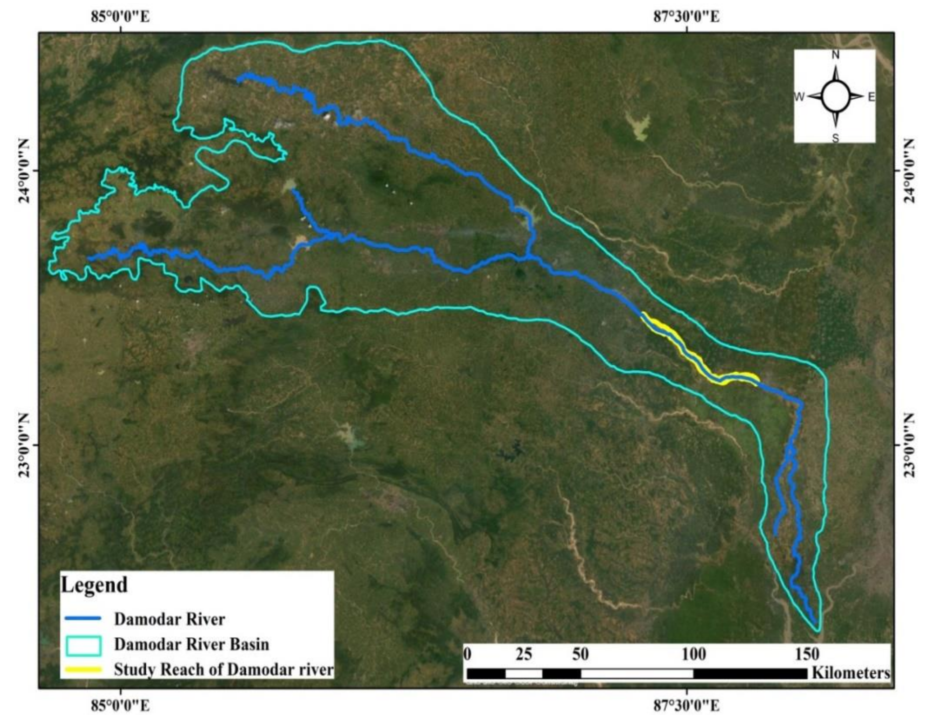

Fig.1 Map showing the study area

3. Methodology

In the present study Remote sensing and GIS application used for the identification of the changes in the river bankline, erosion and deposition along the Damodar river for the year 1990 and 2015 with the help of LANDSAT image. LANDSAT satellite imagery of selected reach for 1990 and 2015 was obtained from USGS earth explorer. The projection of satellite imagery is done using GIS in UTM45N. Landsat image of the year 1990 used as a reference map for detecting the change in bankline of the Damodar river. The first bankline of the Damodar river was prepared for the year 1990 after that for 2015 and based on these shapefile changes were calculated. Surveyed cross-sections data were obtained from DVC for the years 1990 and 2015. Based on these data change in cross-sectional area were calculated. Figure 2 shows the methodology.

