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An ecosystem-based approach to support water quality assessment and management under climate and land-use condition

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Freshwater ecosystems can be negatively affected by climate change and human interventions through the alteration of water supply and demand. There is an urgent need to protect the ecosystems, and the services they provide, to maintain their essential contribution to human wellbeing and economic prosperity, especially in a rapid and unpredictable global change context. In this work, we developed an integrated approach, coupling the outputs of ecosystem services (InVEST), climate (COSMO-CLM) and land use (LUISA) change models utilizing Bayesian Networks (BNs), to map freshwater-related Ecosystem Services (ESs), namely, water yield, nitrogen and phosphorus retention, and to assess their changes until 2050 under different management scenarios. First, InVEST was calibrated and validated with climate and land-use data to map and quantify ESs. Second, outputs of the ES model were integrated into the BN and the changes induced by different learning techniques and input settings were investigated. Finally, thousands of different scenarios were simulated testing multiple input variables configurations, thus allowing to describe the uncertainty of climate conditions, land-use change and water demand. Two types of inferences were conducted, namely, diagnostic and prognostic inference. The former permitted to find the best combination of the key drivers (i.e. precipitation, land-use, and water demand) so that ESs are maximized while the latter concentrated on the quantification of ESs under different scenarios. This approach was applied and validated in the Taro River basin in Italy. The results show that the values of all the three types of ESs would decline in the medium-term period under most scenarios. Moreover, there would be a limit of space to improve those values, especially for nutrient retention services. The obtained results provide valuable support to identify and prioritize the best management practices for sustainable water use, balancing the tradeoffs among services. This analysis allows decision-makers to pick up one scenario with a specific configuration of land-use and water demand to optimize relevant ESs within their basin. Finally, these decisions are transformed into a “decision space” where the values of selected services are plotted in the space of ES to represent the gain/loss of each decision.