Graphically Representing Physical Limits for the Macro Scale of the Circular Economy of Water

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Abstract:
This study addresses a key limitation in Circular Economy (CE) research applied to water management: the lack of clearly defined physical boundaries for the macro scale. While the CE framework commonly distinguishes three analytical levels—micro, meso, and macro—only the micro and meso scales are typically grounded in tangible, physical systems. In contrast, the macro scale often remains conceptual, creating a disconnect between theory and real-world hydrological processes. This gap limits our ability to identify where water originates, how it is shared, and which stakeholders are involved.

To address this issue, we propose a novel method to physically delimit the macro-scale water system supplying a meso-scale entity. The approach is based on tracing the pathways of water through the hydrological network, independently of volume considerations, and representing these connections using a graph-based framework. This allows for a structured and spatially explicit representation of the system, linking water sources, flows, and users.

Although the method is conceptual and does not incorporate quantitative flow data, it oU'ers a transferable framework that can be applied to other territories, including data-scarce environments. It also helps identify data needs for future modelling and supports the exploration of system resilience under global change pressures.

Beyond its methodological contribution, this work questions the hierarchy of Circular Economy principles across disciplines and scales. While eU'iciency and reuse are often prioritized from an economic perspective, restoring natural capital appears fundamental from hydrological and ecological viewpoints. It therefore proposes mobilizing CE principles at the scale of the macrosystem, while recognizing that these principles must be applied where they are most relevant, but also at a global level to address broader water management challenges.