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Towards a comprehensive assessment and framework for low and high flow water risks

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Driven by international organizations such as the Intergovernmental Panel on Climate Change (IPCC) the past years have seen a move from a vulnerability concept of climate change impacts towards a risk framework. Risk is now conceived at the intersection of climate-driven hazard and socioeconomic-driven vulnerability and exposure. The concept of risk so far has been mainly adopted for sudden-onset events. However, for slow-onset and cumulative climate change impacts such as changing water resources there is missing clarity and experience how to apply a risk framework. Research has hardly dealt with the challenge of how to integrate both low and high flow risks in a common framework. Comprehensive analyses of risks related to water resources considering climate change within multi-dimensional drivers across different scales are complex and often missing in climate-sensitive mountain regions where data scarcity and inconsistencies represent important limitations.

Here we review existing vulnerability and risk assessments of low and high flow water conditions and identify critical conceptual and practical gaps. Based on this, we develop an integrated framework for low and high flow water risks which is applicable to both past and future conditions. The framework explicitly considers a water balance model simulating both water supply and demand on a daily basis.

We test and apply this new framework in the highly glacierized Santa River catchment (SRC, Cordillera Blanca, Peru), representative for many developing mountain regions with both low and high flow water risks and poor data availability. In fact, in the SRC, both low and high flow hazards, such as droughts and floods, play a central role especially for agricultural, hydropower, domestic and mining use. During the dry season (austral winter) people are increasingly affected by water scarcity due to shrinking glaciers supplying melt water. On the other hand during the wet season (austral summer) high flow water risks are associated with hazards such as floods and debris flows and high socioeconomic vulnerability and exposure of e. g. infrastructure. Nonetheless, comprehensive water resource risk studies have barely been developed in the SRC and other developing high-mountain regions. To consider all components of risks as well as the economic and social conditions for different processes, a comprehensive risk assessment is needed. The urgency of this matter is emphasized by recent social conflicts in the SRC and the tropical Andes in general, related to prevailing drought conditions in combination with weak state institutions and unequal decision-making as well as differentiated perspectives on low flow versus high flow risks.