

WHAT DOES THE ACADEMIC RESEARCH SAY ABOUT IMPACT ASSESSMENT AND ENVIRONMENTAL LICENSING IN BRAZIL?

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1. Introduction

Possible changes in environmental licensing in Brazil have been discussed in recent years by various entities and organizations (ABAI, 2014; ABEMA, 2013; CNI, 2013). In case of projects of potentially significant impacts, environmental licensing requires environmental impact assessment (EIA) to support decision-making, and this case has been the main focus of the debates. Among the key drivers of the proposals is the perception, mainly from political and business representatives, that the process is slow and hinders economic development. On the other side, there are citizens' organizations and researchers complaining about the current licensing process being excessively lenient towards projects of significant environmental and social impact (ISA, 2015).

This scenario is not unique to Brazil. EIA procedures are employed in at least 181 countries (Morgan, 2012), and changes in laws and regulations relating to public decision-making based on EIA have also occurred in countries such as Canada (Gibson, 2012), Colombia (Toro *et al.*, 2010), Australia, United Kingdom and South Africa (Bond *et al.*, 2014).

The debate about the main problems of current EIA practice and the possible ways to overcome them mirrors differences in the expectations of stakeholders about what the future of environmental licensing based on EIA should be. Different perceptions of the key problems and corresponding solutions stem not only from their different interests and beliefs, but also reflect the influence of professional training (Morgan *et al.*, 2012). Stakeholders' perception is also related to their professional or militant experiences, which is sometimes limited to certain types of businesses or regions, and therefore difficult to extrapolate to the entire EIA system.

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In this sense, scientific research can provide an important contribution to this debate, as (1) it is conducted through systematic procedures, (2) is based on some theoretical framework, (3) their results are peer-reviewed and (4) it is built collectively (Kitcher, 2011).

Thereby, we gathered and analyzed research papers on Brazilian environmental licensing based on EIA, intending to identify their main approaches and conclusions that can possibly assist the debate about the current and future state of this important environmental policy instrument. From a systematic review of three bibliographic databases, papers related to the topic were analyzed to survey the Brazilian scientific production. Although not defined in the Brazilian legislation, the “environmental impact assessment process” nomenclature is used internationally to describe a “set of procedures structured in a logical manner, in order to analyze the environmental viability of projects, plans and programs and to support decision-making” (Sánchez, 2013a, p.102).

The following sections present the methods used in the research (section 2) and the results under four categories of analysis (section 3). The discussion (section 4) presents a reflection on the most frequent and the missing topics, indicating some common as well as divergent conclusions of the analyzed papers.

2. Methods

The search was performed in three databases: Scopus, Scientific Electronic Library Online (SciELO) and Directory of Open Access Journals (DOAJ). The selection of these databases aimed to include international and national journals, open access or not.

The Scopus database was selected for currently being the largest database of scientific publications, with almost 22,000 registered journals (Elsevier, 2015), higher number than what is offered by Web of Science, and concentrated in more recent years; further, most journals indexed in the Web of Science database are also indexed in the Scopus database (Vieira; Gomes, 2009). The SciELO database was selected for its relevance in the Brazilian context, counting 1,221 registered journals (Mugnaini *et al.*, 2014; SciELO, 2015). DOAJ was chosen to include open access journals; it contains 10,484 registered journals from 134 countries (DOAJ, 2015).

Following the specifications of the systematic review (Gough *et al.*, 2012), the search criteria bellow were adopted:

- a. Classification of papers by the type of research: original and review, excluding responses to debates and book reviews;
- b. Terms used in the search: the search was performed in both English and Portuguese for all fields (title, keywords, etc.), with the terms in double quotes. For the search in English, a field with the term *Brazil* was added to the title, abstract and keywords in Scopus and to all the fields in DOAJ. In Scielo, this inclusion was not performed. The terms were:
 - i. Portuguese: licenciamento ambiental, avaliação de impacto ambiental, avaliação de impactos ambientais, estudo de impacto

- ambiental, estudos de impacto ambiental, estudo de impactos ambientais, estudos de impactos ambientais;
- ii. English: environmental impact assessment, environmental impact report, environmental impact statement; environmental licensing; environmental permitting;
- c. Focus: after reading the abstract, papers related to environmental licensing without EIA, or which did not focus on EIA, were excluded. Other forms of impact assessment - notably Strategic Environmental Assessment (SEA) - were not included;
- d. Period: the publication date had no past time limit and considered papers published until December 2015. The papers available in the consulted databases until April 30, 2016, when data collection was finished, were considered.

