

An Integrated Hydro Economic Assessment of Water Footprint, Scarcity, and Social Vulnerability: Evidence from Tuscany, Italy

Topic: Hydrologically Integrated Input–Output Models (HIIO): An Emerging Interdisciplinary Approach

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Freshwater scarcity and unequal exposure to water-related risks are increasingly recognised as constraints on sustainable development, yet most water footprint assessments lack the spatial and social resolution needed to inform subregional policy. This study develops an integrated hydro-economic framework that links multiregional input–output (MRIO) modelling with basin-level hydrological scarcity indicators and a demographic social vulnerability index. Applied to 48 Local Labour Systems (LLSs) in Tuscany (Italy), the approach quantifies production- and consumption-based water footprints, scarcity-weighted impacts, and socially weighted risk displacement across intra-regional supply chains. Results allow the identification of production-oriented hotspots that generate a substantial share of the regional water footprint while exhibiting significantly higher scarcity-weighted and socially weighted risks than neighbouring areas, even when volumetric water use is comparable. In contrast, consumption-oriented LLSs function as large net importers of virtual water, externalising a considerable share of their embodied demand to more hydrologically stressed and socially vulnerable locations. Overall, the findings demonstrate that volumetric indicators alone obscure pronounced inequalities in the spatial distribution of water-related risk, and they highlight the need for socio-hydrological governance strategies that jointly address efficiency, equity, and the redistribution of risk through economic linkages.