Advances in River Science 2011

18-21 April 2011
Swansea, United Kingdom

Accounting for sediment, habitat and morphology in integrated river management

Evolution of rivers in subsiding Sylhet basin: northeast of Bangladesh

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Introduction

The Sylhet basin, which is a low lying subsiding area, is subsiding at a rate of 3-6 mm per year including a 1-2 mm per year soil compaction rate. This area is positioned at the northeast corner of Bangladesh (Figure 1). The basin is starving of sediment since the avulsion of the Brahmaputra River which was the main source of sediment input for this part of the country. Avulsion of the Brahmaputra River has changed the hydro-morphological regimes of the rivers of the area and has thus put the rivers in a position to adjust with the changed situation, which has triggered several changes in river courses. Any interventions for improving the lives and livelihoods in this area require proper understanding of the physical process. Historical maps, Digital Elevation Model and time-series satellite images are analyzed to understand the evolution processes in the basin area.

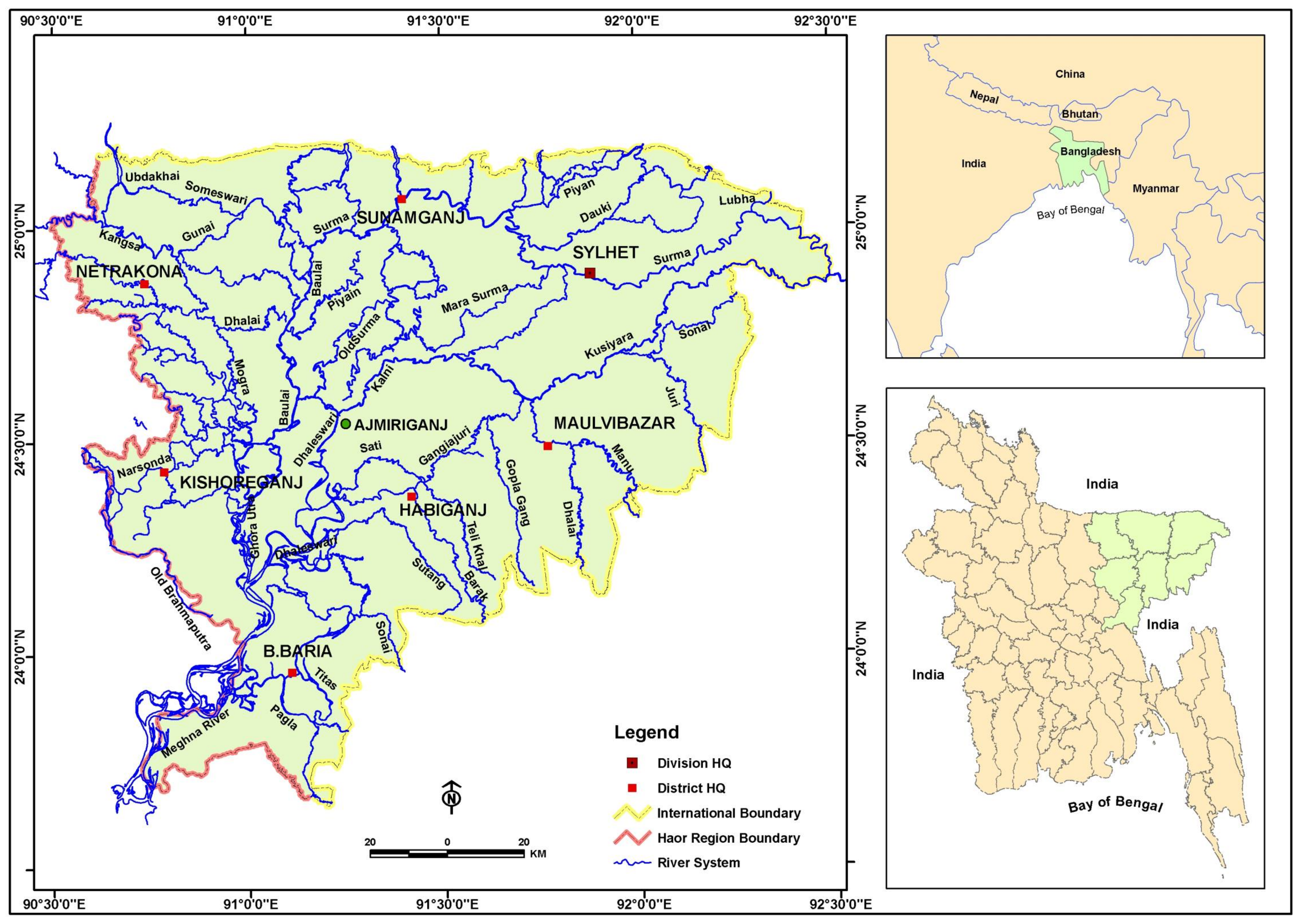

Figure 1: Index Map

Geological Setting of the northeast region of Bangladesh

The Bengal basin started to form through filling with sediment by a process of deltaic sedimentation into a slowly subsiding tectonic basin. After being fractured from the northeast Indian Plate it sunk below the sea-level during Oligocene times (Figure 2). The Sylhet Trough is a sub-basin of the Bengal Basin and consists of 13-20 km thick alluvial and deltaic sediments underlain by much older genesis and granitic rocks. Goodbred and Kuehl (2000) estimated the sediment thickness during the Holocene based on the analysis of borehole data and carbon dating information. The long profile of sediment deposition during the Holocene passing through the Sylhet basin up to the sea indicates that higher deposition occurred at the northern boundary of the basin (Figure 3), which suggests a higher subsiding rate.

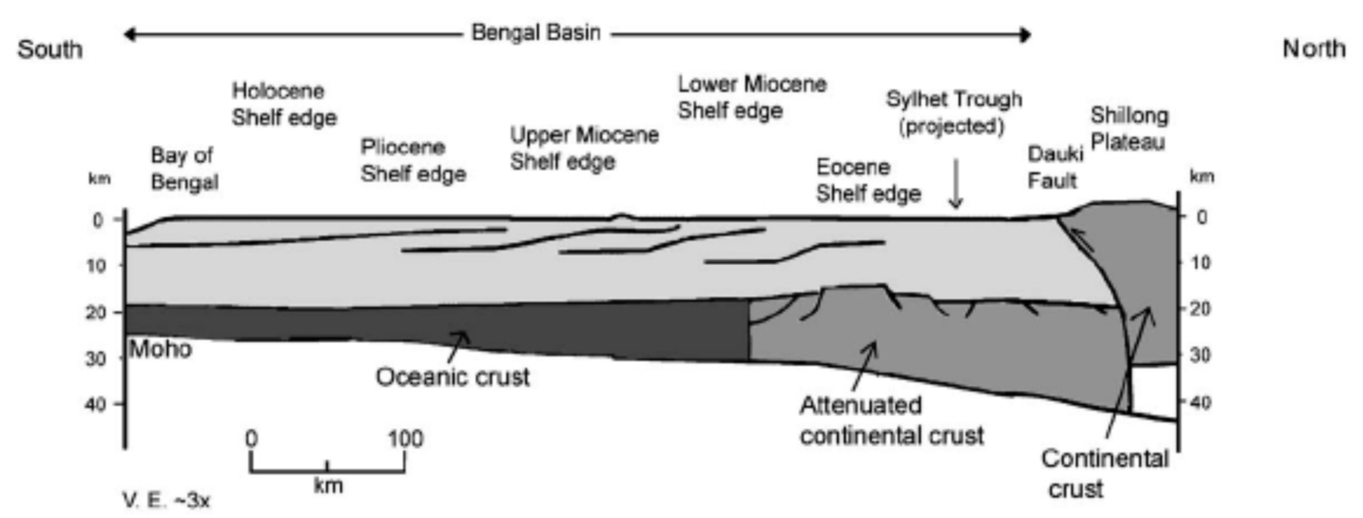

Figure 2: Schematic cross-section of the Bengal basin; N– S, through the Shillong Plateau, after Murphy (1988)

