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A Bayesian Network approach assessing water quality responses under climate change

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Climate change is triggering new water management challenges affecting regional and global water quantity and quality. Despite potential impacts of climate change on water availability have been widely studied in the last decades, the implication for concomitant changes in water quality have been just poorly explored.
Variations in temperature and precipitation patterns, are likely to have profound effects on those hydrological processes (e.g. runoff, river flow, water retention time, evapotranspiration) that regulate the mobilization of pollutants from land to water bodies however, such signals, can be masked by those of concurring local stressors (i.e. point and diffuse pollution sources).
Breaking down the relative role played by each of these pressures and predicting their combined impacts is necessary to mainstream the implementation of well-targeted adaptation measures supporting sectorial policies and legislations. Accordingly, the adoption of a multi-stressor perspective to water quality assessment is required to drawn realistic base lines and reasonable targets steering future water resource management strategies.
A data driven risk framework based on Bayesian Networks was implemented in the Zero river basin (Northern Italy) to characterize the interlacing between climate change and land use practices and assess their cascading impacts on water quality status (i.e. nutrients loadings).
Bayesian Networks were used as meta-modelling tool for structuring and combining the information available by existing monitored data, hydrological models and climate change projections producing alternative risk scenarios to communicate the probability of changes in the amount nutrients (i.e. NO_3, NH4, PO4) delivered from the basin under different climate change projections (i.e. RCP 4.5 and 8.5).
Specifically, an Ensemble of temperature and precipitation projections, downscaled from available Global and Regional Climate models (i.e. GCMs-RCMs), were directly used to inform the Bayesian Network in order to account for uncertainties across climate change scenarios and river basin responses, and to determine the level of confidence of projected water quality alterations between baseline and future climate regimes.
Bayesian Network outputs help in tracking future trends of water quality and in supporting the prioritization of stressors and pollution sources. Overall, developed risk scenarios, can be used as baselines against which test and evaluate existing management and adaptation measures for water quality.
Simulated scenarios show that seasonal changes in precipitation and temperature are likely to modify both the hydrology and nutrients loadings of the Zero River and that diffuse pollution sources play a key role in determining the amount of nutrients loaded while point source have only a marginal effect. Both NH4 and PO4 loadings, in fact, are mainly influenced by changes in the climatic and hydrological variables while NO_3 loadings are strongly affected by agronomic practices and land use.
Results have been evaluated through a cross comparison with existing observed data and hydrological models' simulations (i.e. SWAT) available for the case study providing a reasonable agreement.