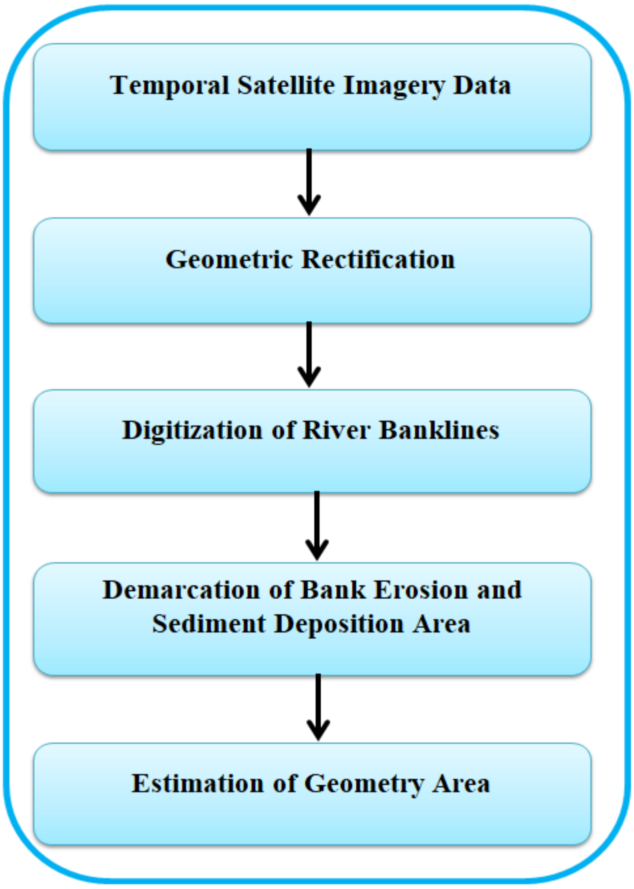

Fig.2: Map showing flowchart of the methodology

4. Result and Discussion

Natural and anthropogenic activities in a river system affect the morphology of the river. Rate of sediment transport, compositions of the bed materials, vegetation and other environmental factors will decide its morphology (Kale 2003). Channel morphology is not the creation of single-channel making flow frequency. Low flow plays part in fine deposit transport and bed formation whereas high flow contributes in modifying the channel morphology. Creation of hydraulic control structures like reservoir, barrage etc. affect the fluvial systems. Flow of the river below these control structure has been changed consequently it disturb the dynamic equilibrium of the river system. The Damodar River has suffered morphological alteration following the creation of the dams, the changes in channel morphology resulted from discharge reduction and diversions for irrigation through canals. Morphological alterations along the Damodar river due to flow control comprise both erosion of bank and deposition of sediment. Fig. 3 shows the bankline shifting in Damodar river from 1990 to the 2015 year taking 1990 as a base year. Shifting in bankline was identified by comparing Landsat satellite imagery of 1990 and 2015 year of same seasons. After that fluvial process based on the satellite imagery was demarcated. Four classes were demarcated which were as follows sediment deposition, erosion Vegetated island and anthropogenic encroachment. Fig. 4 shows the changes in river morphology and Fig. 5 shows the changes overlaid on satellite imagery. Contribution of each class in river morphology is as follows vegetated island 12 km^2, Bankline erosion 2.87 km^2, the encroachment of river system 16.5 km^2 and sediment deposition is 8.95 km^2. This study specified that due to constant deposition of riverbed making sequential reduction of carrying capacity. Generation of multiple channels with passage of time in the Damodar river due to flow concentration caused loss of land significantly by bank erosion. Riverbank erosion leads to progressive changes in the position of bankline as well as various changes within the channel. The development of bars and landmasses happened within fluvial system. The braided configuration in river grows after deposition of coarse sediment, which cannot be moved under limited circumstances of flow within the reach. This granular sediments turn out to be the centre for a bar development and consequently develops into a landmass made up of coarse as well as fine sediments. The creation of the bar deflects the mainstream in the direction of the banks and it cause bank erosion. Sediment carriage takes place over the bar surface while opening in the sideways channels drops the water level to expose the bar which then turn out to be separated. The landmass becomes stable by vegetation growth in the streams and experiences additional high stage siltation.

