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Input-Output Analysis as a Quantitative Tool for Integrated Water Management

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In recent years, one important aim of hydrological science application and research has been the development of concepts and tools for integrated water resource management (IWRM). Europe has also adopted the comprehensive legislative tool of the Water Framework Directive (WFD) for ensuring implementation of such IWRM principles and mechanisms in EU member states, by use of hydrological drainage/river basins as main water management units. Such basins, however, constitute highly heterogeneous systems of coupled natural and engineered water sub-systems, the physical extension and/or influence zones of which may cross several political national and international boundaries. The flows of water and pollutants between such coupled water sub-systems and across political boundaries need to be appropriately understood, quantified and communicated to stakeholders, in order to appropriately guide monitoring, management and regulation decisions for efficient and sustainable water resource use, development, protection and remediation.

We use input-output analysis (IOA), originally developed for quantification of capital flows in economic systems, as a quantitative tool for assessing catchment-scale water and pollutant flows and system interactions. Results of site-specific application of IOA to water and nitrogen flows within and from the Norrström drainage basin, Sweden, show that IOA enables relatively simple, compact and fruitful quantification of: **i)** integral catchment behavior of water flow and nitrogen load responses to changes in the various natural and engineered water subsystems; **ii)** water flow and nitrogen load interactions between the various catchment sub-systems; and **iii)** external water flow and nitrogen load interactions of the catchment and its subsystems. The IOA quantification is highly transparent and readily communicated to stakeholders, and identifies clearly important information and data gaps that require improved monitoring and more detailed dynamic water system modeling. Furthermore, the IOA tool does not only quantify human impacts on water environments, but also environmental target impacts on the engineered-economic systems and sectors that use/affect water for meeting various human needs. Such quantification of catchment-scale cause-effect relations and feedback mechanisms between natural water and engineered-economic systems and sectors is necessary for efficient and sustainable IWRM, but not commonly handled by traditional hydrologic-biogeochemical flow and pollutant transport modeling.