Assessment of the Impacts of Climate Change on Mountain Hydrology: Development of a Methodology Through a Case Study in the Andes of Peru

Author: Buytaert, Wouter

Source: Mountain Research and Development, 32(3) : 385-386

Published By: International Mountain Society

URL: https://doi.org/10.1659/mrd.mm106

Mountain Research and Development (MRD)
An international, peer-reviewed open access journal
published by the International Mountain Society (IMS)
www.mrd-journal.org

Assessment of the Impacts of Climate Change on Mountain Hydrology: Development of a Methodology Through a Case Study in the Andes of Peru

By Walter Vergara, Alejandro Deeb, Irene Leino, Akio Kitoh, and Marisa Escobar. Washington, D.C.: World Bank, 2011. xix + 157 pp. US$ 25.00. ISBN 978-0-8213-8662-0.

Climate change is expected to have strong impacts on water resources worldwide. Mountain regions are especially vulnerable to such impacts because, compared with lowland regions, they tend to rely much less on groundwater for their water resources because of their complex geology and the limited availability of large groundwater aquifers. Instead, water is provided by fragile surface water sources, including wetlands, forests, lakes, and glaciers, all of which are easily perturbed by external stressors such as climate change. The steep topography also significantly increases the costs and technical difficulties of transporting water, which makes it difficult to replenish dwindling water supplies. From a socioeconomic viewpoint, mountain areas tend to host pockets of poverty and vulnerable populations.

All of these are good reasons to be concerned with the potential impacts of climate change in mountains and underline the importance of developing strategies to adapt to changing water supplies in mountain regions. The scientific literature presents a plethora of methods and tools for climate change impact assessments, including global climate models (GCMs), statistical and dynamical downscaling tools, a wide range of hydrological models, and global and local data sets. It, therefore, is very relevant to analyze whether these tools are effectively fit for that purpose in mountain areas. This is the purpose of this report.

In the first part, the authors look at different methods to project climatological change into the future. In the second part, they implement and test a hydrological model as a tool to convert climate projections into changes in monthly streamflow. They use 3 economically important river basins in Peru as case studies: the Santa River basin, which receives water from the largest glacier system in the tropics; the Rimac River, which provides water for the city of Lima; and the Mantaro River basin, which is the food basket for Lima.

Unfortunately, rather than providing a comprehensive overview and discussion of strategies to assess climate change impacts in mountain regions, the report is little more than a set of loosely connected case studies that provide only limited guidance on how to select and apply models and other tools. For example, the first chapters analyze climate projections for Peru as generated by an ensemble of global climate models, a very-high–resolution global climate model, a dynamical downscaling method, and a trend analysis of local stations. However, the results are presented mostly side-by-side rather than in a detailed comparison. For instance, the use of both the high-resolution global climate model (AGCM3.1) and the dynamic downscaling is motivated by the fact that these methods account better for the topography of the Andes. This is indeed a very pertinent issue. Even though the use of GCM ensembles is advocated as a way to get a "non discountable envelope of uncertainty" (Stainforth et al 2007), it is quite likely that, in the case of the Andes, all the models will have a bias in the same direction (insufficient atmospheric blocking by the mountain range). However, model comparison studies in the region show that high-resolution regional models do not necessarily provide better simulations than lower-resolution global models (Buytaert et al 2010). The lack of comparison between, and the evaluation of the results of, the different methods, therefore, seems a missed chance.

The hydrological section is based on the use of the Water Evaluation and Planning (WEAP) hydrological model, which is implemented and evaluated on a monthly time step. Although the study goes to great lengths to implement specific processes of glacier melt and páramo wetlands, the relevance of these efforts is not very clear. On a monthly time step, the catchment water balance will dominate simulation errors. It, therefore, is crucial to get incoming precipitation and outgoing evapotranspiration fluxes correct. The extreme gradients in precipitation result in very large errors in the estimation of the catchment average precipitation, which may well hide errors in the representation of specific processes, such as overland flow or even glacier melt. It is surprising that little attention is paid to the generation of catchment average precipitation inputs and to the parameterization of the evapotranspiration routine and its impact on estimating future evapotranspiration rates. This again is crucial, given the potentially strong impact of increasing temperatures on evapotranspiration processes.

To summarize, the report poses some important questions about the applicability of certain methods and models in mountain regions, and highlights the need for careful assessment of model performance and associated uncertainties. However, it also lacks a coherent discussion about the strengths and weaknesses of each approach and how to address them.

Finally, on a more fundamental level, there is a missed opportunity to discuss how useful model projections riddled with uncertainties are for decision-making. There is a growing consensus in the scientific community that uncertainties in climate projections and related impact assessment are unlikely to decrease in the near future. For every known

http://dx.doi.org/10.1659/mrd.mm106

model deficiency that is addressed, several "unknown unknowns" are discovered that complicate matters further. Given the extreme uncertainties, especially in regions such as the Peruvian Andes, this triggers the question as to whether model projections can inform decision-making at all. Rather then relying upon highly uncertain projections, there is a tendency to move away from a "predict-and-control" paradigm toward a more adaptive approach, with continuous learning and flexibility as key aims. In this sense, infrastructure investments with high sunk costs, irreversible decisions, or fixed management strategies prevent continuous learning and adjustment. A more effective way of dealing with unpredictability perhaps is to create the capacity to respond effectively to changing and unknown conditions in the future rather than making irreversible decisions now. This can be done by developing strategies that are robust under the full range of possible future scenarios and can be flexibly applied when needed, and through diversifying the range of strategies (Brugnach et al 2008). Even though this may be outside the scope of the report, these issues are highly relevant to promote sustainable development.

REFERENCES

Brugnach M, ***Dewulf ARPJ***, ***Pahl-Wostl C***, ***Taillieu T***. 2008. Toward a relational concept of uncertainty: About knowing too little, knowing too differently, and accepting not to know. *Ecology and Society* 13(2):30.

Buytaert W, ***Vuille M***, ***Dewulf A***, ***Urrutia R***, ***Karmalkar A***, ***Célleri R***. 2010. Uncertainties in climate change projections and regional downscaling: Implications for water resources management. *Hydrology and Earth System Sciences* 7(2):1821–1848.

Stainforth DA, ***Downing TE***, ***Washington R***, ***Lopez A***, ***New M***. 2007. Issues in the interpretation of climate model ensembles to inform decisions. *Philosophical Transactions of the Royal Society A* 365(1857):2163–2177.

AUTHOR

Wouter Buytaert
w.buytaert@imperial.ac.uk
Civil and Environmental Engineering, Imperial College London, London SW7 2AZ, United Kingdom

http://dx.doi.org/10.1659/mrd.mm106