A national inventory of potential future lakes in the deglaciating cordilleras of Peru for integrative water and risk management

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Anticipating the formation of lakes in deglaciating mountains represents an important step towards the identification of both, new possible water storage options and potential hazards. This is particularly crucial in the Peruvian Andes which are characterized by strong precipitation seasonality. Dwindling glacier contribution to river streamflow, particularly during the dry season (May-September), combined with increasing water demand suggest considerable levels of potential future water scarcity in some regions. Within the near future, the water use potential of new lakes needs to be further explored for main sectors of water use. At the same time, emerging risks must be considered for downstream populations (i.e. lakes increasingly exposed to landslides, avalanches, rock falls or ice detachments).

In this context, the presented future lakes inventory aims to provide information for long-term planning and comprehensive territorial management. The methodology is based on numerical ice thickness distribution (±30% uncertainty range) and bedrock modelling with the GlabTop (Glacier bed Topography) model. This tool in combination with a visual inspection protocol based on geomorphological criteria allows for reasonable estimates and evaluation of potential future lakes differentiated by confidence levels. The three applied morphological criteria were: i) downslope (priority) and upslope increase of surface slope, ii) lateral glacier narrowing, and iii) heavily crevassed areas following a crevasse-free zone. The results are most robust for the identification of potential formation sites rather than the precise area, depth or volume of potential lakes. Thus, the inventory needs to be understood as a first order of magnitude.

A total of 287 sites of potential future lakes (>1ha) have been identified which would be distributed within 11 out of 18 still glacier-covered mountain ranges in Peru. The total lake volume would be about 231 millions of m³ which corresponds to around 0.5-1.0% of the entire estimated national glacier volume (~38 km³). While on a country scale this might not be much, locally the projected water storage could play an important role. Actually, a major number (175) of the identified lakes has already developed or is likely to form within a few decades. This underlines the need for more research and integrated territorial management within a timely manner.

The current methodology and compiled inventory provide an important tool for prospective and
integrated risk, water and land management within a context of hydroclimatic and socioeconomic impacts in the Andes of Peru and elsewhere. Follow-up studies should use new data and additional methods including in-situ techniques to corroborate and update results within a rapidly changing Andean environment. Additionally, a realistic and detailed evaluation should be particularly conducted for possible lakes of higher priority concerning water supply and outburst flood susceptibility.