Challenges of River Corridor Management in Dynamic Braided River Systems

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Abstract Delineating River Corridor of a large braided river from the mainland is a challenging task, as diverse human activities are often observed within the sand bars and in the point bars of such river. Large spatiotemporal variation in their width adds further complexities to River Corridor management of braided reaches. Dynamic nature and hence the complexities in river corridor delineation are demonstrated by analysing pattern of progressive changes in the river cross-section of the Brahmaputra River within the period 1971 to 2011. Various prevailing human activities within the flow path of some of the large braided rivers of the world are presented to show its genuine utility. Scope and challenges of channelizing braided river are finally demonstrated through application of hydrodynamic model BRAHMA in a 130 km long braided reach of Brahmaputra River. Need of field-based research along with application of modelling techniques to utilize the river corridor of a braided river advantageously without disturbing the river ecology is advocated.

Keywords BRAHMA · Braided-river · River corridor

1 Introduction

Width of river corridor of a braided river system can vary significantly and, therefore, its management involves different challenges and opportunity. In some situations, defining a river corridor itself becomes challenging for a large braided river. Because of exponential population growth, pressure on the land is increasing globally leading to unaffordable cost of land. Apart from the factor of high cost, people started living within the river corridor in different ways due to certain other advantages. Floating village in the Mekong River, habitation and farming in sand bars of the Brahmaputra River are some of such examples. Because of the existence of different economic classes and different means of livelihood, high-rise building also may not serve as the ultimate solution to population pressure, at least in near future. Development of River

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S. Dutta and V. Chembolu (eds.), *Recent Development in River Corridor Management*,
Lecture Notes in Civil Engineering 376, https://doi.org/10.1007/978-981-99-4423-1_2

Front by encroaching into the existing natural river bank alignment in a systematic way is another example of augmenting natural river corridor. Construction of storage structure to augment river flow, collection of bed material through river mining for constructional activities also influences the natural flow characteristic of a river and influence river corridor. Maintenance of navigation channel is another challenge in braided river. With increasing concerns about ecology and water quality, utilizing river corridor for habitation or agricultural activities should also be regulated in a more scientific manner with due emphasis on river ecology. With advancement in the capability of mathematical model and geoinformatics, consequences of various activities mentioned above or impact of any river training work for maintaining river corridor can now be investigated more conveniently. Need and scope of managing river corridor using advanced technology are presented in this chapter.

2 Variation in River Corridor of Braided River

Because of high variation in the seasonal precipitation and in longitudinal gradient, Himalayan Rivers of the sub-tropical region experience high seasonal variations in flow and sediment load. This leads to frequent changes in the river course. Management of River Corridor in a braided river is therefore quite challenging because of huge spatiotemporal variation in their width. In some situations, defining a river corridor itself becomes challenging for a large braided river. While such variations generally create problem to people residing near the river, people with their long experiences have also utilized the river taking advantage of such spatial variation. A morphological study carried out for the Brahmaputra River has shown some interesting facts about spatiotemporal variations of River Corridor in braided river system.

Pattern of progressive changes in the river cross-section, particularly in terms of the total section width, was analysed in the Brahmaputra River starting from Sadia in the east to Dhubri on the west by dividing the river reach into 65 cross sections. Data referred for the purpose are tabulated below (Table 1). It was observed that the river width in some sections has increased significantly during 1970–2011. However, at the nodal points, which exist primarily due to having either hill or rocky formation on both sides, the river width does not change. Some stable bank reach with clay formation was also observed in this reach of the Brahmaputra River. Figure 1 shows the decadal temporal variation of width in different sections of the river Brahmaputra from 1973 to 2011.

From Fig. 1, it is clear that for some of the reaches (sections 2-4, 20-22, 35-37, 51-53, 58-60, 62-64), the change in width exceeds 5 km, and, in some cases, change is reaching nearly 10 km. As such, defining or fixing a river corridor for large braided river, even with a range of few kilometres, needs extensive observation and will have to be made reach specific.

