Flows

News on Payments for Watershed Services

Supported by the International Institute for Environment and Development (IIED) and the World Bank, Bank-Netherlands Watershed Partnership Program

Review: Quantification of cloud forest conversion to pasture on water quantity

With guest co-authors, L.A. Bruijnzeel and Mark Mulligan.

Although there is evidence that conversion of cloud forests reduces dry season flows – in Costa Rica, Guatemala and Honduras, it is largely circumstantial. Due to the variation and site-specific nature of watershed processes, and limitations on capacity for data collection, results can only be applied to small scales in a few locations. This has been a key limitation on hydrological investigations undertaken to support payment initiatives. Data is collected at point and plot scales from which it is difficult or inappropriate to make generalizations without extensive knowledge about the site-specific context.

The available information on the allegedly large amounts of cloud water intercepted by cloud forests provides a case in point. A major factor that limits understanding and quantification of water budgets in cloud forest areas is the difficulty of distinguishing fog intercepted by cloud forests from wind-driven rain as sources of precipitation. The distinction is significant since wind-driven rain is caught by the vegetation or ground whereas fog is a true horizontal flux which, if not caught by vegetation (particularly forest) can pass over a catchment and thus be 'lost' to it, Quantification of this has been a key scientific challenge – at least until now.

One of the ways of overcoming these limitations is to develop equipment and models that permit quantification and better understanding of the various physical processes, and to use and validate these with direct measurements. Recent research conducted in northern Costa Rica (with financial support from the UK Department for International Development Forestry Research Programme) by a team of Dutch, British, Colombian, Swiss and Costa Rican scientists, under the leadership of Sampurno Bruijnzeel of the Vrije Universiteit Amsterdam, has done just that.

Measurements were taken in an undisturbed cloud forest and in a mature pasture area, using an array of specialized instruments, including the 'potential precipitation gauge' developed specifically by project researcher Arnoud Frumau to improve the measurement of wind-driven rain. Using this ingenious device the angle of incoming precipitation could be determined at all times. Combining information on rainfall angles with topographical information, in turn, allowed much more realistic estimates of precipitation inputs to be made. Separate measurements of fog deposition rates using highly sophisticated equipment indicated that fog inputs were dwarfed by precipitation inputs.

In addition to taking measurements at different scales, ranging from plots to operational catchments of up to 100 km2, project activities included the development of process models for use at these different scales, validation of the operational scale model with measured stream flow data, and use of the model to assess the hydrological impacts of various land-cover change scenarios. Another global scale model was used by Mark Mulligan of King's College London to compare the expected impacts of land cover change to those of climate change at the national scale as well as for all of Central America and adjacent areas (Mexico, northern Colombia).

The results for Costa Rica generally reinforce and quantify what has been expected or suspected for a while. Although fog input can be significant in isolated mountain catchment areas such as

Lake Arenal, where average values are up to 240 mm/year, it rarely contributes more than 1-2% of the flow of major downstream rivers. As a percentage of annual water balance this input never exceeds an average of 7%.

Fog inputs are more significant in areas of lower rainfall, and during the dry season. In January and February, fog inputs can reach 25-35% of rainfall on the Pacific side, and represent over 50% of the stream flow within cloud forests. However, the net impact of cloud forest removal on annual and dry season flows is limited because reductions in the capture of fog and wind-driven rain are compensated for by lower water use (evapotranspiration) by replacing vegetation types such as pasture. Only on a few isolated montane slopes did changes in forest cover lead to declines in fog interception that exceeded the corresponding decrease in evapotranspiration. Rainfall and fog inputs as well as evapotranspiration will also be affected by the projected global warming and drying in the Central American region – which is expected to increase evapotranspiration by 10-20 mm/yr, and to decrease rainfall and therefore runoff by 100-150 mm.

On the other hand, the progressive degradation of soil as a result of cloud forest conversion to pasture can lead to a doubling of stream flow volumes during rainfall ('stormflows') and a tripling in peak discharges for small watersheds because of soil compaction by cattle, which reduces the amount of water infiltrating the soil. These impacts have not been observed at operational scales, where they are 'diluted' or averaged out by variations in rainfall and surface characteristics across the landscape. In addition to an improved understanding of the role of cloud forests in the water budget of the Chiquito catchment in Costa Rica, the project has contributed models for application at operational and (inter)national scales that can be used to define hydrological 'hotspots' – where input from fog capture is sufficient to evaluate impacts of land use conversion and climate change on the water budget, and ultimately, for economists to determine whether these changes have significance from a socio-economic perspective. The (inter-)national scale policy model can be used with existing freely available climatic and vegetation datasets. The biggest challenge remains to provide accurate spatial rainfall data for this type of remote mountainous terrain.

