NBS in Environmental Regularization of Hydroelectric Plants in Sao Paulo

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Abstract

Hydropower generation can cause significant environmental impacts on physical, biotic, and socioeconomic components. In the State of São Paulo, Brazil, many hydroelectric power plants were built before the implementation of legal frameworks for environmental licensing. As a result, a process of environmental regularization is now required under the supervision of the state environmental agency. This process involves conducting an Environmental Impact Assessment (EIA) focused on the operational phase of these facilities, aiming to identify existing impacts and potential environmental liabilities. Based on the EIA, it is possible to propose and implement appropriate preventive, mitigating, and compensatory measures, ensuring more sustainable operation. The incorporation of Nature-Based Solutions (NBS) in this context presents an effective strategy to address challenges such as improving water quality, controlling erosion, and promoting ecological restoration. Possible actions include restoring unvegetated areas, recovering spring areas, and installing living support structures along reservoir banks. Defined as actions that conserve and restore natural or modified ecosystems to promote sustainable development and biodiversity, NBS should be supported by public policies and integrated into licensing and environmental regularization processes to ensure their effectiveness and long-term sustainability.

Keywords: Nature-based Solutions (NbS), hydropower, Environmental Impact Assessment, environmental licensing, São Paulo, Brazil

1. Introduction

Hydropower generation has significant potential to cause environmental impacts across various aspects, including physical, biotic, and socioeconomic factors. In Brazilian legislation, environmental licensing use methodology of Environmental Impact Assessment (EIA). According to federal legislation—which must be considered by the states—the EIA must be conducted in three distinct stages of the project: the preliminary phase, to assess the environmental feasibility of the project (application for a Preliminary License – LP); during the construction of the project or activity (application for an Installation License – LI); and during the operational phase (application for an Operation License – LO).

In the State of São Paulo, many hydroelectric power plants were built before the implementation of legal frameworks for Environmental Licensing and Impact Assessments (EIA)[1]. Therefore, a process of environmental regularization is currently required, supervised by the state's environmental agency: the Environmental Company

[1] **BRASIL**. Lei nº 6.938, de 31 de agosto de 1981. *Dispõe sobre a Política Nacional do Meio Ambiente, seus fins e mecanismos de formulação e aplicação, e dá outras providências*. Diário Oficial da União: seção 1, Brasília, DF, 2 set. 1981. Disponível em: <https://www.planalto.gov.br/ccivil_03/leis/l6938.htm>. Acesso em: 17 abr. 2025.

of the State of São Paulo – CETESB[2]. This process aims to mitigate the negative effects of existing infrastructure operations on the environment and ensure compliance with current regulatory standards

To achieve environmental regularization of hydroelectric plants, it is essential to conduct an EIA focused on the operational activities of the enterprise, as it is understood that the earlier stages (planning and construction) of these existing plants are no longer applicable.

This process involves identifying the expected impacts during the operational phase, as well as potential environmental liabilities. Through a thorough EIA, it is possible to propose and implement preventive, mitigating, and compensatory measures for each identified impact or liability, ensuring that the hydropower plant operates in an environmentally sustainable manner and minimizes negative effects on the surrounding ecosystem.

In this context, Nature-based Solutions (NbS) emerge as valuable opportunities to avoid, prevent, mitigate, or compensate for the identified impacts.

NBS can be defined as actions to protect, conserve, and restore natural or modified ecosystems, aiming for sustainable development with resilience and biodiversity gains, and are applicable in both urban and rural contexts[3][4]. However, in order to be more widely disseminated and result in regional-scale biodiversity gains, NBS must be strategically planned and supported by public policies. Public agents from various sectors must contribute to the development and implementation of long-term solutions for sustainable and resilient development, including those required in technical guidelines within environmental licensing and regularization processes.

2. NbS in the context of hydropower environmental regularization

In Brazil, there are three levels of government (federal, state, and municipal). These three spheres of government may establish their own regulations and legal instruments to license projects, with varying levels of complexity, provided that there is no legal conflict with the rules established by the higher-level authority. Among the types of projects subject to licensing that require an Environmental Impact Assessment (EIA), hydroelectric developments stand out due to their high potential to generate environmental impacts across different components (physical, biotic, and anthropogenic).

