Analyzing EIA in Paraná, Brazil and California, United States with Fuzzy-Set Qualitative Comparative Analysis and the Analytical Hierarchy Process

John James Loomis[1]; Maurício Dziedzic[1,2]
[1]Universidade Positivo Graduate, Program in Environmental Management (UP PPGAmb);
[2]University of Northern British Columbia (UNBC), School of Engineering

Abstract

Since its introduction in the US, environmental impact assessment (EIA) has become one of the most widespread environmental policy instruments, which has evolved from solely conservation aims to serve as a tool for sustainable development. Despite its history and dissemination, EIA is routinely criticized for being ineffective at impacting decision-making or promoting more sustainable development. This study performed a comparative case study using the effectiveness dimensions from the EIA evaluative literature and two methodologies. Two states in federalist systems were chosen, Paraná, Brazil and California, United States. This comparative case study formats the cases into contextual conditions using the fuzzy-set Qualitative Comparative Analysis (fsQCA) methodology in order to identify the necessary and sufficient conditions that foster effective outcomes. These effectiveness outcomes and criteria are then ranked by EIA stakeholders via the analytical hierarchy process (AHP) in order to identify stakeholder priorities and to improve stakeholder management. The results show that in Paraná stakeholders identified normative effectiveness as the most important dimension for an ideal effective EIA outcome, and stakeholders in California identified this dimension as the second-most important following substantive effectiveness. For normative effectiveness outcome early project definition and public participation were found to be necessary conditions and stakeholder coordination was found to be a sufficient condition. Following normative effectiveness, Paraná stakeholders identified procedural effectiveness as the second most important. While transactive effectiveness was ranked lowest overall in both case studies, improving procedural effectiveness has been shown to be connected to the transactive effectiveness. Finally, transformative effectiveness ranked third and fourth in California and Paraná respectively, which also had the lowest set membership in fsQCA. This study advances EIA evaluatory literature by assessing various effectiveness dimensions through two complementary methodologies.

Keywords: AHP; environmental impact assessment; EIA effectiveness; EIA system; fsQCA; stakeholder management

Introduction

Since its introduction in the US's National Environmental Policy Act (NEPA) of 1969, environmental impact assessment (EIA) has become one of the most widespread environmental tools, evolving from solely conservation aims to serve towards broader sustainable development ends. Despite its history and dissemination, EIA is routinely criticized for being ineffective at influencing decision-making or promoting sustainable development. Indeed stakeholder management is considered one of the most difficult parts of EIA (Glasson and Therivel 2019).

The aim of this article is to identify the necessary and sufficient conditions that when present lead to an effective EIA outcome and rank the importance of these outcomes in order to identify priorities among EIA stakeholders and improve stakeholder management. To this end, this

study performed a comparative case study along the effectiveness dimensions from the EIA evaluative literature using two methodologies. Two states in federalist systems were chosen, Paraná, Brazil and California, United States (US). The fuzzy-set Qualitative Comparative Analysis (fsQCA) methodology is employed to determine which conditions are necessary or sufficient to result in an effective EIA process using stakeholder assessment complemented by case study data. The importance of these effectiveness outcomes are then ranked by EIA stakeholders via the analytical hierarchy process (AHP).

