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Identification of spatio-temporal patterns and controls in surface water salinity of the Bengal Delta, southern Bangladesh

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Human and ecosystem health within the southern coastal region of Bangladesh, like many other Asian deltas, are at risk from rising salinity linked to climate change and anthropogenic activities. Consumption of drinking water with elevated sodium has been linked to increased rates of hypertensive disorders and infant mortality, with further impacts on human wellbeing resulting from increased soil salinisation, reduced crop yields and decreased ecosystem services. Increased salinity in southwest Bangladesh has been linked to reduced upstream discharge of the River Ganges. Furthermore, widespread salinisation is predicted in the region through modelling of IPCC climate change scenarios. However, a comprehensive and integrated understanding of the controls on salinity within the delta is currently lacking. This study investigates links between various hydromorphological and anthropogenic drivers on the observed spatio-temporal distribution of salinity in southern Bangladesh.

A large amount of data (e.g., surface water salinity, water level, river discharge) is available from the Bangladesh Water Development Board (BWDB). Dry season data (Nov – May) covering 54 sites from 2000 - 2017 were used to identify areas impacted by salinity and to analyse temporal changes in spatial distribution. Hydromorphological parameters were established utilising Landsat 8 image data and digital elevation models developed from Shuttle Radar Topography Mission (SRTM) data available from the United States Geological Survey (USGS). Selected parameters include; elevation, distance from primary river source, distance from the coast, and stream order. Water level data was also incorporated to reflect relative tidal influence. Data processing and preliminary modelling was carried out within the R computing environment, with multiple regression models constructed to show relative correlation of variables to salinity.

Results show high salinity (>10 mS/cm) is routinely found in the southwest of Bangladesh within a region of low elevation (<3 m above mean sea level) and downstream of the Gorai-Madhumuti River bifurcation. Lower salinity (<2 mS/cm) is observed where elevation exceeds 3 m (amsl) and is consistently <1 mS/cm at elevations >6 m (amsl). Inter-annual variation within the southwest is high, with salinity >25 mS/cm extending up to 120 km inland. Lower salinity values (<2 mS/cm) are recorded within the southeast despite the regions proximity to the coast, this is largely due to increased freshwater input from numerous channels. Multiple linear regression models show a strong relative influence of increased distance from the primary river source with increased salinity, which is also correlated with lower elevation. Regions with persistently high salinity are primarily located in areas of low elevation where freshwater input from the Ganges is dispersed through bifurcation of distributary river channels.

Spatial variation within observed river salinity results from complex interactions between multiple geomorphological and hydrological factors. Identification and quantification of regionally specific primary drivers will help guide adaption strategies and focus mitigation efforts on vulnerable areas.