In São Paulo's State, many hydroelectric developments were implemented prior to the existence of federal environmental legislation and the legal frameworks for environmental licensing[5]. As a result, they must now obtain environmental licenses

[2] **CETESB – COMPANHIA AMBIENTAL DO ESTADO DE SÃO PAULO.** *Histórico da Companhia Ambiental do Estado de São Paulo*. São Paulo, 2025. Disponível em: <https://cetesb.sp.gov.br/historico/>. Acesso em: 17 abr. 2025.

[3] **UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP)**. *Emissions Gap Report 2022: The Closing Window – Climate crisis calls for rapid transformation of societies*. Nairobi: UNEP, 2022. 132 p. Disponível em: https://www.unep.org/resources/emissions-gap-report-2022. Acesso em: 17 abr. 2025.

[4] **BONA**, S. et al. *Nature-Based Solutions in Urban Areas: A European Analysis*. Applied Sciences, v. 13, n. 1, p. 168, 2023. Disponível em: https://www.mdpi.com/2076-3417/13/1/168. Acesso em: 17 abr. 2025.

[5] **BRASIL.** Lei nº 6.938, de 31 de agosto de 1981. *Dispõe sobre a Política Nacional do Meio Ambiente, seus fins e mecanismos de formulação e aplicação, e dá outras providências.* Diário

through a regularization instrument issued by the competent environmental authority, specifically through the issuance of a Regularization Operation Environmental License[6].

To regularize hydroelectric plants implemented prior to the legal frameworks for environmental licensing in the State of São Paulo, it is necessary to submit to CETESB a document known as the Environmental Regularization Report (Relatório de Regularização Ambiental – RRA). This report must include an Environmental Impact Assessment focused on identifying operational phase impacts and potential environmental liabilities, along with a proposal for the adoption of preventive, mitigating, and compensatory measures appropriate for each identified impact or liability. The potential environmental impacts expected in the different stages of hydroelectric project licensing can be consulted in the Manual for the Preparation of Environmental Impact Studies[7].

In the context of the environmental regularization of hydroelectric projects, the application of Nature-based Solutions (NbS) is envisioned across various areas to mitigate impacts at both local and regional scales, while simultaneously promoting local biodiversity. The term "Nature-based Solution" was coined around 2009, promoted by the International Union for Conservation of Nature (IUCN)[8]. It was formulated to describe strategic approaches that utilize nature and its processes to address social and environmental problems, particularly in the context of climate change. However, Brazil's 1988 Forest Code[9] (currently replaced by Federal Law 12.651/2012[10]) already included references to activities that could be classified as NbS.

One such action is reforestation with a forest compensation focus. In the case of reservoirs, environmental licensing in the State of São Paulo requires the reforestation of Permanent Preservation Areas (Áreas de Preservação Permanente – APPs), which are protective buffer zones ranging from 15 to 100 meters in width surrounding the

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[6] **BRASIL.** Conselho Nacional do Meio Ambiente – CONAMA. Resolução nº 6, de 16 de setembro de 1987. *Dispõe sobre o licenciamento ambiental de obras do setor de geração de energia elétrica.* Diário Oficial da União: seção 1, Brasília, DF, 22 out. 1987. Disponível em: https://www.ibama.gov.br/sophia/cnia/legislacao/MMA/RE0006-160987.PDF. Acesso em: 17 abril 2025.

[7] **CETESB**. *Manual para elaboração de estudos com avaliação de impacto ambiental*. São Paulo: CETESB, 2019. 245 p. Disponível em: <https://repositorio.cetesb.sp.gov.br/handle/123456789/2492>. Acesso em: 17 abr. 2025.

[8] **BANCO INTERAMERICANO DE DESARROLLO (BID); ACCLIMATISE.** *Mejorando la resiliencia de la infraestructura con soluciones basadas en la naturaleza (SbN): guía técnica de 12 pasos para desarrolladores de proyectos*. Acclimatise, 2020 (página 56). Disponível em: <https://publications.iadb.org/es/mejorando-la-resiliencia-de-la-infraestructura-con-soluciones-basadas-en-la-naturaleza-sbn>. Acesso em: 17 abr. 202**5.**

[9] **BRASIL**. Lei nº 4.771, de 15 de setembro de 1965. Institui o novo Código Florestal. Diário Oficial da União: seção 1, Brasília, DF, 16 set. 1965. Disponível em: <https://www.planalto.gov.br/ccivil_03/leis/l4771.htm>. Acesso em: 17 abr. 2025.