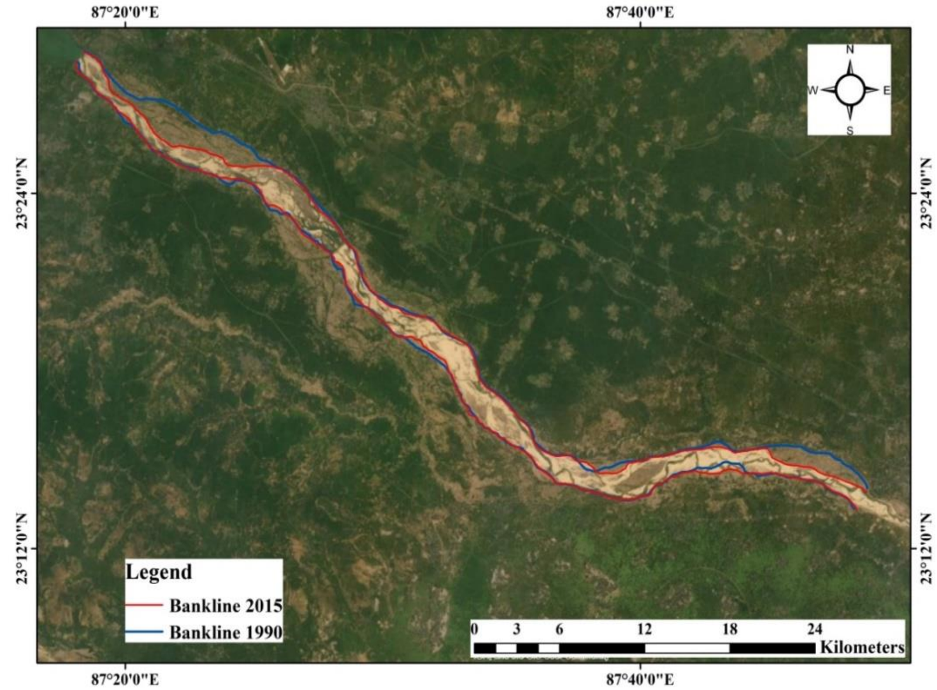

Fig. 3: Map showing bankline shifting between 1990 to 2015

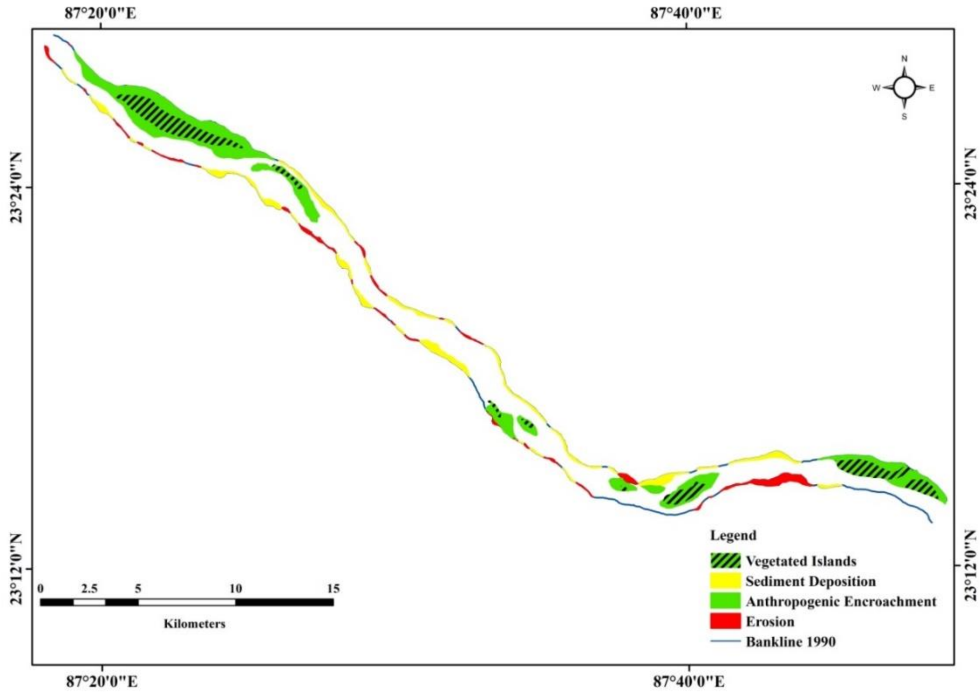

Fig. 4: Map showing changes in Damodar river morphology between 1990 to 2015

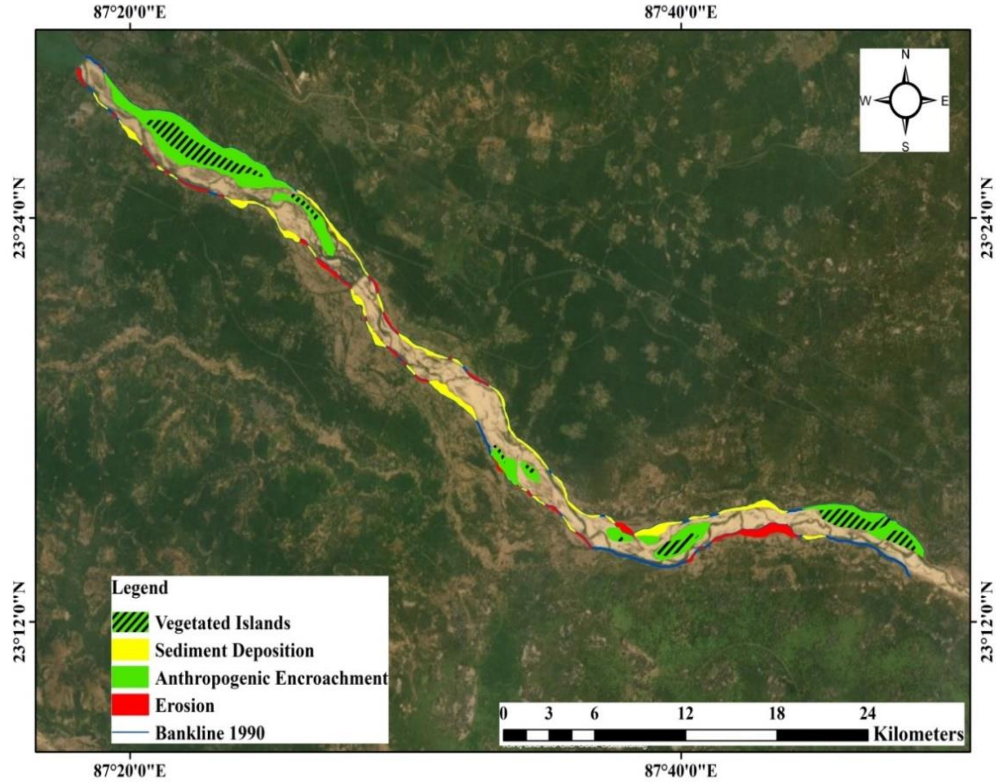

Fig. 5: Map showing changes in Damodar river morphology overlaid on satellite imagery

The carrying capacity of the Damodar river directed by a equilibrium among the erosive forces related with high discharges and the deposition processes composed with vegetation growth connected with lower discharges. The cause of adjustment in river is the unevenness among the progression of sediment movement and energy dissipation. Lower Damodar river bed is an alluvial riverbed. The carrying capacity of lower reaches of the river reduced due to heavy siltation downstream to Damodar barrage. DVC directed ground survey on lower Damodar river in 2015 to check the cross-sectional changes in river historical due river regulation by anthropogenic activities and compared it with that of 1990. Cross-section location of the present study shown in Fig. 5. In selected reach, comparisons of 10 cross-sections are presented in fig.6. Finding of the study shows decline in cross-sectional area from 1990 to 2015 due to siltation. River bed rises due to the deposition of sediments in the river. As the river bed rises due to sediment deposition subsequently, it affects the carrying capacity of the river.

