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Amazon basin: using artificial intelligence to optimise international planning of hydroelectric dams

Press release | 18 February 2022

New methods of digital optimisation to improve international management of hydroelectric dams in the Amazon basin have been proposed in an international study, coordinated by Cornell University (United States) with involvement from IRD researchers as well as their South American partners. These results, published in the journal *Science* on 18 February 2022, show that strategic, transboundary planning makes it possible to minimise the many environmental impacts of these facilities and therefore contributes to developing hydropower more sustainably.

Hydropower is a key component of current and future renewable energy portfolios, limiting CO_2 emissions in the atmosphere and therefore reducing the impact of electricity production on the climate. Though there has been a decline in the construction of large dams in Western Europe and North America, in many emerging countries, particularly in South America, hydropower projects are proliferating.

© Alvaro del Campo / The Field Museum: Rio Santiago, a free-flowing river in the Andean Amazon, with large hydroelectric dams planned.

In the Amazon, Earth's largest and most biodiverse river basin, hydropower expansion has accelerated: 158 dams with individual capacity above 1 megawatt are currently active or under construction in five countries (Peru, Colombia, Brazil, Ecuador, Bolivia) and over 350 new facilities are in the planning stage. Such expansion threatens the region's socio-environmental balance.

Although environmental assessments have been performed for certain sites to measure the impact of these structures, the approaches used rarely take the consequences on the Amazon basin as a whole into account, particularly in cases where rivers cross borders. Support tools for strategic planning are needed, to minimise the environmental impacts of dams and protect the river's ecosystem services for local populations. This is one of the 17 Sustainable Development Goals (SDG 6) adopted by the United Nations for 2030, with target 5 aiming to "implement integrated water resources management at all levels, including through transboundary cooperation as appropriate".

A framework for multi-objective optimisation

The study published in *Science* mobilised researchers from over 25 institutions in the United States, Brazil, Colombia, Ecuador, France and Peru. They shared large digital databases relating to five essential environmental criteria for Amazon river ecosystems: river flow, river connectivity, sediment transport, fish diversity, and greenhouse gas emissions.

Researchers from the Cornell *Institute for Computational Sustainability* then developed a powerful framework for multi-objective digital optimisation. Their approach borrows from Italian economist Vilfredo Pareto.[1] It seeks to determine which configuration of hydropower facilities is

optimal to achieve energy production objectives, while simultaneously minimising impacts on the five environmental criteria.

Guiding strategic planning at the basin level

© Elizabeth Anderson: dried up section of the Pastaza River downstream of the Agoyan dam, in Ecuador.

Thanks to this approach drawing on artificial intelligence, the international team show that the lack of strategic planning at the Amazon basin level has led to a current configuration of dams that is far from ideal from an environmental perspective. For example, the study of impacts on ecosystems over time as hydroelectric dams proliferated throughout the entire Amazon reveals that construction of three large dams, among the largest in the world – two on the Madeira (Santo Antonio and Jirau, operational in 2012 and 2013), and one on the Xingu (Belo Monte, operational in 2016) – increased the fragmentation of the Amazon river network by nearly 40%, leading to an abrupt reduction in river connectivity. According to the results of the study, a different geographic configuration would have led to a minimal loss of connectivity across the entire basin for the same energetic yield, thereby minimising attacks on biodiversity.

The results illustrate how strategic planning at the basin level would make it possible in the future to site dams in configurations with less destructive environmental impacts overall. However, in practice, hydropower planning occurs at the national level. In this way, "optimal planning at the country level produces suboptimal environmental results at the overall basin level for one or more of the five criteria," explains Céline Jézéquel and Thierry Oberdorff, ecologists at IRD and co-authors of the study.

"An important outcome of this study is that we combined data from many different kinds of expertise in hydrology, sedimentology, climatology, ecology and social sciences in a single optimisation tool. This makes it possible to develop a more holistic approach to dam planning, taking multiple SDGs into account (energy, biodiversity, water), and shows that we can produce hydropower in a way that is more sustainable for nature and local populations," emphasizes Olivier Dangles, ecologist, IRD's deputy associate science director in charge of sustainability science and co-author of the study.

An online portal to visualise and simulate impacts of the positioning of Amazonian dams according to the five environmental criteria is now available. Researchers urge decision-makers to make use of the data and tools produced by this study, to draw collective advantages from strategic planning at the Amazon basin level and beyond.

This study mobilised teams from the International Joint Laboratory (IML) Biodiversity and Sustainable Andes (Bio_INCA). Some of the data used was collected as part of HYBAM Amazon Basin Water Resourc the Amazon Fish program.

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Alexander S. Flecker et al. Reducing Adverse Impacts of Amazon Hydropower Expansion, *Science*, 18 February 2022.

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[1] Pareto efficiency is defined as a situation in which no individual can be better off without making another individual worse off. Everyone maximises their satisfaction while taking others into account.