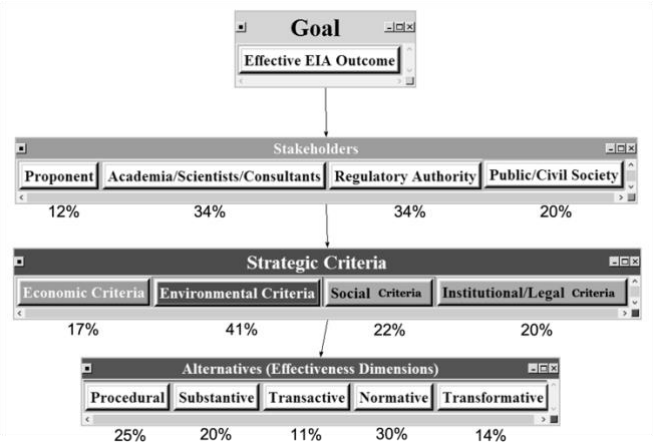
Literature Review

A detailed comparison of the EIA systems of Paraná, Brazil, California, and the US can be found in (Loomis, de Oliveira, and Dziedzic 2021) where a comparative case study is reported, analyzing the systems' operationalization, legislation, administration, and procedures. The present study evaluated the case studies along five dimensions of effectiveness: procedural, substantive, transactive, normative, and transformative (Loomis, Bond, and Dziedzic 2022; Loomis and Dziedzic 2018; Sadler 1996). Procedural effectiveness entails the policy and institutional infrastructure and adherence to the regulations. Substantive effectiveness is the degree to which the EIA mitigates negative environmental impacts, thus securing its immediate objectives, and positively influences decision-making. Transactive effectiveness is the degree to which EIA is performed in a cost-efficient manner. Normative effectiveness is the degree to which EIA promotes wider policy goals such as sustainable development and more transparent and participatory policy processes. Finally, the transformative effectiveness dimension entails the long-term learning aspects in the EIA process and wider EIA system that over time fundamentally change stakeholders' values, assumptions, and understandings of sustainability issues leading to changes in problem conceptualization, decision-making structures, and stakeholder collaboration.

Methodology

This comparative case study employed two methods, fuzzy-set qualitative comparative analysis (fsQCA) (Ragin 2009) and the analytical hierarchy process (AHP) (Saaty 2006). Both methodologies utilized stakeholder interviews and questionnaires. Stakeholder assessments were conducted via questionnaire and semi-structured interviews over the period of 2016 to 2018 in the states of California and Paraná. During this phase, both the fsQCA (13 questions) and AHP questionnaires (82 questions) were applied. Stakeholder responses were cross-examined with secondary data available on the respective case studies. The fsQCA method analyzed the EIA systems to determine the necessary and sufficient conditions for effective EIA outcomes. The AHP model sought to analyze the importance of major stakeholder groups typically involved in EIA processes, the strategic criteria surrounding a typical EIA processes, and which effectiveness dimensions were most important to these strategic criteria.

Data Model



Paraná AHP Results

California AHP Results

Limitations

The application of these methods to these case studies both have their limitations. In the case of AHP, extensive hierarchies necessitate more value judgments from stakeholders and can discourage its use. Still, the method integrates qualitative, quantitative, and value-laden information into one framework, which could help elicit tradeoffs and disagreements among stakeholders in a more transparent manner. The framework, as was done in this study by allowing respondents to define the goal, also allows for different frames of reference to exist alongside one another. This would not result in the sort of deliberative democracy devoid of power, as the construction of the hierarchy (criteria and alternatives), the means for aggregating stakeholders pairwise comparisons (in this study by geometric mean, but negotiation or voting are other potential means of determining pairwise comparison values), and use of stakeholder weights all must be agreed upon. Still, eliciting the priorities of stakeholders in a framework where the "rules of the game" are clear to everyone could promote dialogue among stakeholders that could impact decision-making and ultimately be more cost-effective than contested public hearings and legal battles.

Conclusion

AHP and fsQCA provide complementary means of organizing a comparative case study. The former can identify priorities and areas of agreement and conflict among stakeholders. The latter offers a means of assessing the presence and absence of conditions that lead to these priorities. This study focused on two EIA systems, but AHP offers a means of structuring an EIA decision in a transparent manner and could be used during individual projects or studies focused on evaluating specific projects. The fsQCA method lends itself more to a comparative case study of EIA systems, but can be applied to projects and EIRs to identify sufficient and necessary conditions for effective EIRs.

References

Glasson, John, and Riki Therivel. 2019. *Introduction to Environmental Impact Assessment*. 5th ed. Milton : Routledge.

Loomis, John J., Alan Bond, and Maurício Dziedzic. 2022. "Transformative Effectiveness: How EIA Can Transform Stakeholders' Frames of Reference." *Environmental Science & Policy* 136 (October): 207–15. https://doi.org/10.1016/j.envsci.2022.06.007.

