# Being cautious about hydropower dams in the Pantanal

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**Keywords:** Floodplain; climate change; land use; ecosystem services.

**ABSTRACT –** Transition energy plans from many developing countries rely on hydropower expansion as climate-friendly energy sources. However, cumulative impacts from multiple dams still need to be integrated into environmental impact assessments. Establishing better connections among the ecosystem services and dams within each river basin can enable us to identify forgone ecological benefits or optimize inevitable trade-offs. Here, we highlighted the main challenges for the Pantanal ecoregion, a broad floodplain in the shadow of a fast-track dam-building program. Synergetic effects of climate extremes, dams, and agricultural intensification have led to the shrinking of aquatic environments and, consequently, reduced regulating and supporting services, such as carbon sink and habitat provision. At this point, balancing socioeconomic and ecological needs is mandatory to maintain the Pantanal floodplain's integrity. We urge the policy communities to take basin-wide strategic planning seriously to reduce environmental costs.

## Sendo cauteloso com as barragens hidrelétricas no Pantanal

**Palavras-chave:** Planície de inundação; mudança climática; uso da terra; serviços ecossistêmicos.

**RESUMO –** Os planos de transição energética de muitos países em desenvolvimento dependem da expansão da energia hidrelétrica, como fontes de energia renováveis. Contudo os impactos cumulativos de múltiplas barragens ainda precisam ser integrados às avaliações de impacto ambiental. Estabelecer melhores conexões entre os serviços ecossistêmicos e barragens dentro de cada bacia hidrográfica nos permite identificar benefícios ecológicos perdidos ou otimizar compensações inevitáveis. Aqui, destacamos os principais desafios para a ecorregião do Pantanal, uma ampla planície de inundação à sombra de um programa acelerado de construção de barragens. Os efeitos sinergéticos dos extremos climáticos, barragens e intensificação agrícola tem levado ao encolhimento dos ambientes aquáticos e, consequentemente, à redução dos serviços de regulação e suporte, tais como sequestro de carbono e provisão de habitats. Neste sentido, equilibrar as necessidades socioeconômicas e ecológicas é obrigatório para manter a integridade da planície de inundação do Pantanal. Nós solicitamos que as comunidades políticas levem a sério o planejamento estratégico de toda a bacia para reduzir os custos ambientais.

## Siendo cauteloso con las represas hidroeléctricas en el Pantanal

**Palabras clave:** Planicie aluvial; cambio climático; uso del suelo; servicios ecosistémicos.

**RESUMEN –** Los planes de transición energética de muchos países en desarrollo se basan en la expansión de la energía hidroeléctrica como fuente de energía amigable con el ambiente. Sin embargo, los impactos acumulativos de múltiples represas aún deben integrarse en las evaluaciones de impacto ambiental. Establecer mejores conexiones entre los servicios ecosistémicos y la construcción de represas dentro de cada cuenca fluvial permitirnos identificar los beneficios ecológicos perdidos u optimizar las compensaciones inevitables. En este artículo, destacamos los principales desafíos para la ecorregión del Pantanal, una gran planicie de inundación a la sombra de un programa acelerado de construcción de represas. Los efectos sinérgicos de los extremos climáticos, las represas y la agricultura intensiva han llevado a la reducción de los ambientes acuáticos y, en consecuencia, a la reducción de los servicios de regulación y suporte, tales como el secuestro de carbono y la disponibilidad de hábitat. En este punto, es obligatorio equilibrar las necesidades socioeconómicas y ecológicas para mantener la integridad de la planicie de inundación del Pantanal. Instamos a los actores políticos a que tomen en serio la planificación estratégica de toda la cuenca para reducir los costos ambientales.

## Introduction

The notion of dams as sources of climate-friendly energy is a paradox. Hydropower development is essential in the Brazilian transition energy plan [1], promoting a business context for investment and industrial expansion. However, dam impacts are not minimal, and much more detailed research is needed to address the cumulative effects of multiple dams and prevent their far-reaching and costly socio-environmental consequences. The individual dams lead to river fragmentation, sediment flow disruption, and extensive modification in the landscape associated with habitat flooding and disruption of seasonal water level fluctuation [2]. Evidence showed that some tropical reservoirs emit as much greenhouse gases as fossil-fueled power plants [3][4] and that the poor dam placement has already resulted in forgone ecosystem service benefits [5]. Although food resources and other services are well-perceived by human populations, essential regulating and supporting services (e.g., water purification and *habitat* provision) associated with river floodplains are not often recognized by the general public and policymakers. Thus, establishing better connections among the ecosystem services and dams within each river basin can enable us to reduce or avoid the effects of future energy projects. We are already behind schedule for this analysis because what happens in a dam-regulated river does not stay in the valley-affecting all biodiversity in the floodplains downriver and the thousands of people depending on them.

