Understanding wetland dynamics using geostatistics of multi-temporal Earth Observation datasets

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Wetlands are important but fragile ecosystems. Half of the world's wetlands are already lost and most of the remaining ones are in a degraded state. Such wetlands warrant immediate management and restoration works. Further, with changing land-use patterns and climate, it is essential to monitor the dynamics of such wetlands, which is in turn driven by hydrology, vegetation pattern, and geomorphology. All biogeochemical processes in the wetlands are influenced by hydropattern and water level. Understanding vegetation-hydrology nexus is an important challenge in wetland management and restoration activities. In addition, the spatial characterization of the fragmentation and shrinkage is essential to manage the wetlands.

A geostatistics-based assessment of a large floodplain wetland namely the Kaabar Tal in eastern India has been performed using multi-temporal Landsat datasets in a GIS (Geographical Information System) framework by applying linear regression method and Mann-Kendall Trend Tests. With an area of 51 km$^2$ and a total catchment size of 250 km$^2$, the Kaabar Tal is the largest wetland of the north Bihar in the East Ganga Plains of India. A historical assessment of the wetland spanning over four decades (1976-2016) has been performed by formulating a novel framework which encompasses the following six indicators: (a) pixel-wise net trend assessment of wetness and vegetation, (b) seasonal hydropattern, (c) average drying rates, (d) seasonal and annual patch dynamics (fragmentation assessment), (e) annual shoreline shrinkage rates, and (f) multi-temporal geomorphic mapping. To understand the influence of these indicators in different parts of the wetland, a sectorial approach has been followed by dividing the wetland in nine zones, and each zone was ranked from least to most degraded based on the six indicators. A linear combination of these ranks was used to decide the overall degradation rank of the zones. The different zones of Kaabar Tal were ranked in terms of increasing order of degradation. The western zone W, the most degraded zone, has suffered the highest quantum of encroachments coupled with the highest rates of shoreline shrinkage. The central zone C ranked least on the degradation scale; however, it is still degrading, and the wetness trend is 'very severely decreasing' while the vegetation (or eutrophication) trend is 'severely increasing.'

The framework developed in the current work is based on the freely available satellite datasets, easily implementable remote sensing and GIS approaches, and well-known geostatistical methods. Further, the method can be adapted to analyze the hydrogeomorphic dynamics and degradation scenarios of any wetland systems, irrespective of their geographical and climatic settings.