Table 1 Data used for temporal change detection of Brahmaputra River

Year	Data used (Toposheets/satellite data)
1973–1974	GSI Toposheet; 1:50,000 scale
1976–1980	Landsat MSS; 80 m resolution
1993–1995	IRS 1B LISS 1; 72.5 m resolution
2003–2004	IRS P6 LISS 3; 23.5 m resolution
2008–2011	IRS P6 LISS 3; 23.5 m resolution

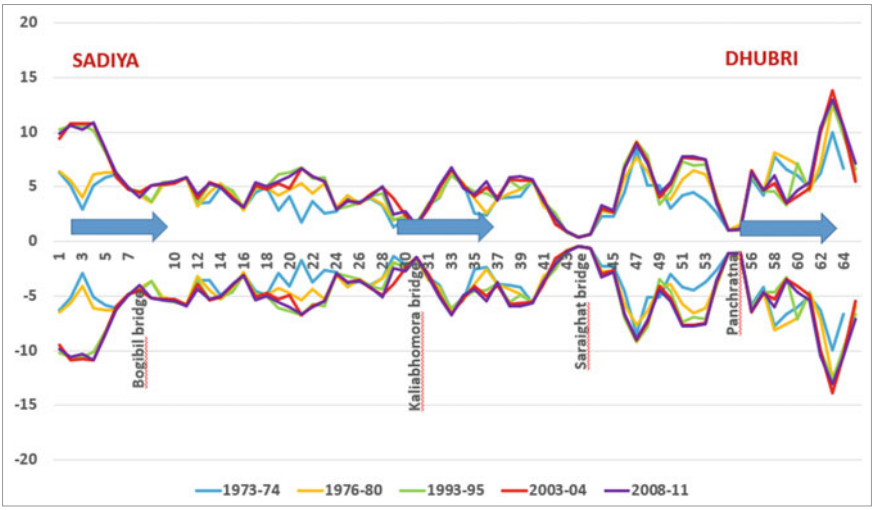

Fig. 1 Plot of river width (km) of Brahmaputra in 65 sections from Dhubri to Sadia

3 Utility of River Corridor

Because of exponential population growth, pressure on the mainland is increasing globally leading to unaffordable cost of favourable land. Because of this, many communities, more particularly those falling in the category of low-income group, encroach into the bank line of river to utilize the land in the lean period for their diverse benefits. Apart from the factor of high cost, people also started utilizing the river corridor in different ways due to certain other advantages. The possible impacts of such utilizations and their relevance to the concept of river corridor in case of large braided river are presented below.

Floating village in the Mekong River and Tonle-sap Lake is an example of utilizing river corridor for living purpose and business activities. However, this kind of utilization basically uses the water bodies of the river and, being floating structures, they allow flow even in the location where they exist, particularly when such floating structures are located in a flowing river and not in the lake portion with relatively stagnant water. There can be direct dumping of solid waste and wastewater from

these establishments into the river and thus can affect the water quality as well as the flow cross-section of the river.

Habitation and farming in the mid sand bar or in the point sand bar attached to the river bank are common practices in the Brahmaputra River, which is highly braided in nature. Because of the availability of fertile land within the river, people carry on cultivation in such sand bars almost on a regular basis during the period of lean flow. Some of the sand bars have now become almost permanent with well-established vegetation and people have started living in these sand bars. In some cases, people also claim such sand bars as their own land, as they have lost their original land due to river erosion. These forms of river utilization have direct relevance to the concept of demarcating river corridor, as people utilize the land masses located within the bank line of the river. The presence of these forms of river utilization has raised a question as to whether we can really demarcate a river corridor in large braided river and can keep it completely free dedicating the space solely for movement of flow alone. Considering the prevailing practices, we can also think of allowing such activities within the river corridor in a more planed manner by analysing the process scientifically and arranging it in a way that ecological disturbance to the system is minimum. A study carried out on utilization of sand bar [3] of river Brahmaputra is perhaps the first attempt in this direction. While optimal combination of crops for deriving maximum benefit from sand bar cultivation can be decided considering various constraints, impact of such agriculture on the water quality also should be considered with due emphasis. For example, the use of chemical fertilizer should not be allowed in sand bar cultivation and they can affect the aquatic habitat.

River mining is another common exercise of braided river, which changes the river bathymetry. Need of soil for various constructional activities cannot be denied. In developing countries, such activities will continue for many years to come. Collection of river sand is therefore essential for such activities, as the alternative to this at similar cost is the hill cutting, which is far more detrimental to environment and ecology. While the concept of sustainable mining can easily be applied in a small river, quantification of sustainable mining is quite a difficult task in case of braided river. Barman et al. [1] carried out some study to identify best sediment transport equation applicable in mining pit constructed in laboratory using sand of river Brahmaputra. Continuous monitoring of aggradation, degradation, sand bar formation and their washing out is essential for taking a scientifically acceptable decision about sustainable river mining in braided river. With denudation of hills in the upper catchment, sediment influx and subsequent deposition of the same in the river bed is increasing at a faster rate reducing flow carrying capacity of the river with time. Considering this, river mining in a sustainable manner should be permitted in braided river and more research in this direction is necessary to understand sediment dynamics in a better way.

