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Editorial: Transformational strategies for equitable water distribution in a changing climate

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Editorial on the Research Topic
Transformational strategies for equitable water distribution in a changing climate

The accelerating impacts of climate change are causing water managers and policy makers to rapidly transform our water systems. Achieving and sustaining water security in water scarce regions while mitigating longstanding inequities is a grand challenge. This Research Topic presents eight studies that collectively elicit pathways toward more equitable, sustainable, and resilient water futures, spanning from Idaho's snowmelt watersheds to California's overdrafted aquifers, Iran's circular economy initiatives, and Mexico's contaminated groundwater supplies.

The Research Topic includes technical innovations in managed aquifer recharge (MAR) that reimagine traditional approaches to address multiple challenges simultaneously. The report on Treasure Valley, Idaho USA (Ferencz et al.) demonstrates how MAR can be leveraged to redistribute seasonal flows to create "enhanced baseflow" during critical periods, representing a paradigm shift toward managing groundwater and surface water as an integrated system. An article on root zone modeling (Flores-López et al.) complements this by providing a framework for modeling and implementing aquifer recharge in agricultural fields while protecting agricultural productivity. This addresses key challenges to expanding managed aquifer recharge in agricultural regions.

Several papers in the Research Topic address California's recently implemented Multibenefit Land Repurposing Program (MLRP). An MLRP multicriteria decisions-support toolkit presented by Nuñez-Bolaño et al. exemplifies how complex spatial analyses can be democratized so as to narrow the gap between technical, nature-based, and social approaches to improve water resilience. This empowers diverse stakeholders to explore trade-offs between competing objectives such as groundwater recharge, habitat restoration, flood mitigation, and environmental justice considerations. Two papers on the treatment of cropland repurposing in California (Penny et al. and Fernandez-Bou et al.) provide both a review and a comprehensive vision for achieving groundwater sustainability through justice-centered approaches. Rather than simply reducing irrigated acreage to achieve balance in recharge and extractions, the MLRP framework demonstrates how strategic land transitions can simultaneously address water security, environmental health, economic

diversification, and social equity. This approach recognizes that agricultural communities facing long term water use reductions to comply with groundwater regulation often bear disproportionate environmental burdens. By centering community engagement and ensuring that land repurposing generates local benefits, these strategies offer pathways for just transitions that enhance rather than diminish community resilience. The conceptual analysis further develops this theme through a theory of change spanning individual projects, regional coordination, and institutional transformation, with California's MLRP integrating over 100 organizations to demonstrate scalable collaborative approaches.

Our Research Topic also encompasses institutional dimensions of water system transformation, including barriers to change and funding misalignment. The Pajaro River project analysis by Grimm et al. reveals how existing funding structures, designed for single-purpose gray infrastructure, impede multibenefit solutions. Despite clear advantages of integrated approaches, project champions must navigate fragmented funding landscapes that fail to recognize or support other potential benefits. This represents a critical bottleneck for scaling transformational approaches, highlighting an urgent need for institutional innovation to match technical advances.

International contributors to the Research Topic underscore the global nature of water security and equity challenges and the importance of context-specific solutions. An analysis of Iran's marginal water reuse experience (Al-Saidi and Dehnavi) highlights how circular economy principles can be adapted to different institutional contexts while revealing policy constraints that limit implementation. The Aguascalientes Valley aquifer case from Mexico (Nicte Ha Hughes Lomelin et al.) presents a clearly unsustainable scenario, with fluoride and arsenic contamination affecting over 1.35 million people while the same aquifer supports extensive irrigated agriculture in the region.

These studies illuminate several critical principles for transformational water management. Technical innovation must be coupled with institutional innovation, as existing governance and funding structures often constrain promising solutions. Stakeholder engagement and participatory approaches are practical necessities for navigating complex trade-offs inherent in multibenefit solutions. Most importantly, equity considerations must be centered rather than peripheral in water system transformations, both to ensure just outcomes and build social license for large-scale change. The work also reveals important research frontiers, particularly in integrating social, technical, and ecological dimensions in water system modeling when addressing equity and justice questions that extend beyond traditional optimization frameworks. Scaling participatory approaches from local to regional levels requires continued innovation in technological platforms and governance mechanisms.

In a world where water security and climate resilience are increasingly synonymous with social justice, transformational strategies like those discussed in this Research Topic offer essential building blocks for equitable water futures. The studies provide both inspiration for what is possible and practical guidance for translating demonstrated benefits from pilot projects to system-wide transformation through sustained attention to institutional barriers and policy reform. The journey demands continued integration across disciplines, sustained community engagement, and persistent attention to institutional conditions that constrain or enable transformation.

Author contributions

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Conflict of interest

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