Research article

Modelling hydrological strength and alteration in moribund deltaic India

Satyajit Paul [a], Swades Pal [b]

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https://doi.org/10.1016/j.jenvman.2022.115679

Abstract

The Ganga-Brahmaputra moribund deltaic floodplain region hosted many socio-ecologically precious freshwater wetland ecosystems experiencing hydrological alteration. The present study aimed to model hydrological strength (HS) to show the spatial difference and account for the degree and direction of hydrological alteration of Indian moribund deltaic wetland in three phases e.g. (1) phase I (1988–1997), (2) phase II (1998–2007) and phase III (2008–2017). Three key hydrological parameters, such as Water Presence Frequency (WPF), water depth, and hydro-period were considered for hydrological strength modelling using two ensemble Machine Learning (ML) techniques (Random Forest (RF) and XGBoost). Image algebra was employed for phasal change detection. Hydrological strength models show that around 75% of the wetland area was lost in-between phases I to III and the loss was found more intensive in moderate and weak HS zones. Existing wetland shows a clear spatial difference of HS between wetland core and periphery and river linked and delinked or not linked wetlands. Regarding the suitability of the ML models, both are acceptable, however, the XGBoost outperformed in reference to applied 15 statistical validation techniques and field evidence. HS models based on change detection clarified that more than 22% and 55% of the weak HS zone in phases II and III respectively were turned into non-wetland. The degree of alteration revealed that about 40% of wetland areas experienced a negative alteration during phases I to II, and this proportion increased to 63% in between phases II to III. Since the study figured out the spatial nature of HS, degree and direction of alteration at a spatial scale, these findings would be instrumental for adopting rational planning towards wetland conservation and restoration.

Introduction

Severe water crisis, climate change, and rapid degradation of biodiversity of different ecosystems are among the utmost global risks to human well-being (World Economic Forum, 2019). Wetland being a crucial hydrological component with paramount ecological importance, can help to reduce and overcome such crises up to a certain extent (Ma et al., 2021). It plays a significant role in flood regulation, groundwater recharge, carbon sequestration, drinking water supply, microclimate regulation, and many other socio-economic and ecosystem services (Vári et al., 2022; Jakubínský et al., 2021). Such services can support effective human well-being and targeted, sustainable development by mitigating ecological and economic risks (King et al., 2021; Dou et al., 2021). Agreeing with the environmental significance of wetlands, the importance of wetland ecosystem services is often neglected (Saha et al., 2021). The direct-indirect human interventions through channel modification (Pal and Sarda, 2021b), habitat encroachment (Ballut-Dajud et al., 2022), overutilization and exploitation of wetland water (Xiqin et al., 2022), and economic and infrastructural developments (Thamaga et al., 2022) along with climate change (Konni et al., 2022) triggered the rate of wetland loss and degradation (Ramsar Convention Secretariat, 2016).

The global trend of wetland indicates that ~35% of wetland area was lost within just 45 years from 1970 to 2015 (Fluet-Chouinard et al., 2021). Though both coastal and inland wetlands are highly exposed to rapid degradation, the inland wetlands area declined by about 75% from the 1700 to 20th and 21st centuries (Fluet-Chouinard et al., 2021). According to the Space Application Centre (2011) report, India has lost 3% of wetland area every year while 33% of existing wetlands suffered from hydrological instability, among which the majority of the wetlands belong to floodplain areas (Sarkar et al., 2021, Das Das Sarkar et al., 2020).

Ramsar Convention Secretariat (2016) identifies habitat encroachment through agricultural and infrastructural developments, eutrophication, pollution, and climate