Construction of storage structure or diversion structure to augment river flow is very common in almost all countries. Generally, such structures are not made in the mainstream of large braided river, rather they are made in the tributary of such large braided river. Such tributaries can also take a braided form in its alluvial reach. Operation of such reservoirs can influence the flow and significant flow variation, both

seasonal and diurnal, can be experienced at downstream. Flow variation becomes more significant when the flow from one tributary is diverted and transferred for power production to power house located on the bank of another tributary to have higher head difference. Such river flows through a narrow channel during the period of normal flow, as power release goes to another tributary, and therefore, people start different activities in the free space of the river corridor. In countries having low population density, such river reaches are generally barricaded and no activities are allowed in such segments. However, in a developing country, having high population density, it becomes extremely difficult to regulate and prohibit activities in such river reach. Sensor-based real-time monitoring and coupled reservoir operation and hydrodynamic modelling [2] can help in providing a dynamic warning system to facilitate safe utilization of such otherwise risky corridor of river reach.

4 Scope of Channelizing Braided River

Large braided river generally moves in multiple channels even in the flood period except for the nodal points, where the river covers its full width. Even though the river does not cover the entire width, its banks suffer severe erosion because of existence of active near bank channel. Therefore, to get rid of erosion problem and also to acquire land from such wide braided river, scope of channelizing such river through a designed waterway of smaller width is now in active consideration for troublesome river reach of braided channel. Navigation in braided river is another important aspect, so far management of river corridor is concerned. For maintaining waterway, it becomes necessary to dredge the identified channel to maintain require depth. Channelization can, therefore, help in navigation as well. So far narrowing down of channel width is concerned, it is possible to reduce the width to a much narrow width without increasing the velocity alarmingly. For example, the present width of the Brahmaputra River varies approximately from 2.00 km to 20.00 km. A mathematical model study of Brahmaputra River carried out by us for a length of about 130 km starting from Bhumuraguri near Tezpur to Pandu near Guwahati has shown that the width of the river reach can be reduced to a much smaller width without increasing the velocity significantly. The maximum velocity computed by the hydrodynamic model BRAHMA-2D (Braided River Aid: Hydro-Morphological Analyzer) considering the entire width is 3.65 m/s, which changes to 3.53 m/s, 3.73 m/s and 3.74 m/s for maximum channel width of 5.00 km, 4.00 km and 3.00 km, respectively. Although from the consideration of velocity, channelization appears to be a feasible task, many other socio-economic considerations need to be examined for establishing feasibility from socioeconomic and ecological viewpoint. For example, many small streams flow into the braided river from the nearby areas. People use small boats to move from the interior area to the main river through these small channels. Such connectivity has lots of implications and can affect the livelihood of people. Therefore, any measures taken for augmenting or maintaining river corridor should be done with a detailed investigation.

5 Conclusion

Encroachment into the waterway of river by human beings for various needs has raised a concern among scientific community regarding need of maintaining river corridor. The problem becomes more complex in developing country because of economic need of encroaching into river corridor. Because of the existence of different economic classes and different means of livelihood, high-rise building also may not serve as the ultimate solution to population pressure, at least in near future and therefore, such encroachment into unfavourable habitats like river corridors and hills will continue in a haphazard manner if not planned scientifically. Unplanned urbanization and deforestation in hilly area will also indirectly contribute to the reduction in river corridor space by releasing excessive sediment from the catchment to make the river shallow. With increasing concerns about ecology and water quality, utilizing river corridor for habitation or agricultural activities should also be regulated in a more scientific manner with due emphasis on river ecology. With advancement in the capability of mathematical model and geoinformatics, consequences of various activities mentioned above or impact of any river training work taken up for maintaining river corridor can now be investigated more conveniently. Therefore, we should always take recourse to such technology to utilize the river corridor advantageously without disturbing the river ecology.

References

1. Barman B, Sharma A, Kumar B, Sarma AK (2017) Multiscale characterization of migrating sand wave in mining induced alluvial channel. Ecol Eng 102:199–206. Elsevier
2. Devi D, Baruah A, Sarma AK (2022) Characterization of dam-impacted floods hydrograph and its degree of severity as potential hazard. Nat Hazard. https://doi.org/10.1007/s11069-022-05253-7
3. Talukdar G, Sarma AK, Bhattacharjya RK (2020) Mapping agricultural activities and their temporal variations in the riverine ecosystem of the Brahmaputra River using geospatial techniques. Rem Sens Appl Soc Environ. https://doi.org/10.1016/j.rsase.2020.100423