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Visualizing resource dependencies of the urban system at multiple scales: a hydrological case study

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Freshwater is one key component of the resource dependency of urban areas, linking concentrated population centers to geophysical and ecosystem processes operating at regional and global scales. Resources like water, food, biofuels, fibers or energy that sustain cities directly depend on the productive or assimilative capacities of the hydrological system, operating at multiple nested scales (from catchment to river basins) —areas orders of magnitude greater than the extent of the built-up urban areas.

Although the freshwater systems–urban population relationship has a broad regional and sectorial scope, the quantification of the extent of regional and global impacts of cities' resource demands, and more importantly, their integration into decision-support frameworks continues to be overlooked in water-management and urban planning practice. A key limitation of understanding the scope of impacts of urban systems is the characterization of the distributed and non-linear nature of the regional relationship of water and cities, wherein a given region can simultaneously supply resources to—or be affected by—multiple urban areas (and vice-versa), and the heterogeneity of physical and biotic processes of freshwater systems.

Here we introduce a novel approach to assess and visualize the interactions between urban resource demands and the freshwater system. We propose a set of indicators that make use of freshwater drainage structure to incorporate the cumulative effects and concurrent resource dependency of urban areas across multiple nested scales. The cumulative character of the proposed indexes aims to replace the fixed control boundary (i.e. basin, sub-basin, etc -the current practice in water resources appraisals), with the (topological) integral of the process across the multiple nested scales present in a river basin. This approach allows: (i) visualizing how factors like patterns of size, spatial distribution and interconnection of urban resource demands or the nested and hierarchical character of freshwater systems, influence the cumulative pressure exerted or a urban system on the freshwater system, (ii) mapping the spatial patterns of resource import and export across different scales and regions of a freshwater system, and (iii) quantifying the scales of the process required to sustain the resource supply of the multiple cities sharing the same provisioning freshwater system. The presented advances can inform regional urban planning to determine options to avoid, minimize or offset regional impacts of urban populations. An example

of this proposed approach is presented for the Magdalena River Basin (Colombia).