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Modeling Floodplain Vegetation Response to Groundwater Variability Using ArcSWAT Hydrological Model, Moderate Resolution Imaging Spectroradiometer - Normalised Difference Vegetation Index Data, and Machine Learning

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Abstract : This study modelled the relationships between vegetation response and available water below the soil surface using the Terra's Moderate Resolution Imaging Spectroradiometer (MODIS) generated Normalised Difference Vegetation Index (NDVI) and soil water content (SWC) data. The Soil & Water Assessment Tool (SWAT) interface known as ArcSWAT was used in ArcGIS for the groundwater analysis. The SWAT model was calibrated and validated in SWAT-CUP software using 10 years (2001-2010) of monthly streamflow data. The average Nash-Sutcliffe Efficiency during the calibration and validation was 0.54 and 0.51, respectively, indicating that the model performances were good. Twenty years (2001-2020) of monthly MODIS NDVI data for three different types of vegetation (forest, shrub, and grass) and soil water content for 43 sub-basins were analysed using the WEKA, machine learning tool with a selection of two supervised machine learning algorithms, i.e., support vector machine (SVM) and random forest (RF). The modelling results show that different types of vegetation response and soil water content vary in the dry and wet season. For example, the model generated high positive relationships (r=0.76, 0.73, and 0.81) between the measured and predicted NDVI values of all vegetation in the study area against the groundwater flow (GW), soil water content (SWC), and the combination of these two variables, respectively, during the dry season. However, these relationships were reduced by 36.8% (r=0.48) and 13.6% (r=0.63) against GW and SWC, respectively, in the wet season. On the other hand, the model predicted a moderate positive relationship (r=0.63) between shrub vegetation type and soil water content during the dry season, which was reduced by 31.7% (r=0.43) during the wet season. Our models also predicted that vegetation in the top location (upper part) of the sub-basin is highly responsive to GW and SWC (r=0.78, and 0.70) during the dry season. The results of this study indicate the study region is suitable for seasonal crop production in dry season. Moreover, the results predicted that the growth of vegetation in the top-point location is highly dependent on groundwater flow in both dry and wet seasons, and any instability or long-term drought can negatively affect these floodplain vegetation communities. This study has enriched our knowledge of vegetation responses to groundwater in each season, which will facilitate better floodplain vegetation management.

Keywords : ArcSWAT, machine learning, floodplain vegetation, MODIS NDVI, groundwater
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