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Disentangling the water quality dimension of the Water-Energy-Food nexus in the Adige river basin (Italy)

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Understanding and effectively managing water quality within the context of global changes necessitates a nexus approach that embraces the interconnected facets of the water-energy-food-environment system. This perspective acknowledges the intricate interplay between diverse processes—physical, chemical, biological, ecological—and human activities that collectively influence water quality. Climate change can impact these components individually and interactively, leading to cascading effects. Only by considering the whole system, including both natural and human factors, we can capture complexity understanding multiple stressors and feedback loops that affect water quality.

One of the major challenges of adopting a nexus approach for water quality assessment is primarily represented by the need to access and combine data and model from many different scientific domains which often remains compartmentalized in silos, to pre-defined scales and fields, into a single, logically consistent integrated framework of analysis. Leveraging integrative technology like Artificial Intelligence emerges as a viable solution to foster this integration permitting to maximize the value of available information. A systemic integrated model for the assessment of the conjoined impacts of climate and land use changes on water quality has been developed and tested at the catchment scale in the Adige river basin in Northern Italy. The model is developed using ARIES (Artificial Intelligence for Environment and Sustainability), an open-source Artificial Intelligence modeler which, using semantics and machine reasoning, allows independently developed models and data to be integrated and automatically assembled into workflows running at the scale most appropriated for the context of analysis. Once trained and validated the model permits to: i) predict the impact of different climate change and land use scenarios on water and ecological quality indicators (e.g. nutrients, suspended solids, water temperature, dissolved oxygen, ecological status); ii) identify sources and hot spots of pollution related with different economic sectors in the catchment; iii) test pollution reduction measures permitting to minimise trade-offs between economic activities and ecosystem health. By presenting the preliminary outcomes of pilot application, this analysis aims to showcase the potential of AI-driven approaches in enhancing data reusability and interoperability, crucial for comprehensively addressing environmental quality challenges and modelling intricate anthropic-

environmental interactions at the catchment scale.