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Present and future water quality affects water use and cross-sectoral competition globally

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Human activities strongly rely on the availability of sufficient water and of adequate quality, yet water use sectors (e.g. irrigation, domestic, industry and energy), already experience clean water scarcity. Additionally, the availability of clean water is further compromised by increasing water demand of the growing population, deterioration of water quality due to pollution by emissions by the different sections, and by more frequent and intense hydroclimatic extremes (e.g. droughts, heatwaves, and compound events). These developments increase the cross-sectoral competition for the available water (Cárdenas Belleza et al, 2023). Current research on large-scale water scarcity related to insufficient water of good quality has provided limited understanding of the sector-specific impacts. This limits our understanding of how water quality affects water sources allocation to different water use sectors and how such responses will impact sector-specific and total water scarcity under global change.

The main objective of this research is to assess cross-sectoral water scarcity due to sectoral competition for limited clean water resources, explicitly considering water quantity and water quality requirements under global change. To address this, we developed a new globally applicable sectoral water use and allocation model, *QUAlloc v1.0*, that incorporates water quality requirements across main water use sectors (domestic, irrigation, livestock, manufacturing, and energy). QUAlloc v1.0 is linked to the PCR□GLOBWB 2 hydrological model (Sutanudjaja et al, 2018) and the DynQual v1.0 global surface water quality model (Jones et al, 2023), forming a sectoral water quality, use and allocation modelling framework.

Our results show that present surface water quality strongly affects both water source allocation and sectoral water use competition in river basins globally, resulting in a significant reduction in global surface water withdrawals (by 17%) and an increased dependence on groundwater (e.g., Latin America, the Middle East, North Africa). Additionally, we show that sectors with less stringent water quality requirements, namely livestock and manufacturing, benefit by the reduced surface water withdrawal from other sectors (i.e., domestic, irrigation), enabling to increase its withdrawal. Projections of sector-specific water scarcity under climate change and socio-economic changes for the whole 21st century suggest that these inter-sectoral impacts will become increasingly stronger in the future. Our study is the first in exploring the impacts of present and future water quality in

the cross-sectoral water use competition and their effects on sector-specific water scarcity globally.

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