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Framework for co-development of an open hydrological data system to enhance climate resilience in climate vulnerable countries: Experience from a digital groundwater monitoring pilot in Nepal

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Groundwater constitutes the major source of global freshwater supply - making groundwater data critical for supporting adaptation to climate change. This is especially relevant for climate vulnerable countries like Nepal, where the data needed to characterise water security risks is often either not collected, not made available, or does not meet the needs and interests of decision makers. This constitutes a gap between the availability and demand of hydrological data. Countries have limited capacity for streamlined hydrological research and data collection, which does not correspond to the numerous needs and stakeholder's interest to handle water stress in agriculture, maintain adequate water supply for biodiversity, and ensure that drinking water is of sufficient quality. A systematic framework for reconciling these capacities and stakeholder interests is therefore necessary. Through the development of an open data collection system, the framework can (i) provide an inclusive space for multi-stakeholder dialogue and (ii) substantiate debates on water resources management and policy – both of which are currently disconnected from each other and from the hydrological realities. Without following an integrated framework, initial pilots to build open hydrological data systems are less likely to be effective as they do not deliver on their potential synergy and cross-sectoral benefits that go in hand increased awareness of scientists about the needs and interest in hydrological data for different user groups.

Here we present such a framework of using novel technologies and approaches to build an open and inclusive hydrological data system in climate vulnerable countries. The framework highlights the issues of inclusion and social sustainability, the use of models, digital technologies, and open

and citizen science approaches and considers direct the policy implication of the social-ecological nature of water management: (i) field data availability as a key constraint for advancing the hydrological sciences and making informed policy decision, (ii) social aspects of the hydrological cycle for advancing our understanding of the dynamics between water and nature, and (iii) the social power of models and datasets for influencing policy processes.

The framework is based on ongoing work of piloting a digital groundwater monitoring system in Nepal, co-created by a diverse group of stakeholders, scientists and policymakers. Nepal is currently increasing investments into groundwater irrigation for which decision-makers require better data to target investments in irrigation infrastructure and gauge sustainable limits of groundwater use. A standardized system for collecting and sharing groundwater level data would cater to these information needs: Decreased transactions costs for researchers incentivize collaboration for building models that incrementally fill the gap in information availability and supply. Using our framework for the data system development will further ensure that the systems capability for early warning of localized groundwater depletion and its function as a platform for stakeholder engagement are fully leveraged. Doing so allows decision-makers and researchers to move beyond silo thinking in the agricultural sector and to learn with other sectors, build alliances towards a more integrated water information system, and include issues such as water quality and specific interests of the drinking water community.