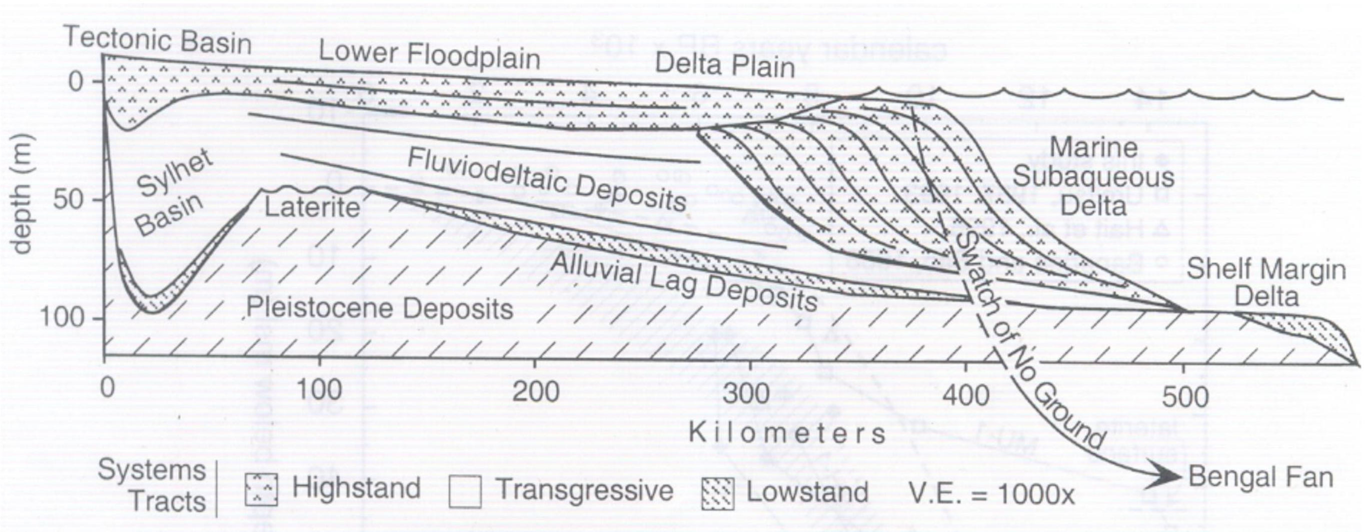

Figure 3: Generalized sequence stratigraphy for the Late Quaternary Ganges-Brahmaputra delta after Goodbred and Kuehl (2000)

River System

The avulsion of the Brahmaputra River from the east of the Madhupur tract to the west has pronounced effects on the shifting characteristics of rivers like the Surma, the Kushiyara, the Someswari, the Mogra and the Kangsha (Figure 1). The Surma coming from India flows westward and turns southward after falling into the basin. The Kushiyara River, south of the Surma, is another large river from the east which flows almost west and turns south at Ajmiriganj. After flowing south both the Surma and the Kushiyara meet at the southern boundary of the basin. The Someshwari, the Kangsha and the Mogra of the western part meet the basin, flows along the north-south direction and meet with Surma in different places within the basin.

Defining the Sylhet Basin

Flooding in the Sylhet basin is very frequent. RADARSAT images of seven years from 1998 to 2010 have been analyzed and flood extents have been superimposed to assess the flood incidence and mostly flood prone locations in the basin area (Figure 4). Incidence of inundation is found to occur almost every year at several locations. At the north-south axis of the area incidence of flood is almost 100%, which covers a vast area of 4,500 km^2. The Digital Elevation Model of 300 m resolution shows that the elevation of this area is very low. Although the rivers flow in this low area from north to south direction, the topography shows a negative slope (Figure 5).

The east-west sections of the Sylhet basin shows that land elevation from both the east and west sides starts to drop at a very high rate of about 15 cm to 30 cm per kilometer compared to the typical topographic slope of other plains in Bangladesh and there is a flat bottom width which varies from 30 to 50 km. The long profile shows that the sudden drop of elevation from the alluvial fans in the north and the deepest part of the topography exists close to that area. Ground elevation towards the south increases about two meters.

