

Excessively large-scale slumping of Sajnekhali creek banks in the Sundarban delta mangrove complex: a consequence of rising sea

Recent rise in sea level at alarming rates (0.9–2.4 mm/year)^{1,2} is a matter of serious global concern in general and for a country like India in particular with about 5700 km of coastline. The devastating effects of rising sea level on coastal environments and ecosystems have already enforced several mitigation measures like doubling the height of coastal barrier in the Netherlands and shifting of human settlements away from the eastern coastal plains of northern America, and have also initiated prioritized research studies across the globe. Concrete field evidences known suggesting rising sea condition are submerged coral reefs, mangrove peat, beach rocks, beach ridge systems, littoral and valley-mouth terraces^{3–6}. Field evidences in support of rising sea in the Bay of Bengal include retreating coastline, submerging delta front islands, destruction of mangroves^{7,8}, etc. The present study reports some evidences of large-scale slumping of Sajnekhali (near Gosaba and Baghmara) creek banks (Figure 1) in the Sundarban delta complex, West Bengal, which could be attributed to rising sea level.

The Sundarban delta complex is represented by an intricate network of rivers, rivulets, creeks and multi-generation deltas and islands (Figure 1). The thick mangrove forests here are patterned into islands by deeply meandering and reticulate creek systems having variable width (from a few metres to about 500 m) and length (from a few metres to several kilometres). In general, all the creeks show high-angle (30–60°) banks with U-shaped cross profile (Figure 2). During low tide the banks of creeks expose 3–4 m thick mud surface over which mangrove plants thrive. All the creeks experience strong tidal (ebb and flow) current of extremely muddy water.

The Sajnekhali creek is about 20 km long and 300–400 m wide. It flows in a meandering course defining a nearly semi-circular shape (Figure 1). The average tidal velocity of flow at 20 km/h is strong enough to cause considerable lateral erosion of soft and muddy creek bank sediments. The following processes and features (Figure 3) were observed along the Sajnekhali creek along several kilometres.



Figure 1. Google map showing the location of the studied Sajnekhali creek.

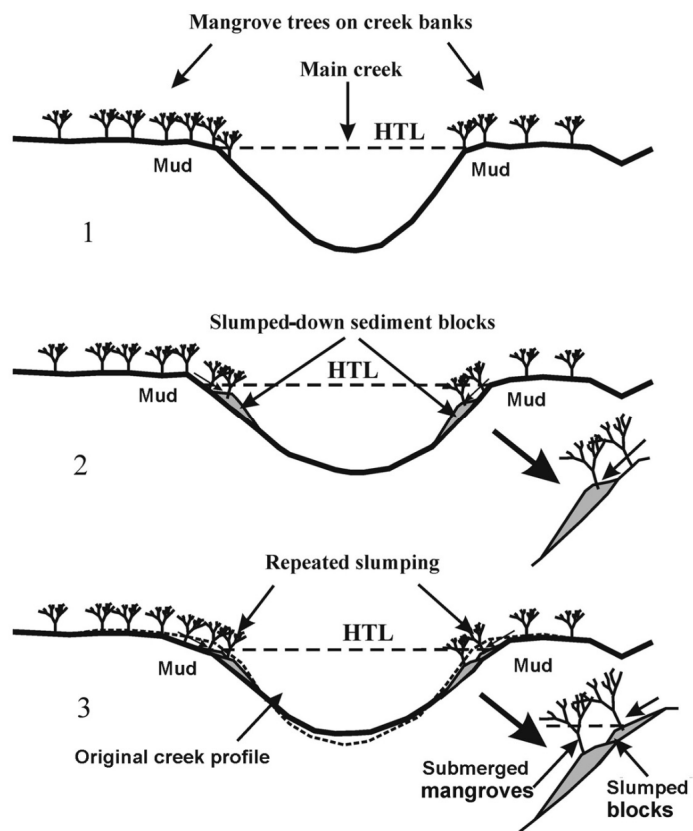


Figure 2. Schematic serial creek profiles (1–3) explaining the mechanism of repeated slumping of creek bank sediment blocks under the influence of gravity and undermining of sediment by strong tidal current. Note inclination of tree heads towards water on slumped-down sediment blocks and widening of creek profile.

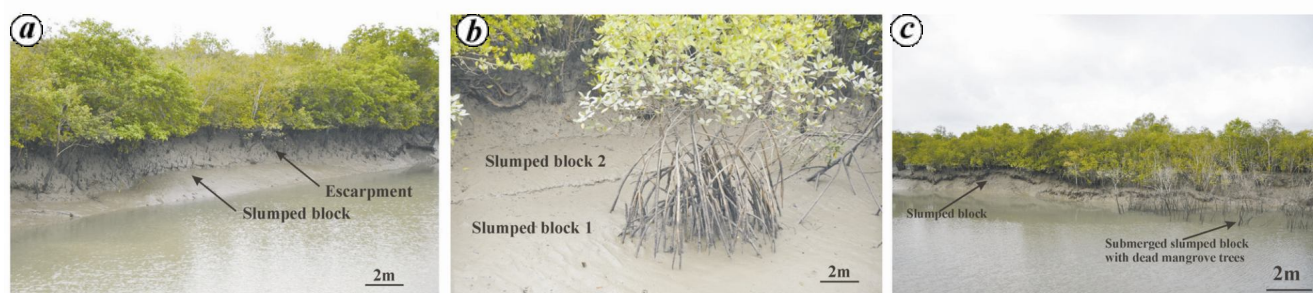


Figure 3. Creek bank slump structures being developed on either side of the Sajnekhali creek in the eastern Sundarban Delta Complex. *a*, The slumped sediment block and adjacent terrace; *b*, Repeated slumping of creek bank sediment; *c*, Long and linear slumped block with overlying perished mangrove plants.

1. Linear slumped blocks of creek bank sediments with vertical bluffs on the new exposed bank. These features are observed on both the creek banks all along the length of 20 km of the creek (Figure 3 a).
2. At places, there was sequential slumping resulting in stepped appearance of banks (Figure 3 b).
3. Over the slumped blocks mangrove plants are tilted and partly or fully submerged and eventually perish because of continued submergence underwater (Figure 3 c).
4. The sediments of the slumped blocks are gradually flowing away along with mangrove plants because of strong tidal currents.
5. Similar processes and features are observed along other creeks in the neighbourhood of the Sajnekhali creek.

The presence of soft and muddy bank sediment, steep bank slope (30–60°), strong ebb and flow of the tidal current (20 km/h), undermining of over-saturated bank sediment through side seepage are all normally conducive to bank failure. However, in the case of Sajnekhali creek and in its neighbourhood, the slumping is abnormally excessive, though the creek

banks are somewhat stabilized by the presence of mangrove forest. Observations reveal that this process is not limited to Sajnekhali creek alone, but is also prevalent along the creeks in the neighbourhood (e.g. Gosaba, Sandeshkhali and Baghmara creeks).

Several mathematical models have been proposed to evaluate coastal effects due to sea-level rise². In the creek systems close to the sea with ebb and flow of tides, though occasional slumping of creek banks is normal, excessive and abnormal slumping at a regional scale can be linked to rise in sea level/base level and the resultant lateral erosion of creek banks. Under normal circumstances when creek bank erosion takes place, there is deposition on the other side or on the bed. In the present case there is no deposition, but only erosion. So, it can be inferred that this excessive creek bank erosion could be due to rise in sea level. A detailed quantitative study in the Sundarban delta complex on this particular aspect of creek bank erosion is recommended.

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