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Assessing wetland habitat vulnerability in moribund Ganges delta using bivariate models and machine learning algorithms

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Abstract

The present study aims to measure wetland habitat vulnerability (WHV) in moribund deltaic part of India using ten conditioning parameters e.g., WPF, water depth, change in WPF, change in depth, APF, seasonality, fragmentation, distance from river, distance from road, and settlement area. For developing suitable models integrating the data layers, four bivariate models namely, logistic regression (LR) frequency ratio (FR), Shannon entropy (SE), and weights of evidence (WoE), and four machine learning (ML) algorithms namely, artificial neural network (ANN), J48 decision trees (DTs), random forest (RF), and reduced error pruning (REP) tree have been used. Results reveal that the 20 km^2 (11.13%) to 35.70 km^2 (19.88%) and 18.43 km^2 (10.27%) to 29.01 km^2 (16.16%) of area to total wetland area has emerged as high and very high habitat vulnerable zones in phase II, whereas, 17.60 km^2 (11.72%) to 31.10 km^2 (20.75%) and 16.23 km^2 (10.82%) to 28.61 km^2 (19.07%) of area found as high to very high vulnerable in phase III in case of both bivariate and ML models. Accuracy assessment of using AUC (ROC), Kappa, and overall accuracy have confirmed the acceptability of all the models but result of machine learning based model is more precise than bivariate models. Frequency ratio from bivariate models and REP tree from machine learning models are found to be the most acceptable. Sensitivity analysis shows that WPF factor followed by depth of wetland are the most important contributing factors. So, application of machine learning model for vulnerability study is recommended.

Introduction

Wetland is well known precious bio-physical system. It is a major component of natural capital includes wide range of socio-economic and ecological services to human being (Assessment, M. E., 2005, Thapa et al., 2020, Cao et al., 2018). The direct and indirect of wetland services includes water supply, flood control, water storage and purification, micro climate regulation, carbon sequestration, soil erosion privation, disaster risk reduction, and most importantly biodiversity protection (Xu et al., 2020, Thapa et al., 2020, Meng and Dong, 2019, Leon et al., 2018, Xu and Chen, 2019). As a source of fresh and nutrient rich water wetland supports many essential biological productivity (Prakash and Singh, 2019). According to Ramsar Convention on Wetlands report (2018), 6% of world wetlands provides habitat for more than 40% of all world's species including one third of threatened and endangered species (Finlayson and Davidson, 2018; Ramsar Convention on Wetlands, 2018). In spite of vast ecological importance, wetland faces rapid threat than any other ecosystems due to population growth, agricultural extension, urbanization, and industrialisation (Pal and Talukdar, 2018, Saha and Pal, 2019a, Saha and Pal, 2019b). Extension of agricultural land towards wetland partially affects its habitat initially, but urbanization and industrialisation destroyed the habitat completely (Zhou et al., 2020, Saha and Pal, 2019a, Saha and Pal, 2019b). According to Davidson (2014) 87% of wetland area have been lost since 1700, and this rate increased up to 71% in late 1900 (Darrah et al., 2019, Dixon et al., 2016). It is estimated that rate of wetland loss increased 0.78% annually since 1990, due to rapid transformation, pollution and fragmentation (FAO, 2016, Dixon et al., 2016). Wetlands of many world's regions like, Mekong delta of China, Willamette valley, Oregon and floodplain regions of Indian and Bangladesh lost at greater extent, during this period (Mao et al., 2018, Saha and Pal, 2019a, Saha and Pal, 2019b; Munishi and Jewitt, 2019, Mondal and Pal, 2018). In India 2–3% of wetland loses every year, which is much higher than the global wetland loss (Prasher, 2018). According to the study of Space Application Centre (2018) every year 32.5% wetlands of India shrinks seasonally showing the direct effect of rainfall regime. Anthropogenic pressure on wetlands of India increases conflicts between wetlands and its stakeholders,