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Spatio–temporal variation of species diversity in groundwater dependent ecosystems: Insights from the Rao's Q

Climate change, landcover change, and groundwater over–abstraction threaten the existence of Groundwater Dependent Ecosystems (GDE), despite these environments being biodiversity hotspots. Species diversity in GDEs requires routine monitoring to conserve the biodiversity status and preserve the ecosystem services in these environments. However, in–situ monitoring of species diversity in extensive or transboundary groundwater resources remains a challenge. Inherently, the Spectral Variation Hypothesis (SVH) and, remotely sensed data provide a unique opportunity to monitor GDEs response to seasonal or intra–annual environmental stressors, which is key in achieving national or regional biodiversity targets. This study presents the first attempt towards monitoring intra–annual spatio–temporal variations in species diversity in the Khakea–Bray Transboundary Aquifer using Landsat 8 OLI Operational Land Imager (OLI) derived metrics. The coefficient of variation was used to measure spectral heterogeneity, which is a function of environmental heterogeneity. The coefficient of variation was used to calculate the α- and β measures of species diversity (Shannon–Weiner Index and the Rao's Q, respectively), whilst monotonic trends in the spatio–temporal variation of species diversity were derived, using the Mann–Kendall non–parametric test. Lastly, to explain the spatio–temporal variation of species diversity we used a set of environmental variables along with a machine learning algorithm (random forest). We observed that species diversity was relatively high during the wet season and low during the dry season and these changes were mainly driven by landcover and climate–related variables. Specifically, significant changes in species diversity were around natural water pans, along roads and rivers, and cropping areas. Furthermore, these changes were better predicted by the Rao's Q (RMSE = 6.63 and %RMSE =42.41) more than the Shannon–Weiner Index (RMSE = 33.25 and %RMSE =63.94). Our observations on the drivers and changes in species diversity provide new insights on the possible effects of futuristic landcover change and climate variability on GDEs. This information is imperative considering that these environments are biodiversity hotspots capable of supporting livelihoods. More importantly, this work provides a spatially explicit framework on how GDEs can be monitored to achieve Sustainable Development Goal 15.