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Global assessment of water policy vulnerability under uncertainty in water scarcity projections

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Water scarcity is a critical environmental issue worldwide, which has been driven by the significant increase in water extractions during the last century. In the coming decades, climate change is projected to further exacerbate water scarcity conditions in many regions around the world. At present, one important question for policy debate is the identification of water policy interventions that could address the mounting water scarcity problems. Main interventions include investing in water storage infrastructures, water transfer canals, efficient irrigation systems, and desalination plants, among many others. This type of interventions involve long-term planning, long-lived investments and some irreversibility in choices which can shape development of countries for decades. Making decisions on these water infrastructures requires anticipating the long term environmental conditions, needs and constraints under which they will function. This brings large uncertainty in the decision-making process, for instance from demographic or economic projections. But today, climate change is bringing another layer of uncertainty that make decisions even more complex.
In this study, we assess in a probabilistic approach the uncertainty in global water scarcity projections following different socioeconomic pathways (SSPs) and climate scenarios (RCPs) within the first half of the 21st century. By utilizing an ensemble of 45 future water scarcity projections based on (i) three state-of-the-art global hydrological models (PCR-GLOBWB, H08, and WaterGAP), (ii) five climate models, and (iii) three water scenarios, we have assessed changes in water scarcity and the associated uncertainty distribution worldwide. The water scenarios used here are developed by IIASA's Water Futures and Solutions (WFaS) Initiative. The main objective of this study is to improve the contribution of hydro-climatic information to effective policymaking by identifying spatial and temporal policy vulnerabilities under large uncertainty about the future socio-economic and climatic changes and to guide policymakers in charting a more sustainable pathway and avoiding maladaptive development pathways.
The results show that water scarcity is increasing in up to 83% of all land area under a high-emission scenario (RCP 6.0-SSP3). Importantly, the range of uncertainty in projected water scarcity is increasing; in some regions by several orders of magnitude (e.g. sub-Saharan Africa, eastern Europe, Central Asia). This is further illustrated by focusing on a set of large river basins that will be subject both to substantial changes in basin-wide water scarcity and to strong increases in the overall range of uncertainty (e.g. the Niger, Indus, Yangtze). These conditions pose a significant challenge for water management options in those vulnerable basins, complicating decisions on needed investments in water supply infrastructure and other system improvements, and leading to the degradation of valuable resources such as non-renewable groundwater resources and water-dependent ecosystems. The results of this study call for careful and deliberative design of water policy interventions under a wide range of socio-economic and climate conditions.