The implication of the project's findings for payments for environmental services schemes is that cloud forest benefits for water quantity are surprisingly limited and rarely significant. Although the benefit for water quantity is easier to sell, it is unlikely to sustain a payment scheme. Justification for cloud forest protection therefore needs to be based on the broader range of benefits they provide, which include first of all the safe- guarding of water quality, long-term regulation of flows, as well as suppression of erosion and shallow landslides but also biodiversity, carbon sequestration, and aesthetic and eco-tourism values.

References and further information

Based on the report:

Hydrological impacts of converting tropical montane cloud forest to pasture with initial reference to northern Costa Rica. Final Technical Report DFID-FRP Project no. R7991. Compiled by L.A. Bruijnzeel (project leader), based on the work of: Reto Burkard, Alexander Carvajai, Arnoud Frumau, Lars Köhler, Mark Mulligan, Jaap Schellekens, Simone Schmid, and Conrado Tobón. With assistance from: Sophia Burke, Julio Calvo, Jorge Fallas, Gemma Duno-Denti, Robert Figueras, Lieselotte Tolk, and Michiel Zijp. Vrije Universiteit, DFID Forestry Research Programme. 31 January 2006.

The report and descriptions and results of the operational and national-scale models developed by the project, and a hydrological measurement protocol can be found at: http://www.geo.vu.nl/~fiesta

Models and data can be found at: http://www.ambiotek.com/fiesta/

Feedback and Commentary

If you have a good rule-of-thumb, or other comments, please send them to comments@flowsonline.net for inclusion in the next bulletin. We also welcome input and references for forthcoming bulletins.

New Resources

Emerton, L. (2005) Values and Rewards: Counting and Capturing Ecosystem Water Services for Sustainable Development, IUCN Water, Nature and Economics Technical Paper No. 1. IUCN — The World Conservation Union, Ecosystems and Livelihoods Group Asia

ETFRN News, Special Issue on Forests, Water and Livelihoods, Guest edited by Meine van Noordwijk. A publication of the European Tropical Forest Research Network No. 45-46 Winter 2005/06.

Nellemann, C. Ed. (2005) The Fall of the Water: Emerging threats to the water resources and biodiversity at the roof of the world to Asia's lowland from land-use changes associated with large-scale settlement and piecemeal development. UNEP and IUCN

Rosales, R., Kallesoe M., Gerrard P., Muangchanh P., Phomtavong S. and Khamsomphou S. (2005) Balancing the Returns to Catchment Management: The Economic Value of Conserving Natural Forests in Sekong, Lao PDR (2005) IUCN Water, Nature and Economics Technical Paper No. 5. IUCN — The World Conservation Union, Ecosystems and Livelihoods Group Asia

Turpie, J., Ngaga Y.and Karanja F. (2005) Catchment Ecosystems and Downstream Water: The Value of Water Resources in the Pangani Basin, Tanzania IUCN Water, Nature and Economics Technical Paper No. 7, IUCN - The World Conservation Union, Ecosystems and Livelihoods Group Asia

UNESCO (2006) Water: A shared responsibility, UN World Water Development Report 2. World Water Assesment Programme, UNESCO. Executive summary; Press release

Wunder, S.; The B.D.; Ibarra, E. 2005. Payment is good, control is better: Why payments for forest environmental services in Vietnam have so far remained incipient. Bogor, Indonesia, CIFOR. 61p

About the Flows Bulletin

The Flows Bulletin is produced by Sylvia Tognetti, an independent consultant on environmental science and policy, with the collaboration and support of IIED project on Policy Learning in Action: Developing Markets for Watershed Protection Services and Improved Livelihoods, and the World Bank, through the Bank-Netherlands Watershed Partnership Program.

The Flows Bulletin is a forum for multiple perspectives, and does not necessarily represent the views of the sponsoring organizations.

Previous issues of the Flows Bulletin are archived at www.flowsonline.net

Flows is also available in Spanish - to receive it is Spanish, please send an e-mail to subscribe-spanish@flowsonline.net

Flows bulletins 7-12 are available also in Indonesian, online at www.flowsonline.net. To receive future bulletins in Indonesian as they become available, please send an e-mail to subscribe-indonesian@flowsonline.net

To subscribe please send an e-mail to: join-flows@list.flowsonline.net or visit www.flowsonline.net

To unsubscribe, please send an e-mail to: leave-flows@list.flowsonline