Brazilian hydropower plants: good practices of cumulative effects assessment

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Abstract: The practice of evaluating cumulative impacts for planning is not widespread in Brazil. However, a tool – locally named Integrated Environmental Assessment (IEA) – focuses on the analysis of the cumulative impacts of a set of dams in a watershed has been used to oversee the impacts of the Brazilian hydroelectric planning. This research aims to analyze how the evaluation of cumulative impacts has been carried out in this context in comparison to the best practices of cumulative effects assessment (CEA) for a watershed. Because the Amazon river basins concentrate a large part of the hydroelectric plants projected to meet the demands of the national electricity, the Teles Pires river basin was chosen for developing this research. The main results reveal that some of the best practices of CEA are embedded in the Brazilian environmental planning of hydroelectric dams. However, CEA is used in a limited way without considering actions other than hydroelectric projects and there is absence of mitigation measures.

1. Introduction

Hydropower plants are the predominant source of power in Brazil. According to the agency responsible for regulating Brazilian power, the hydropower sources currently represents 61.34% of the electric power grid and 1,254 hydropower plants produce 98,059,082 MW of energy (ANEEL, 2017).

There is a huge potential for expanding the use of this kind of energy in Brazil. In 2007, only 28.4% of the total capacity of Brazilian hydropower was installed; almost half of this capacity (50.2%) is located in the Amazon region (Bermann, 2007). The Brazilian electricity sector intends to build 43 large hydropower plants, 10 of which are scheduled to be completed by 2022 in the Tapajós river basin in the Amazon region.

At the same time, there is a recognized negative legacy on the environment caused by hydroelectric plants in the Amazon Basin. The main ecological impacts of hydroelectric dams in the Brazilian Amazon basin are associated with: population displacement, soil loss, loss of plant and animal species, loss of natural and historic monuments, loss of timber resources, modification of the hydraulic geometry of the river and in its hydrology, modifications of the sediment load of the rivers, floristic and faunistic changes upstream and downstream the dams, impacts on fishing and agriculture, growth of aquatic macrophytes, deterioration of water quality, health problems, CO2 emissions, among others (Fearnside, 2016).

The Amazon socio-environmental vulnerabilities contrast with the wide availability of hydroelectric potential. According to Fearnside (2016), the socio-environmental impacts of hydroelectric plants in the Amazon do not only affect the project footprint but also the whole watershed.

The Brazilian hydropower sector has been recognized not only for causing environmental impacts but for pioneering the application of Impact Assessment (IA) instruments. Brazil has a long history in the EIA of hydropower plants and only few applications of SEA, which is not mandatory in the country. Although the practice of evaluating cumulative impacts for planning is not widespread in Brazil, an instrument – locally named Integrated Environmental Assessment (IEA) – focuses on the analysis of the cumulative impacts in a watershed with a planned set of dams. This instrument has been used to oversee the impacts of the Brazilian hydroelectric planning.

This research means to analyze how the evaluation of cumulative impacts has been carried out in an Amazon river basin in comparison to good practices of cumulative effects assessment (CEA) in a watershed. The Teles Pires river basin was chosen because is one of the Amazon river basins that concentrates a significant part of the hydroelectric plants projected to meet the Brazilian demands for electricity.

2. Integrated Environmental Assessment (IEA) and good practices of CEA

For Seitz et al. (2011), some hydropower projects in a watershed interact in a synergistic way over time and space, threatening the sustainability of water resources.

Cardinale and Greig (2013) describes the CEA as an instrument for analyzing the potential impacts of one or more projects combined with the potential effects of other human activities in a same area in order to propose measures to prevent, reduce and / or mitigate cumulative impacts. For Noble et al. (2011), the practice of CEA has to include individual projects and also a regional scale analysis of where the watersheds are represented and the source of cumulative impact changes are situated.

Canter et al. (2013), after undertaking a comprehensive review of methods for water resource planning, synthesized some guidelines for applying CEA in this context. The methods presented by Canter et al. (2013) consolidate previous work by the Canadian Council on Environmental Quality (1999) and by Canter and Ross (2010) presented in Canter et al. (2013). These authors have consolidated checklists for assessing cumulative impacts in the context of water resource planning, synthesizing good practices of CEA applied to river basins.

