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Analysis of key thresholds leading to upstream dependencies in global transboundary water bodies

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Transboundary water bodies supply 60% of global fresh water flow and are home to about 1/3 of the world's population; creating hydrological, social and economic interdependencies between countries. Trade-offs between water users are delimited by certain thresholds, that, when crossed, result in changes in system behavior, often related to undesirable impacts. A wide variety of thresholds are potentially related to water availability and scarcity. Scarcity can occur because of the country's own water use, and that is potentially intensified by upstream water use. In general, increased water scarcity escalates the reliance on shared water resources, which increases interdependencies between riparian states.

In this paper the upstream dependencies of global transboundary river basins are examined at the scale of sub-basin areas. We aim to assess how upstream water withdrawals cause changes in the scarcity categories, such that crossing thresholds is interpreted in terms of downstream dependency on upstream water availability. The thresholds are defined for different types of water availability on which a sub-basin relies:
- reliable local runoff (available even in a dry year),
- less reliable local water (available in the wet year),
- reliable dry year inflows from possible upstream area, and
- less reliable wet year inflows from upstream.
Possible upstream withdrawals reduce available water downstream, influencing the latter two water availabilities. Upstream dependencies have then been categorized by comparing a sub-basin's scarcity category across different water availability types. When population (or water consumption) grows, the sub-basin satisfies its needs using less reliable water. Thus, the factors affecting the type of water availability being used are different not only for each type of dependency category, but also possibly for every sub- basin.

Our results show that, in the case of stress (impacts from high use of water), in 104 (12%) sub- basins out of 886 sub-basins are dependent on upstream water, while in the case of shortage (impacts from insufficient water availability per person), 79 (9%) sub-basins out of 886 sub-basins dependent on upstream water. Categorization of the upstream dependency of the sub-basins helps to differentiate between areas where i) there is currently no dependency on upstream water, ii) upstream water withdrawals are sufficiently high that they alter the scarcity and dependency status, and iii) which are always dependent on upstream water regardless of upstream water withdrawals. Our dependency assessment is expected to considerably support the studies and discussions of hydro-political power relations and management practices in transboundary basins.