Both cross and long profiles and DEM exhibit a depressed basin which had a shallow and narrow outlet in the south. The regular shape of the basin was interrupted by the levee of the present or old river courses. The boundaries of the Sylhet basin and basin bottom were delineated based on the discontinuity of slopes. The alignments of the rivers are nearly toward the east-west direction in the basin slopes, while the rivers are flowing in the north-south direction at the bottom (Figure 6). These rivers have divided the large Sylhet basin into several flood basins one to two meters lower than their levees.

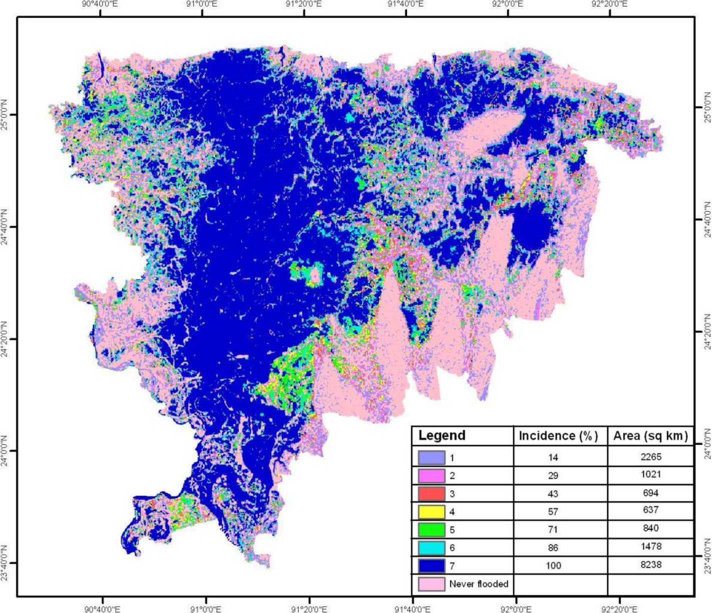

Figure 4: Incidence Map

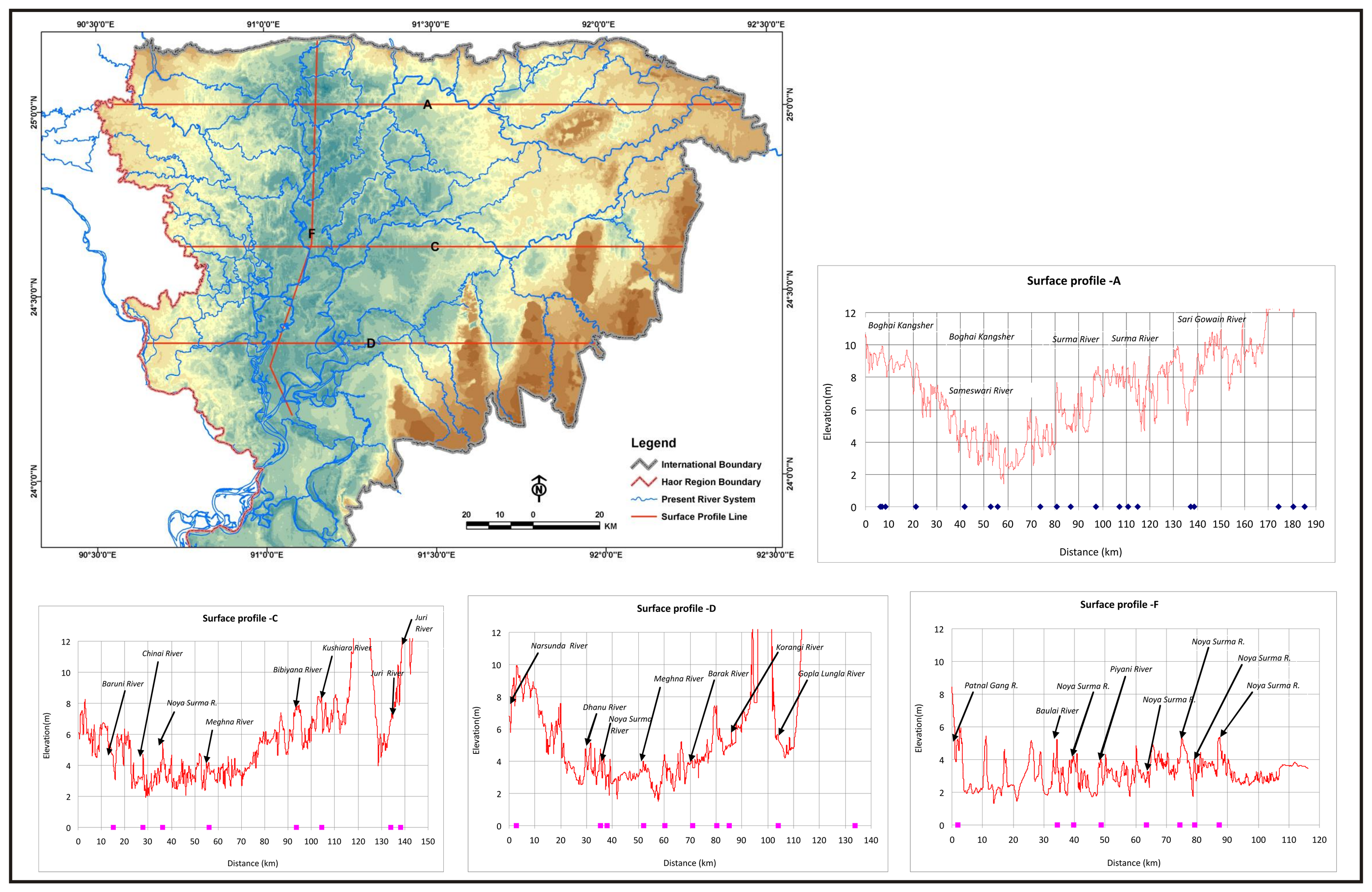

Figure 5: Surface, cross and long profiles

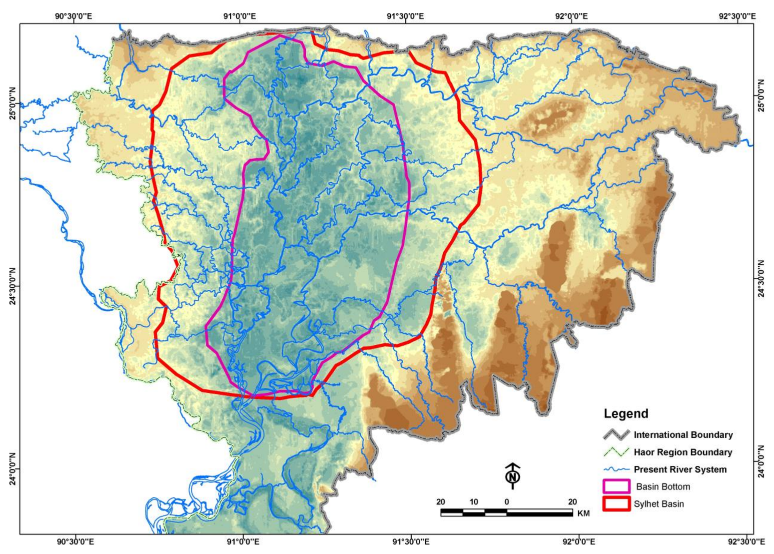

Figure 6 : Delineation of Sylhet basin

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Evolution of the River in the Sylhet basin

After the avulsion of the Brahmaputra River, the Sylhet basin receives very little sediment through the rivers from the Meghalaya Hills and the Surma and Kushiara rivers. It is thus likely that subsidence has become the dominating process in the Sylhet basin, especially at the northern part of the basin. It is likely that the net subsidence during the last 200 years might be reflected on the shifting of the river courses. A comparison between the present river courses and that of the end of the eighteenth century shows that the rivers from both the west and the east shifted towards the north before turning towards the south, which is possibly an indicator of net subsidence in the north (Figure 7).