In Brazil, according to Tucci and Mendes (2006), IEA is an instrument for assessing the environmental baseline of the watershed with the hydroelectric projects in operation and the planned hydropower plants considering: (i) the cumulative effects on natural resources and on human populations of this set of hydropower plants; and (ii) the current and potential uses of water resources balancing the need to guarantee energy generation with biodiversity conservation, socio-diversity and socioeconomic development in accordance with the environmental legislation.

3. Methods

Our case study is the Teles Pires river basin in which six hydropower plants and seven small hydropower plants are projected. The documentary research object refers to the IEA report of the Teles Pires river basin. The IEA report follows Tucci and Mendes (2006) guidelines for evaluating cumulative effects on the Teles Pires river basin.

Since there is limited practice and there is no conceptual-theoretical framework established in Brazil for applying CEA, we chose the guidelines for analyzing cumulative impacts in watershed proposed by Canter et al. (2013) as a research instrument. From these guidelines, we adopted a six-step checklist developed by Canter and Ross (2010) presented in Canter et al. (2013) for analyzing how the valued environmental and social component (VEC – valued environmental component) was considered in the CEA process. Then this checklist, understood as a good practice, was analyzed in relation to the IEA process of the Teles Pires river basin.

4. Results and Discussion

Table 1 presents the analysis of the IEA process of the Teles Pires river basin described in the IEA report compared to what the good practices established were for assessing cumulative impacts by Canter and Ross (2010) presented in Canter et al. (2013).

Table 1 – Documental analysis of IEA process of the Teles Pires river basin as compared to the contents of the six steps of CEA good practices as recommended by Canter and Ross (2010) apud Canter et al. (2013).

Steps of CEA Good Practices	Documental Analysis from the IEA Report	Rationale Analysis
Step 1 – the cumulative impact assessment and management process; identification of direct and indirect effects on VEC	the cumulative impact assessment and management process was carried out from the cumulative and synergistic effects discussed for VECs in the river basin; the VECs were analyzed based on indicators proposed for the current scenario (without the hydroelectrics in) and the planned scenario future (without the hydroelectrics)	Analysis performed.
Step 2 – prediction of past, present and future actions to identify the spatial and temporal limits for each VEC	the current, past and future socio-environmental features of the basin were analyzed only for actions related to hydroelectric projects	Analysis partially completed. It was restricted to the analysis of the hydroelectric projects in the river basin. Actions not included in this scope were not analyzed; these actions were only mentioned.
Step 3 – appropriately defining the indicators for the VECs	the VECs were analyzed by using indicators in the current and future scenarios; the framework of policies, plans and programs associated with the river basin was also considered.	Analysis performed.
Step 4 – connecting the project, plan or policy with other actions in the area considering the VECs	the proposed hydroelectric plants were analyzed in terms of their repercussions on policies, plans and programs in that context. However, other actions in the basin that may affect the VECs were not discussed. This analysis was based on indicators and on socio-environmental conflicts	Analysis: partially completed, because it was only directed to hydroelectric projects, disregarding other possible actions that may occur in the river basin and affect resources, ecosystems and society.
Step 5 – evaluating the importance of the cumulative effects on each VEC within the horizon of time established for the project or plan. The focus should be on the VEC and not on the project or action.	the importance of the cumulative effects on each VEC within the horizon of time established for implementing the hydroelectric projects was analyzed. This analysis was focused on the VECs.	Analysis performed.
Step 6 – for VECs whose cumulative effects will be significant to the project or plan, proposing appropriate mitigation measures. Providing multi-stakeholder collaboration to coordinate such management at local or regional level or both.	indicators have been identified that allow monitoring and maybe adapting the solutions for mitigating cumulative impacts. Although the conflicts have been identified, the mitigation measures, the residual impacts as well the associated policies, plans and associated programs are not detailed.	Analysis: partially completed. The measures were not deeply discussed and there is only partial provision – the identified conflicts – for managing this.

By analyzing Table 1, the steps 2, 4 and 6 not to fully comply with the statements of the checklist of good practices of CEA and the IEA of the Teles Pires river basin. The main limitation refers to: a) the lack of comprehensive consideration of actions other than hydroelectric projects in the river basin; b) the limited detail of the mitigation measures for the cumulative impacts.

