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Operationalizing the freshwater planetary boundary for local to global water management and sustainability

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The planetary boundaries framework identifies thresholds that, if exceeded, may push the Earth out of its present Holocene-like conditions. In other words, the planetary boundaries define the 'safe operating space' for modern society. While the planetary boundaries are a useful way of identify critical thresholds within and interconnections between Earth systems, one criticism is that the planetary boundaries do not provide meaningful guidance at subglobal scales (e.g. basin to national) where natural resources are managed. Here, we explore how the planetary boundary framework can define a safe operating space and inform water management and policy at local to regional scales. Specifically, we identify three pathways by which the freshwater planetary boundary can be used to inform local water management: (i) externalizing local impacts by quantifying the local contributions to the global threshold; (ii) internalizing global change by determining the impacts of global planetary boundary exceedance on local resources; and (iii) revealing local water thresholds by applying the planetary boundary framework at a smaller spatial scale to define the local to regional safe operating space. Translating the global planetary boundaries to local thresholds requires integration with existing frameworks for assessing global human impacts on ecosystems including virtual water trade, indirect land use change, and partitioning global contributions to climate change; and also considering local social boundaries that define acceptable levels of change based on local conditions. Thus, we do not intend to suggest that the planetary boundaries replace existing water management paradigms such as the EU Water Framework Directive. Rather, we show that operationalizing the planetary boundaries for local water management can provide a complementary approach guided by a cross-scale understanding of water which can provide unique scientific and management insights.