Linking hydrological security and landscape insecurity in the moribund deltaic wetland of India using tree-based hybrid ensemble method in python

Swades Pal [a], Satyajit Paul [b]

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Abstract

The main goal of the present study is to develop hydrological security model (HSM) and landscape insecurity model (LIM) of the wetlands in moribund deltaic floodplain using a tree-based hybrid ensemble method. The study employs four tree-based novel hybrid approaches such as Random Forest (RF), Extremely randomized forest (ETC), gradient boosting (GBM), and eXtreme gradient boosting (XGB) for modelling hydrological security and landscape insecurity. Six hydrological parameters such as water presence frequency (WPF), water depth, Hydro-duration, variability of water depth using standard deviation, distance from rivers, and regression slope of wetland depth have been employed for hydrological security modelling, and nine landscape parameters such as aggregation index, patch cohesion index, edge density, mean radius of gyration arithmetic, largest patch Index, mean perimeter-area ratio, percentage of landscape, splitting index, total edge have been employed for landscape insecurity modelling. The performance of each model is evaluated by estimating precision, recall, F1-score, Matthew's correlation coefficient (MCC), and the area under the receiver operating characteristic (ROC) curve (AUC). The outcomes revealed that GBM and XGB pose the highest accuracy level (AUC more than 0.95 for HSM and 0.85 for LIM), followed by RF, ETC models. Models' outcome shows that about 50% of wetland area belongs to the low hydrological secure zone. From phase I to phase III this area increased by more than 18%. The area under high hydrological secure zones reduces by about 55%. Landscape insecurity in this region raised by 41% from phase I to phase III. Linking HSM and LIM shows that reduction of hydrological security is responsible for enhancing landscape insecurity in this region.

Introduction

Wetlands of the Gangetic delta region provide multidimensional ecosystem services (Nicholls et al., 2016). Floodplain wetlands in this region, provides shelter for rich biotic community, microphytes, periphytons, planktons, insects, fishes and diverse flora and fauna community (Davidson et al., 2019; Pal et al., 2020; Sarkar et al., 2021). Wetlands of floodplain region also act as flood-buffer, aquifer rechargers, pollution controllers, and sources of safe drinking water (Sarkar et al., 2020: Talukdar et al., 2020). About 6% of the global wetland contributes 40% of the global ecosystem services, and floodplain wetland has a major role in there (Janse et al., 2019; Mitsch, 2010). India is blessed with good number of floodplain wetlands and its aquatic and economic resources (Dutta et al., 2016; Sarkar et al., 2020). Due to the rising demand of riparian stakeholders in the economic, sociocultural, and infrastructural sphere from the past few decades, floodplain wetlands of India faces unprecedented challenges like habitat degradation, loss of native community, abolition of biotic forms etc. (Sarkar and Borah, 2018; Singh and Sinha, 2020). Perforation, dissection, dissipation, and shrinkage are the four major processes by which wetlands are downgraded from oligotrophic state to eutrophic state (Flowers et al., 2020; Wiegand et al., 2021). These processes in long term deeply affect landscape ecology and enhance landscape insecurity of the wetland area (Das Sarkar et al., 2020; Talukdar et al., 2020a, Talukdar et al., 2020b). The socioeconomic and infrastructural activities together provoke ecological loss and cause and increase landscape insecurity through fragmentation (Gbanie et al., 2018; Saha and Pal, 2019b).

Landscape fragmentation occurs due to the segregation of large spatial entities into numerous small patches (Legrand et al., 2017; Wei et al., 2020). Wetland fragmentation is one of a kind of fragmentation that leads to degradation and gradual loss of wetland area (Cosentino and Schooley, 2018; Pal and Saha, 2018). Wetland fragmentation enhances habitat vulnerability and also threatened the natural landscape ecology (Brauer and Beheregaray, 2020; Pal and Paul, 2020; Sarkar and Mondal, 2020). Studies like Li et al.