[10] **BRASIL.** Lei nº 12.651, de 25 de maio de 2012. *Dispõe sobre a proteção da vegetação nativa*. Diário Oficial da União: seção 1, Brasília, DF, 28 maio 2012. Disponível em: https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm. Acesso em: 17 abr. 2025.

reservoir operating water level. Reforesting these APPs tends to promote the formation of ecological corridors, facilitating gene flow among regional flora and fauna[11].

However, for projects implemented prior to Provisional Measure number. 2.166-67, dated August 24, 2001[12], and therefore subject to environmental regularization, the APP was limited to operational levels (*Normal Maximum* and *Maximum Maximorum* Water Level). In this context, for hydroelectric projects undergoing environmental regularization, ecological restoration will only achieve the objectives of reservoir preservation if applied on a broader scale, such as restoration around the headwaters of contributing tributaries. These actions require incentives and engagement from landowners, as well as municipal and state authorities.

Ecological restoration also contributes significantly to controlling erosion, sedimentation, and the collapse of reservoir banks. In such cases, restoration should be applied on a broader scale, such as the restoration of headwater areas of tributaries that feed into the reservoir.

Furthermore, in other existing structures within hydroelectric developments, techniques based on Nature-Based Solutions (NBS) and additional integrated solutions can be adopted to optimize the beneficial effects of "green structures." Examples include the installation of living support walls along sections of the reservoir banks that are most susceptible to water level fluctuations, or at spillway points downstream from the dam[13]. Within a context that encourages the implementation of NBS, it is also possible for this type of project to adopt additional integrated solutions such as bioswales, green roofs, constructed wetlands for effluent filtration, and rain gardens and terraces around the administrative areas of hydroelectric facilities, to promote climate resilience and support local biodiversity.

3. Conclusion

Considering the above, it becomes evident that the potential of Nature-based Solutions (NbS) to provide climate resilience while enhancing biodiversity in a given region aligns with the role of environmental agencies in the environmental regularization of projects. This role consists of reducing the impacts inherent to the operation of an activity or enterprise, as well as identifying and addressing environmental liabilities.

In hydroelectric developments cases, which have a high potential to impact local biodiversity and affect connectivity for maintaining gene flow, the importance of maintaining a vegetated buffer zone around the reservoir is evident. Such a buffer also helps minimize the effects of erosion and sedimentation. However, for Brazilian

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[11] **ARAÚJO, T. M. S.; BASTOS, F. H.** Corredores ecológicos e conservação da biodiversidade: aportes teóricos e conceituais. *Revista de Geografia*, v. 5, n. 2, 2019. Disponível em: https://www.researchgate.net/publication/336885727_CORREDORES_ECOLOGICOS_E_CONSERVACAO_DA_BIODIVERSIDADE_APORTES_TEORICOS_E_CONCEITUAIS. Acesso em: 17 abr. 2025.

[12] **BRASIL.** Medida Provisória nº 2.166-67, de 24 de agosto de 2001. *Altera os arts. 1º, 4º, 14, 16 e 44 da Lei nº 4.771, de 15 de setembro de 1965, e dá outras providências*. Diário Oficial da União: seção 1, Brasília, DF, 27 ago. 2001. Disponível em: <https://www.planalto.gov.br/ccivil_03/mpv/2166-67.htm>. Acesso em: 17 abr. 2025.

[13] **BANCO INTERAMERICANO DE DESARROLLO (BID); ACCLIMATISE.** *Mejorando la resiliencia de la infraestructura con soluciones basadas en la naturaleza (SbN): guía técnica de 12 pasos para desarrolladores de proyectos*. Acclimatise, 2020 (página 56). Disponível em: <https://publications.iadb.org/es/mejorando-la-resiliencia-de-la-infraestructura-con-soluciones-basadas-en-la-naturaleza-sbn>. Acesso em: 17 abr. 202**5.**

reservoirs built prior to the current environmental legislation, this buffer zone (APP) was defined with a width restricted to the reservoir's operational levels, which may limit its beneficial effects.

This way, it is recommended that public policies be created and implemented to promote and encourage the adoption of additional NbS-inspired measures, such as: (i) the ecological restoration of spring areas of water bodies that contribute to the reservoir; (ii) the installation of living support walls along reservoir banks that experience significant and constant water level fluctuations or in downstream sections of the dam; and (iii) the implementation of additional integrated solutions, such as bioswales, green roofs, rain gardens, and green terraces in the administrative areas of hydroelectric facilities, in order to promote climate resilience and support local biodiversity.

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