Integrated modeling for assessing water-energy-land nexus: Application of a hydrological and hydro-economic modeling framework for the Zambezi basin

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Water demands for agricultural, industry, domestic and environmental uses in arid and semiarid regions continue to grow, while available surface and ground water resources remains the same or could even decline because of climate change. Decision makers need tools to support the implementation of sustainable water management policies. Hydro-economic modeling could be used for this task, because of its capacity to integrate key biophysical and socio-economic components within a unified framework. However, linking a hydro-economic model with a high-resolution hydrological model is needed in order to incorporate an adequate representation of present and future elements of the water balance.

Here we show the coupling of the Extended Continental-scale Hydro-economic Optimization model (ECHO), an integrated economic-technological modeling tool for application to long-term transboundary river basin planning with the Community Water Model (CWATM), a high-resolution global hydrological model. The trajectories of run-off and baseflow are simulated at high resolution (5’, daily) with CWATM and processed to define average inflow scenarios (monthly) for the sub-basin units represented in ECHO. Estimates of industrial, domestic and agricultural water withdrawals, return flows and environmental flow requirements are also taken from the hydrological simulations. Based on this, the ECHO model assesses the cost-effective combination of solutions that could address water scarcity at basin level. Solutions in this context represent transformative policies, basin-wide infrastructure configurations, and investment strategies that enable sustainable development.

As an example the novel framework is applied to the Zambezi basin, the largest river basin in Southern Africa, covering 1.4 million square km across eight countries and home to about 40 million people. CWATM provides projections of water availability and demand till 2050 at high spatial resolution under alternative socio-economic and climatic scenarios, while ECHO provides information on the least-cost combination of water management options that can satisfy those water demands subject to available water resources at basin level.

Keywords: Hydro-economic model, Global hydroloical model, Zambezi, Extended Continental-scale Hydro-economic Optimization model (ECHO), Community Water Model (CWATM)