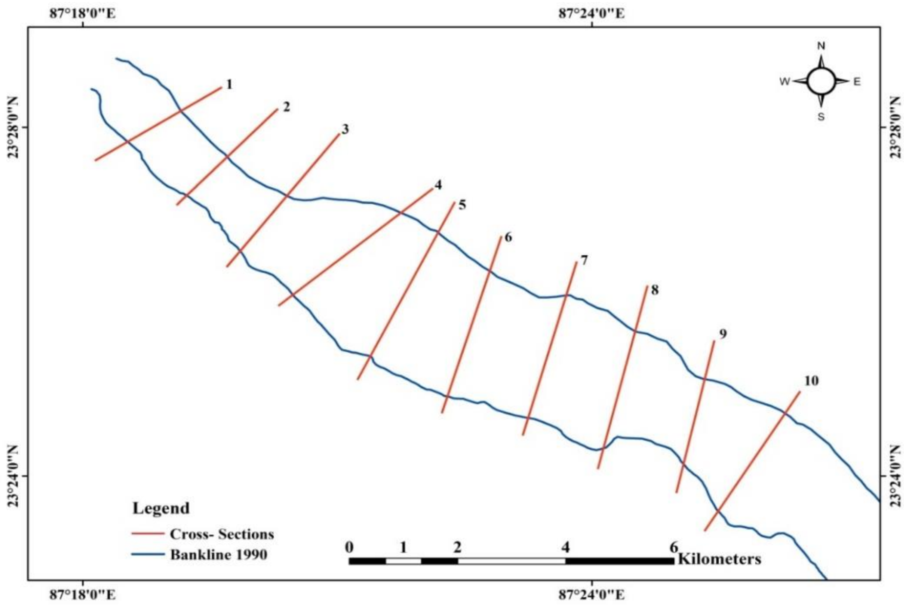

Fig.6: Map showing the location of cross-section.

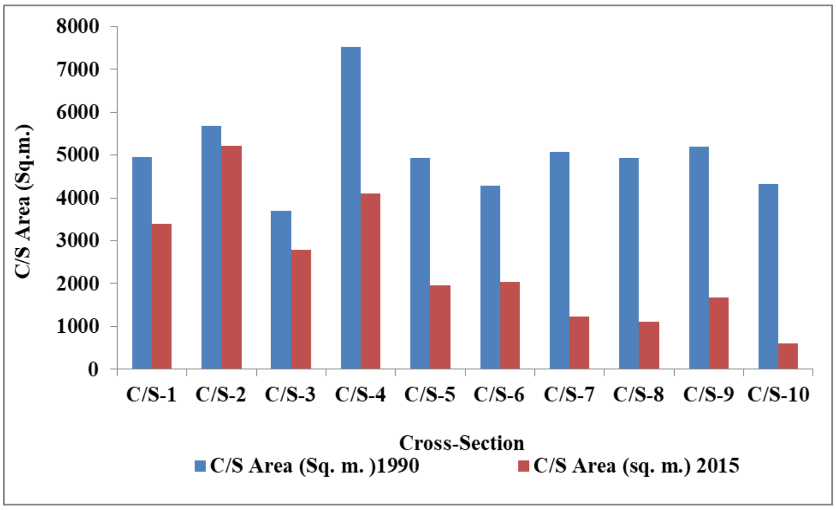

Fig.7: Cross-sectional area comparisons between 1990 and 2015

5. Conclusion

Investigation of spatio-temporal changes in Damodar river over 25 years from Durgapur barrage to Bardhhaman town was done in the present study. In this study sediment deposition and bank erosion area were calculated by comparing multi-date Landsat satellite imagery of 1990 and 2015 using GIS. Finding of the study shows that dam construction on the Damodar river affect the flow of the river consequently changes the fluvial system and forced it to enter a new dynamics. Morphological alterations along the Damodar river due to flow control include both erosion of bank and deposition of sediment. Four classes were demarcated with the help of Landsat satellite imagery of 1990 and 2015 year of same seasons which were as follows sediment deposition, erosion Vegetated island and anthropogenic encroachment Contribution of each class in river morphology is as follows vegetated island 12 km^2, Bankline erosion 2.87 km^2, the encroachment of river system 16.5 km^2 and sediment deposition is 8.95 km^2. This study specified that due to constant deposition of riverbed making sequential reduction of carrying capacity. Generation of multiple channels with passage of time in the Damodar river due to flow concentration caused loss of land significantly by bank erosion. Riverbank erosion leads to progressive changes in the position of bankline as well as various changes within the channel.

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