## Case report

The Upper Paraguay River Basin (UPRB) supports the Pantanal ecoregion, where ~30 thousand people rely on the direct fishery for sustenance [6]. Besides, the ecoregion has wetlands of significant value for humanity (around 35,000 km$^2$) recognized as Ramsar sites. Most Pantanal faces seasonal flood pulse triggered by river overflow and rainfall runoff. Modest differences in the flood amplitude are sufficient to determine a mosaic of vegetation types [7]. There are 41 upstream dams in the UPRB, and there are plans for another 128 to provide hydroelectric energy [6]. The operation of existing dams has already altered natural Pantanal hydrology and poses a substantial risk to the fishery resources [8][9]. For example, the Manso hydropower plant resulted in a 20% reduction in water discharge during the beginning of the rainy season, delaying the flooding in the Pantanal [10]. However, the only study on the cumulative effects of dam construction in the Upper Paraguay River Basin focuses on maintaining the fishing stocks and sediment load changes [6]. In the meantime, hydropeaking may reach far more than 100 km inside the Pantanal. Maintaining the hydrological regime is essential to the Pantanal because several organisms exhibit reproduction and dispersion patterns adjusted to these variations in the vegetation and water level [11][12][13]. For example, aquatic-terrestrial zones serve as the primary *habitat* and dispersal corridor for iconic elements of nature-based tourism in the Pantanal, such as the jaguar, marsh deer, and yellow anaconda [14][15][16].

## Discussion

The current challenge is to match multiple dams with uncertainties in the river basins, such as climate change and agricultural intensification. Aquatic environments in the Pantanal have significantly decreased during the past three decades, even within protected areas [17]. Weaker flood pulses and harsher droughts are becoming routine. Meanwhile, studies indicate that some Pantanal landscape elements are more susceptible to climate change and land use intensification than others [18][19]. Intensification of human land use is a widespread phenomenon in central Brazil that may interact synergistically to affect environmental integrity [20][21].

Perhaps the most emblematic example in the Pantanal is the avulsion of the Taquari River (i.e., the river left the original bed because it was raised by silting and dried up) as a result of agricultural expansion at the top of the basin [22]. At this point, balancing socioeconomic and ecological needs is mandatory to maintain the Pantanal floodplain's integrity. The "Pantanal Statute" bill, which provides for conservation and sustainable exploitation, is under discussion at the Brazilian National Congress [23].

However, ideas conflicting with the ecoregion integrity have also gained strength. For example, the Paraguay-Paraná waterway will incur more ecological, social, and economic costs for the Pantanal ecosystem than economic benefits [24].

Changes in the water discharge (due to irrigation and dam flow control), sediment load from agricultural erosion, and water pollution by agrochemicals are impending threats to the rivers forming the Pantanal [25]. Therefore, the conservation of the Pantanal Rivers should be conditional on public policies that have science as a basis for their construction.

Optimizing UPRB dams regarding Pantanal integrity requires several steps. An obvious one is to improve the monitoring and management of energy distribution. For example, Brazil lost 13.9% of total power generated because of grid transmission issues and theft, while Pantanal states lost an average of 15.5% [26]. Given that hydropower dams are often far from large consumption centers, it is also essential to encourage micro and mini-generation inside urban centers to reduce technical distribution losses. Second, the dam capacity and the energy output in South America have been greatly affected by climate extremes [27][28].

There are several examples of drops in generation from Brazilian plants because of low streamflow. Alone, the water shortage projected by climatic forecasts signs a slowdown in hydropower expansion. So, Brazil needs to reconsider its transition energy strategy. Lastly, we urge the policy communities to take basin-wide strategic planning seriously to reduce environmental costs. Clear opportunities exist for optimizing dam networks for multiple ecosystem services [5].

The hydropower network needs to be revised to promote minimal changes in the geomorphic structures of UPRB. Measuring the actual impacts of dams on the Pantanal wetlands is difficult because of the variety of wetlands per se and the lack of their integration into ecosystem services assessment and regulatory permitting. In this context, addressing functional landforms and *macrohabitat* inside them is paramount [19][29]. These constitute key steps towards, among others, wetland characterizations and classifications and Pantanal ecosystem service standards.

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