Sustainable Sediment Management in the Amazon River Basin through Strategic Dam Planning

Gestion durable des sédiments dans le bassin de l'Amazone grâce à la planification stratégique du barrage

Vicente Tinoco*, Mathias Kondolf

Dept. of Landscape Architecture and Environmental Planning, University of California, Berkeley, USA.
* PhD student
vicente.tinoco@berkeley.edu

RÉSUMÉ

Neuf pays partagent le bassin amazonien et y cherchent une source de développement économique. L'Équateur, le Pérou, la Bolivie et le Brésil ont l'intention d'exploiter son potentiel de production hydroélectrique, avec 400 nouveaux barrages pour des projets hydroélectriques dans le bassin de l'Amazone, dont 150 dans les rivières andines. Alors que ce développement à grande échelle aura de nombreux impacts environnementaux, dans cette étude, nous nous concentrons sur les perturbations du flux naturel de sédiments et considérons des stratégies pour optimiser les emplacements des barrages afin de produire de l'hydroélectricité tout en en minimisant les impacts. J'y exploite des scénarios avec différentes combinaisons de barrages, en tenant compte de la quantité de sédiments piégés dans les barrages et de la quantité de sédiments qui atteindra les principaux confluents de la rivière et le courant dominant en aval. Les scénarios permettront aux décideurs de visualiser les compromis entre la production d'énergie et le volume de sédiments piégés dans les barrages. Je résume les stratégies de gestion des sédiments des réservoirs et les applique dans le modèle avec différents facteurs d'efficacité des pièges. Habituellement, la gestion des sédiments dans les réservoirs n'est pas prise en compte dans ces projets, ce qui entraîne non seulement des impacts environnementaux élevés, mais aussi une réduction de la durée de vie productive de ces projets lorsqu'ils se remplissent de sédiments.

ABSTRACT

Nine countries share the Amazon basin and seek from it a source for their economic development. Ecuador, Peru, Bolivia, and Brazil aim to exploit its hydropower generation potential, with 400 new dams for hydropower projects are planned in the Amazon River Basin, of which 150 dams will be in Andean rivers. While this large-scale development will have many environmental impacts, in this study we focus on disruptions to the natural sediment flux and consider strategies to optimize dam locations to produce hydropower whilst minimizing impacts. Using estimates of sediment yield and sediment grain size by subbasin, I run scenarios with different combinations of dams, accounting for the amount of sediments trapped in the dams and the amount of sediments that will reach the main river confluences and the mainstream downstream. The scenarios will allow decision-makers to visualize tradeoffs between energy generation and volume of sediment trapped in dams. I summarize reservoir sediment management strategies, and implement them in the model with different trap efficiency factors. Usually, reservoir sediment management is not considered in these projects, resulting not only on high environmental impacts, but also in reduced productive lifetimes for these projects as they fill with sediment.

KEYWORDS

Dams, watershed management, sediment management, river continuum

1 INTRODUCTION

400 new dams for hydropower projects are planned in the Amazon River Basin, from which 150 dams are in the Andean Tributaries Rivers tributaries of Colombia, Bolivia, Ecuador and Peru (Finer and Jenkins, 2012). The Andean Region provides to the Amazon Basin with rivers with steep slopes and high discharges, and thus high sediment loads (Fig 1).

Fig. 1. Typical transition from the eastern Andes Cordillera in Ecuador to the foothills in the Amazon. a) Pastaza River. b) Upano River. c) El Molino Hydropower Dam in the Paute River. (Photos: Tinoco, V.)

Dams trap sediment, which affects both the reservoir sustainability (by impairing dam functions, reducing storage capacity, increasing risk of dam failure) and negatively impacts the geomorphology and ecology of downstream reaches (Kondolf et al. 2014).

The high sediment loads of these steep Andean tributaries makes sediment problems likely, and they are already evident in projects in the area, although not in the Amazon Basin, such as: Poechos, the largest reservoir in Peru, completed in 1997, has already lost half of its original capacity. Ocaña, a small hydro power project in Ecuador, 25 MW, fills its reservoir with sediments annually. Fig. 2, illustrate sediment removal process, which takes at least three weeks per year. This small project, besides the sedimentation problem, has an excellent scale to illustrate the issue, which may not be evident in large dams, which may hold many years of sediment accumulation before siltation problems manifest.

Reservoir sedimentation problems need not be inevitable, as there are multiple approaches to pass sediment through or around dams that can work in many contexts (Kondolf et al. 2014). Such measures are best developed and implemented in the initial design stage, as retrofits tend to be costlier, less effective, and riskier.

While this large-scale development will have many environmental impacts, in this study we focus on disruptions to the natural sediment flux and consider strategies to optimize dam locations to produce hydropower whilst minimizing impacts.

Fig 2. Sediment trapped in the off-stream reservoir of the Ocaña Hydropower Project, Ecuador, during the rainy season Jan - May. (Photos: Tinoco, V.)

2 METHODS

We implement the following steps for analazing the Amazon Basin:

2.1 Characterization of Geomorphic Units

We classified the Amazon Basin in geomorphic units, which are land areas that share similar characteristics of the following parameters: soil texture, slope, geology, seismic risk, and land cover.

2.2 Sediment yield and sediment grain distribution

With rainfall data, and the parameters from the geomorphic units, we estimated sediment yield and sediment grain size by subbasin.

2.3 CASCADE

Using estimates of sediment yield and sediment grain size by subbasin, we will apply the method: CAtchment Sediment Connectivity And DElivery (CASCADE). (Schmitt et al., in press), for running scenarios with different combinations of dams, accounting for the amount of sediments trapped in the dams and the amount of sediments that will reach the main river confluences and the mainstream downstream. We summarize reservoir sediment management strategies, and implement them in the model with different trap efficiency factors.

3 EXPECTED RESULTS

The results from the modeled scenarios allow decision-makers to visualize tradeoffs between energy generation and volume of sediment trapped in dams. Counting with a public analysis of these trade-offs, not only empower more sustainable solutions, but also call for a transboundary decision-making in the Amazon Basin.

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