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Toward hydro-social modeling: Merging human variables and the social sciences with climate-glacier runoff models (Santa River, Peru)

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Summary

Glacier shrinkage caused by climate change is likely to trigger diminished and less consistent stream flow in glacier-fed watersheds worldwide. To understand, model, and adapt to these climate-glacier-water changes, it is vital to integrate the analysis of both water availability (the domain of hydrologists) and water use (the focus for social scientists). Drawn from a case study of the Santa River watershed below Peru's glaciated Cordillera Blanca mountain range, this paper provides a holistic hydro-social framework that identifies five major human variables critical to hydrological modeling because these forces have profoundly influenced water use over the last 60 years: (1) political agendas and economic development; (2) governance: laws and institutions; (3) technology and engineering; (4) land and resource use; and (5) societal responses. Notable shifts in Santa River water use—including major expansions in hydroelectricity generation, large-scale irrigation projects, and other land and resource-use practices—did not necessarily stem from changing glacier runoff or hydrologic shifts, but rather from these human variables. Ultimately, then, water usage is not predictable based on water availability alone. Glacier runoff conforms to certain expected trends predicted by models of progressively reduced glacier storage. However, societal forces establish the legal, economic, political, cultural, and social drivers that actually shape water usage patterns via human modification of watershed dynamics. This hydro-social framework has widespread implications for hydrological modeling in glaciated watersheds from the Andes and Alps to the Himalaya and Tien Shan, as well as for the development of climate change adaptation plans.