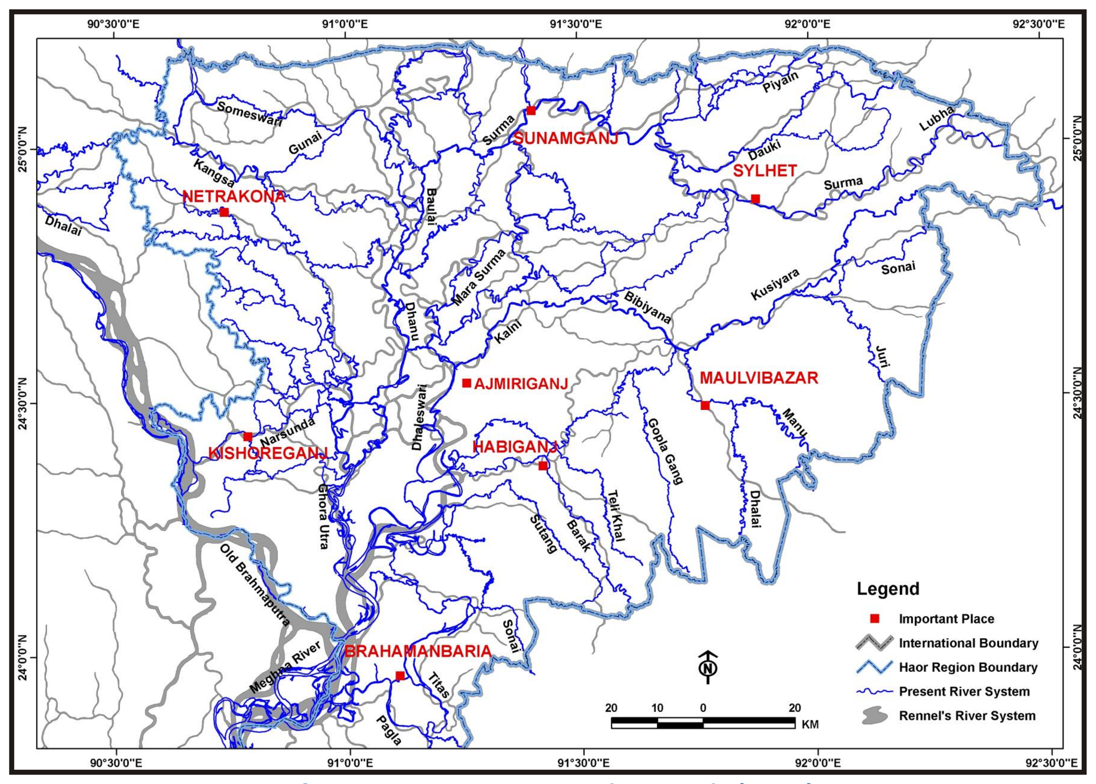

Figure 7: Comparison of present river course with Rennels (1776)

Two main processes of channel avulsion are active in the Sylhet Basin–one process is related to the hydro-morphological changes in the whole basin, and the other is the local flood basins. The high rate of subsidence or building of high levee triggers the avulsion of the major rivers like the Surma, the Kushiara or the Kangsha towards the deeper part of the basin.

After reaching a certain height of the levee, a new channel often starts to develop through the flood basin. The process of formation of such rivers is demonstrated in Figure 8. This process is valid for the channel evolution into the flood basin and also for the avulsion of the large rivers in the Syhet basin. Within a few years to a few decades the rivers divide the flood basins. The newly formed rivers may also create a passage for the avulsion of large rivers as well. The time-scale of the formation of new rivers is mainly dependent on sediment caliber and concentration and hydrological regime.