The evaluation of cumulative impacts presents evidence of good practices in the Teles Pires river basin by analyzing the IEA report. This finding reinforces one of the possible benefits of CEA, as reported by Cooper and Sheate (2004): that the use of the instrument allows reducing the incremental contribution of cumulative impacts in the river basin, by anticipating them in the planning process.

Noble et al. (2011) highlight some challenges to progress in CEA in watersheds: an agreement on the nature and definition of cumulative environmental impacts; the scale of analysis; monitoring indicators for assessing and managing cumulative impacts. These aspects of good practices of CEA were observed in the IEA of the Teles Pires river basin.

Given the synergistic way in which impacts have been accumulated in river basins by multiple hydroelectric dams, the assessment of cumulative impacts should be improved to capture these transformations more comprehensively, as also highlighted by Seitz et al. (2011), protecting the potential multiple uses of water in the river basins and in the environment.

5. Conclusions

The Integrated Environmental Assessment (IEA) instrument used by the Brazilian electric energy planning is considered to allow analyzing the cumulative impacts on hydroelectric planning at the river basin level. We conclude that the evaluation of cumulative impacts in the environmental planning of the Teles Pires river basin has been practiced, including some of the international good practices of Cumulative Effect Assessment (CEA).

The procedures for evaluating cumulative impacts of the planned set of hydroelectric projects in the Teles Pires river basins used in the Integrated Environmental Assessment are in line with those recommended by international good practices. The failure to consider other actions of the past and the future within the river basin beyond the projected hydroelectric plants remains the main shortcoming of this cumulative evaluation. Despite the objective of IEA of focusing on the cumulative impacts of hydroelectric projects in a watershed, this approach limits the identification of the cumulative impacts on the socioenvironmental resources and the proposition of mitigation measures in this context.

However, encompassing other actions than only the ones related to hydroelectric plants can enhance the approach of cumulative impacts on the water resources on which the operation of hydroelectric plants depend, and which can be compromised over time.

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References

ANEEL – Agência Nacional de Energia Elétrica. *BIG - Banco de Informações de Geração*, 2017. Disponível em: <http://www2.aneel.gov.br/aplicacoes/capacidadebrasil/OperacaoCapacidadeBrasil.cfm>. Acesso em: mar. 2017.

Bermann, C. Impasses and controversies of hydroelectricity. *Estudos Avançados*, 21(59), 139-153, 2007. http://dx.doi.org/10.1590/S0103-40142007000100011

Canter, L.; Chawla, M; Sport, T. Expanding environmental emphases in water resources planning. *Journal of Environmental Assessment Policy and Management*, 15(4), 1350023, 2013. https://doi.org/10.1142/S1464333213500233

Cardinale, P.; Greig, L. *Good practice handbook*: cumulative impact assessment and management: guidance for the private sector in emerging markets. Washington, DC: International Corporation, 2013.

Cooper, L. M.; Sheate, W. R. Integrating cumulative effects assessment into UK strategic planning: implications of the European Union SEA Directive. *Impact Assessment and Project Appraisal*, 22(1), 5-16, 2004. http://dx.doi.org/10.3152/147154604781766067

Fearnside, P. M. Environmental and social impacts of hydroelectric dams in Brazilian Amazonia: Implications for the aluminum industry. *World Development*, 77, 48-65, 2016. https://doi.org/10.1016/j.worlddev.2015.08.015

Noble, B. F.; Sheelanere, P.; Patrick, R. Advancing watershed cumulative effects assessment and management: lessons from the South Saskatchewan River watershed, Canada. *Journal of Environmental Assessment Policy and Management*, 13(4), 567-590, 2011. https://doi.org/10.1142/S1464333211004012

Seitz, N. E.; Westbrook, C. J.; Noble, B. F. Bringing science into river systems cumulative effects assessment practice. *Environmental Impact Assessment Review*, 31(3), 172-179, 2011. https://doi.org/10.1016/j.eiar.2010.08.001

Tucci, C. E.; Mendes, C. A. *Curso de avaliação ambiental integrada de bacia hidrográfica*, 2006. Disponível em: <http://www.mma.gov.br/estruturas/sqa_pnla/_arquivos/sqa_3.pdf> Acesso em: out. 2017.