

Final Progress Report
Sustainability Science Program
Term: September 1, 2014 – July 31, 2015

Name: Mauricio E. Arias

Your fields:

Water resources engineering; hydrology; freshwater ecology

Your degree program, institution and graduation date:

PhD, Civil Engineering, University of Canterbury, New Zealand, 2014

Faculty host at Harvard name and department:

Paul Moorcroft, Organismic and Evolutionary Biology Department

Description of SSP-related research activity, including a title:

Tradeoffs between hydropower and river alterations in the Tapajós Basin in the Amazon

Abstract: Hydropower will continue to play a major contribution to Brazil's energy agenda. With more than 20% of the country's planned hydropower development, the Tapajós Basin in Southeast Amazonia will have an increasingly important role in the national electricity market. Given the environmental and hydrological changes this basin has faced and will likely continue to experience in the future, the main questions that this project asks are: what is the fate for hydropower generation in the Tapajós under the changing climate and forest conversion in the Amazon? What can be done to maintain the basin's wellbeing? These questions are being addressed with long-term environmental datasets, a series of computation tools, and stakeholder consultation and engagement. Thus far, a number of computer models have been developed, which are able to estimate daily scale, decadal patterns of the regional climate, the basin's biosphere, river flows, and hydropower generation. A number of simulations of historical and future conditions are being computed and validated against monitored environmental data. An initial workshop to share some of the initial results was organized in Brasilia in November 2014 and another will follow later the same month in 2015. Meanwhile, the initiative continues stakeholder consultation and engagement through frequent communication and discussions with Brazil's Electricity Research Bureau and The Nature Conservancy.

Identification of the problem you address:

The Amazon Basin is the next frontier for hydropower development in Brazil and there is a great need for understanding the impacts of climate change and forest conversion on future electricity generation as well as potential alterations on river flows.

Key question asked about the problem:

What is the future fate for hydropower generation in the Tapajós under the changing climate and forest conversion in the Amazon? What can be done to maintain the basin's wellbeing?

The methods by which you answered that question:

These questions are being addressed with analyses of long-term environmental datasets, estimates from a series of numerical models tools, and stakeholder consultation and engagement.

Principle literature upon which the research drew:

- Climate and global environmental change
- Tropical hydrology
- Water resources management and engineering
- Sustainable hydropower and environmental flows

Empirical data acquisition description:

Information required for this study was primarily collected from Brazilian federal agencies and international organizations. River surveys and historical flow records were compiled from the National Water Agency (ANA) and from the Environmental Research Observatory based in Toulouse (France). Information on hydropower dams was provided by the National Electricity Agency (ANEEL) and from The Nature Conservancy. Finally, terrain elevation information was obtained from the Shuttle Radar Topography Mission.

Geographical region studied:

Tapajós Basin in Brazil's Southeast Amazonia

Recommendations that might be relevant for your problem:

Design plans and environmental impact assessments of hydropower projects are typically done on an individual project basis and assume that hydrological inputs are stationary (i.e., no long-term changes). The interim results of this project reveals that such factors need to be incorporated as a prerequisite for sustainable hydropower projects in environmentally sensitive areas.

A description of the final product(s) you have/are aiming to produce:

The SSP Amazon Initiative is working as a team on a number of publications that aim to be completed within the next year. Tentative titles and author lists:

Impacts of climate and land cover on historical river flows in the Tapajos River Basin
Mauricio Arias, Eunjee Lee, Fabio Farinosi, Fabio Pereira, Paul Moorcroft

Tradeoffs of hydropower development and river flow alterations in the Tapajos River Basin
Mauricio Arias, Fabio Farinosi, Eunjee Lee, Angela Livino, Fabio Pereira, Paul Moorcroft

A river routing scheme in the ED2 model
Fabio Pereira, Fabio Farinosi, Mauricio Arias, Eunjee Lee, Paul Moorcroft, John Briscoe

Land use and climate change feedbacks in the Amazon water cycle
Eunjee Lee, Marcos Longo, Fabio Farinosi, Mauricio Arias, Paul Moorcroft

Future hydrology of the Tapajos River Basin
Fabio Farinosi, Mauricio Arias, Fabio Pereira, Eunjee Lee, Paul Moorcroft

Agriculture and climate in the Upper Tapajos River Basin. Estimates of the water requirement for agriculture under climate stress and potential impact mitigation strategies.
Fabio Farinosi, Rachael Garrett, Ian Sue Wing, Mauricio Arias, Eunjee Lee, Carlo Giupponi, Paul Moorcroft

Tradeoff between hydropower and agriculture in the Tapajos River Basin – Synthesis Paper
Eunjee Lee, Fabio Farinosi, Mauricio Arias, Rachael Garrett, Angela Livino, Paul Moorcroft

Future scenarios for hydropower development Tapajos - Summary for policy makers
Angela Livino, Eunjee Lee, Fabio Farinosi, Mauricio Arias, Fabio Pereira, Paul Moorcroft

Description of major other intellectual or professional advancement activities over the past academic year, including working titles:

- Seminar at Colorado State University, March 30th, 2015.
- Publication of book chapter: Piman, T., Cochrane, T.A., **Arias, M.E.**, Dat, N.D., Vonnarart, O. (2015) Managing Hydropower under Climate Change in the Mekong Tributaries. In S. Shrestha (Ed.), *Managing Water Resources under Climate Uncertainty: Examples from Asia, Europe, Latin America, and Australia*. Springer Water.
- Invited paper under review for *Hydrobiologia*: Arias, M.E., Wittmann, P., Parolin, P., Murray-Hudson, M. A., Cochrane, T.A. Interactions between flooding and upland disturbance drives species diversity in large river floodplains.
- Oral presentation at the American Geophysical Union Fall Meeting: Uncertainty and variability in sediment loads in the largest tributary of the Mekong Basin using the Soil and Water Assessment Tool, December 19, 2015.
- Invited seminar panelist at Boston University's Pardee Center: Freshwater, Floods, Fish, and the Future of a Nation.

Citations for reports, papers, publications and presentations that built on your fellowship research:

- Harvard's Brazil Studies Program Seminar: Sustainability of the Amazon: Tradeoffs Between Environmental Change, Hydropower and River Alterations, April 30, 2015.
- Workshop at Brazil's National Electricity Agency: Sustainable Development of the Amazon and its Surrounding Regions: The Interplay of Changing Climate, Hydrology, and Land Use - Impacts on Hydropower Planning and Operation and Flood Risk. Brazilia, December 2014.

Collaborative activities with other SSP Fellows that you are involved with.

- A number of collaborative papers are being prepared among the Amazon Initiative researchers
- Active contributor to the sustainability evaluation working group

Principal collaborators outside Harvard:

- The Nature Conservancy: Paulo Petry, Edenise Garcia, David Harrison
- Boston University: Les Kaufman, Irit Altman
- University of Washington: Jeff Richey, Gordon Holtgrieve