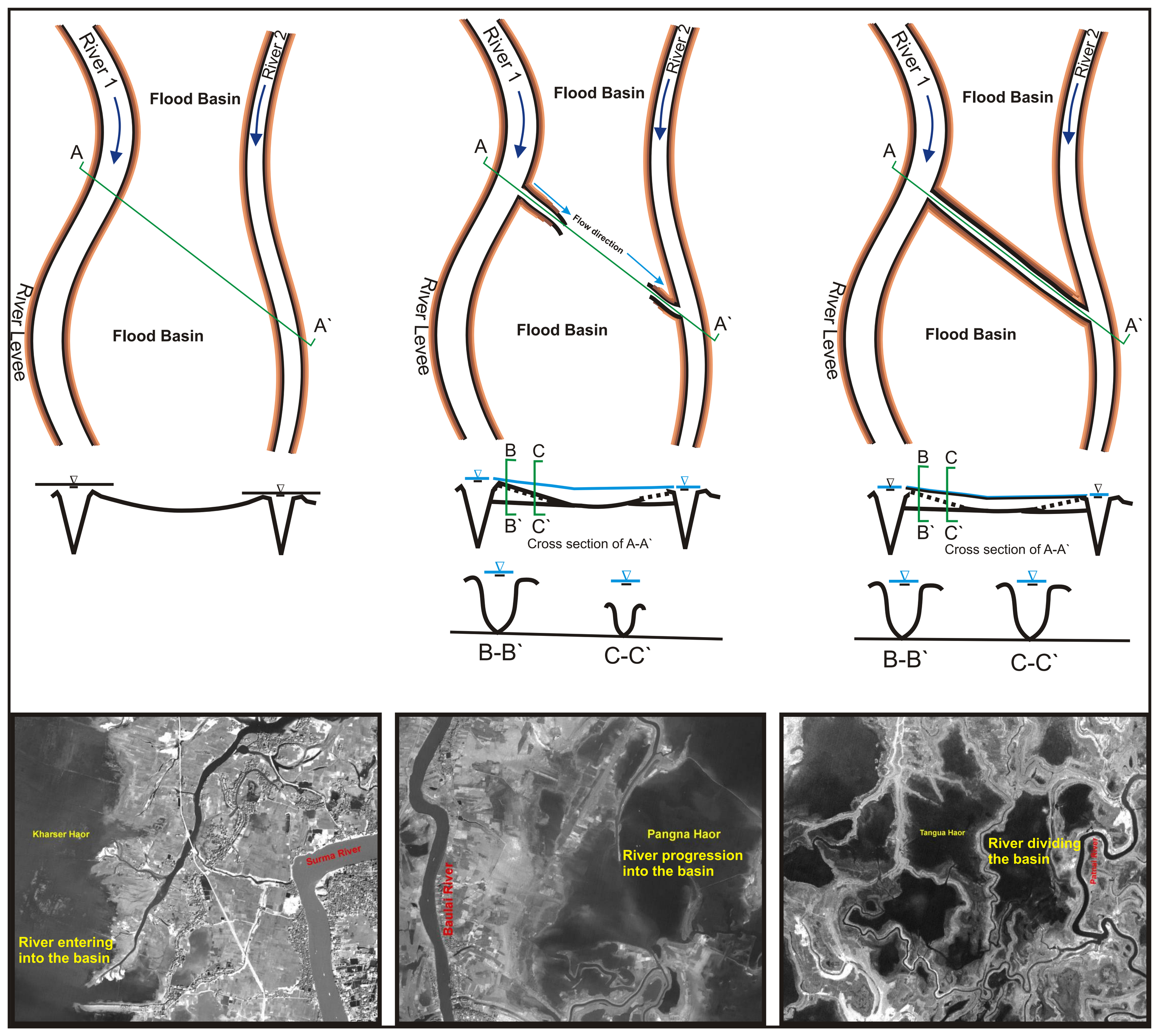

Figure 8: Process of formation of rivers in a flood basin

Conclusion

The Sylhet basin is a subsiding basin having an area of 8700 km^2. Avulsion of the Brahmaputra River about 200 years ago put the rivers in a changed hydro-morphological condition. The large rivers from the east such as the Surma and the Kushiyara shifted towards the northwest direction and rivers from the west such as the Kangsha and the Someswari shifted towards the northeast. The river avulsion is frequent both in basin scale and in local flood basin scale. Understanding of the processes of channel avulsion and subsequent prediction is useful for any intervention in the Sylhet basin for the development of the lives and livelihoods in the area.

References

Murphy, R.W., 1988; Bangladesh enters the oil era, Oil and Gas Journal, Feb. 29, 76–82.

Goodbred Jr., S.L., Kuehl, S.A., 2000; Enormous Ganges-Brahmaputra sediment load during Strengthened early Holocene monsoon, Geology, Vol. 28, 1083-1086.