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Irrigation storage is a blind spot for analyzing and mitigating externalities of future water infrastructure

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Dams and reservoirs are crucial components for the water-energy-food (WEF) nexus but have major impacts on rivers and people. Future dams would compound impacts of existing dams and threaten so far undammed river systems. Recent research has highlighted threats from future hydropower dams and opportunities to reduce impacts through better infrastructure planning and proliferation of other renewable energy. Yet, while irrigation storage was a major driver for dam development in the past, the role of water storage in future food systems and the associated benefits and impacts has not been part of debates around future dams.

Here, we provide a global analysis that fuses global hydrologic modeling and infrastructure assessments to (1) quantify future demands for irrigation storage, (2) its role for food security, and (3) the contribution of existing and identified potential reservoirs to future irrigation. For that, we firstly analyze potentials for future sustainable (i.e., on existing croplands and without depleting environmental flows) irrigation and determine how much storage is needed to match water availability and crop water demand on a river basin level. Secondly, we quantify how much food could be grown with that water. Lastly, we perform a Monte-Carlo Analysis for all current and potential dams to robustly estimate possible water allocations from current and future dams to irrigation, and thus the role of this water infrastructure for global food security.

We find that future irrigated agriculture will require 460 km³/yr of water storage, 265 km³/yr on land that is already irrigated and 195 km³/yr on land that is currently rainfed. Much of that additional storage will be required in South Asia and West Africa. This storage-fed irrigation could grow enough food for 1.15 billion people. Yet even all current and future dams could only meet around 60 % of that potential.

Our results provide spatially explicit global information on (1) irrigation storage as important externality and cost factor for future food systems, (2) challenges for the WEF nexus in meeting concurrent demands for irrigation and hydropower, (3) the need to include irrigation in strategic impact/benefit assessments for future dams, and (4) urge to evaluate alternatives to large dams for future agricultural water storage.