Loomis, John J., and Maurício Dziedzic. 2018. "Evaluating EIA Systems' Effectiveness: A State of the Art." *Environmental Impact Assessment Review* 84 (January): 29–37. https://doi.org/10.1016/j.eiar.2017.10.005.

Loomis, John J., Cíntia Mara Ribas de Oliveira, and Maurício Dziedzic. 2021. "Environmental Federalism in EIA Policy: A Comparative Case Study of Paraná, Brazil and California, US." *Environmental Science & Policy* 122 (August): 75–82. https://doi.org/10.1016/j.envsci.2021.03.015.

Ragin, Charles. 2009. "Qualitative Comparative Analysis Using Fuzzy Sets (FsQCA)." In *Configurational Comparative Methods Qualitative Comparative Analysis (QCA) and Related Techniques*, 51:87–121. Applied Social Resarch Methods. SAGE Publications, Inc.

Saaty, Thomas L. 2006. *Fundamental of Decision Making and Priority Theory with the Analytic Hierachy Process*. 2nd ed. Vol. 6. U.S.: RWS Publications.

Sadler, Barry. 1996. "International Study of the Effectiveness of Environmental Assessment." Canadian Environmental Assessment Agency.

Appendix

Matrices

California	n	ASC	Prop	NGO	Gov
Total	26	7	3	7	9

Alternatives	Averages	ASC	Prop	NGO	Gov
Normative	21.7%	21.9%	21.3%	20.1%	0.237088
Procedural	15.9%	12.4%	14.3%	17.3%	0.256982
Substantive	29.5%	34.0%	25.0%	24.4%	0.275004
Transactive	14.3%	10.8%	24.3%	12.4%	0.098362
Transformative	18.6%	20.8%	15.1%	25.9%	0.132564

Stakeholders	Averages	ASC	Prop	NGO	Gov
ASC	43.7%	47.2%	39.6%	40.8%	39.4%
Prop	13.6%	10.7%	20.9%	10.3%	12.3%
NGO	14.7%	19.4%	6.0%	31.1%	10.6%
Gov	28.0%	22.7%	33.5%	17.9%	37.7%
Inconsistency	0.5%	0.2%	3.2%	1.2%	0.9%

Strategic Crit	Averages	ASC	Prop	NGO	Gov
Economic	14.8%	8.3%	29.5%	13.5%	12.0%
Environment	40.0%	49.8%	41.8%	25.8%	36.3%
Institutional	24.3%	20.0%	12.6%	28.4%	37.0%
Social	21.0%	21.9%	16.2%	32.3%	14.7%
Inconsistency	0.2%	1.1%	8.1%	6.6%	5.4%

Paraná	n	ASC	Prop	NGO	Gov
Total	25	14	4	4	3

Alternatives	Priority	ASC	Prop	NGO	Gov
Normative	30.5%	22.1%	20.8%	36.5%	42.4%
Procedural	24.5%	19.7%	25.4%	30.8%	21.2%
Substantive	20.4%	26.4%	27.2%	15.4%	12.8%
Transactive	10.9%	13.7%	12.6%	6.4%	11.2%
Transformative	13.7%	18.1%	14.0%	10.4%	12.5%

Stakeholders	Averages	ASC	Prop	NGO	Gov
ASC	33.6%	25.9%	28.4%	43.1%	37.4%
Prop	12.1%	17.4%	15.2%	8.8%	7.9%
NGO	19.8%	22.3%	19.0%	23.4%	13.2%
Gov	34.5%	34.3%	37.4%	24.6%	41.6%
Inconsistency	0.9%	0.7%	12.8%	7.0%	2.0%

Strategic Crit	Averages	ASC	Prop	NGO	Gov
Economic	15.7%	21.2%	11.4%	16.2%	0.14894
Environment	41.1%	33.6%	32.6%	48.2%	0.47608
Institutional	21.0%	21.9%	32.6%	15.4%	0.16111
Social	22.2%	23.4%	23.4%	20.2%	0.21387
Inconsistency	1.1%	0.3%	3.9%	13.1%	0.03169