The search terms in Portuguese resulted in 560 papers indexed in Scopus; 97, in SciELO; and 137, in DOAJ. The search in English resulted in 643, 112 and 350 papers, in the respective directories. The selection was based on the analysis of the titles, abstracts, aims and findings to check if the criteria of papers inclusion for this research were met. Each selected paper was analyzed and classified according to its research focus, approach and objectives. The definition of topics emerged from reading the documents, with no pre-defined categories (Krippendorff, 2004). The method of double checking was adopted, in which two authors performed the same procedure for search, selection and analysis of papers, with subsequent comparison and discussion of the results. Divergent findings were discussed among authors. At the end of the analysis, each paper was classified in one of the following categories:

- i. Case analysis: papers reviewing the EIA process of one or more projects, often focusing on procedural aspects such as public participation or decision making and identifying shortcomings;
- ii. Analysis of the EIA system: papers that provide theoretical reflections, address concepts, legislation, procedures, consider the relationship of EIA with other planning tools, or the legal or institutional aspects of EIA as applied to different economic sectors or at municipal, state and federal level;
- iii. Methods and tools for EIA: papers that review or develop methods and approaches that are used or can be applied in licensing process with EIA;
- iv. Evaluation of EIA documents quality: papers that apply systematic criteria to evaluate the quality or the contents of Environmental Impact Statements (EIS) or other EIA process documents; this category differs from the first as it focuses on documents (Terms of Reference or EISs, for example), and treats multiple cases (with one exception).

The definition of the four categories was refined until there was no overlap between the classifications, so that each paper could be classified in only one of the categories.

Besides peer-reviewed papers, the academic literature on EIA includes theses and dissertations, book chapters, papers published in proceedings of scientific conferences as well as journals not indexed in the consulted. Together, all those sources would offer a broader perspective of what has been researched regarding EIA in Brazil. This research - covering only peer-reviewed papers published in indexed journals - gathers the academic production usually considered as the most relevant.

3. Results

The survey of scientific literature on licensing with EIA in Brazil found 131 papers, out of which 59 in English; 66 in Portuguese; 5 published in both languages; and 1 in French.

In terms of the four categories of research, 59 papers (45%) deal with case analysis; and 42 (32%), with the EIA system. There are 19 papers (15%) on methods and tools for EIA, while studies that evaluate the quality of EIA documents add up to 11 (9%).

The papers were published in 76 different journals. Such a dispersion results from 55 journals having published only one paper, 8 journals having published two papers, while the remaining 60 papers were published in 13 journals, as shown in Figure 1. Environmental Impact Assessment Review is the journal with the largest number of papers, with 11 records, whereas *Ambiente & Sociedade* is the Brazilian journal with more records, featuring 5 papers.

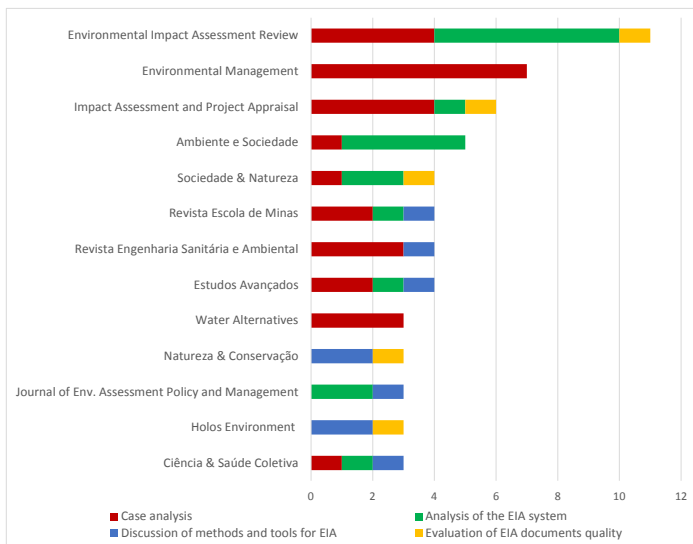


Figure 1. Scientific journals with three or more papers published related to EIA in Brazil, by category, between 1985 and 2015.

The total number of authors in the 131 papers is 253, out of which 224 authored a single paper; 21 authored two papers; and 3 authors published three papers. This fact deserves attention because it shows that the community that continuously publishes their research in scientific journals is small, comprising only five authorsⁱ with five or more papers published.

Likewise, the set of authors is affiliated to 97 research institutions, environmental agencies or consultancy companies, with emphasis to the University of São Paulo - USP (30 authors), São Paulo State University Júlio de Mesquita Filho - UNESP (12 authors), Federal University of Rio de Janeiro - UFRJ (9 authors) and Fluminense Federal Institute of Education, Science and Technology (9 authors).

The temporal distribution of publications is shown in Figure 2. Between 1985 and 2003, only 18 papers (14.5%) were published and the remaining 113 were published between 2004 and 2015.

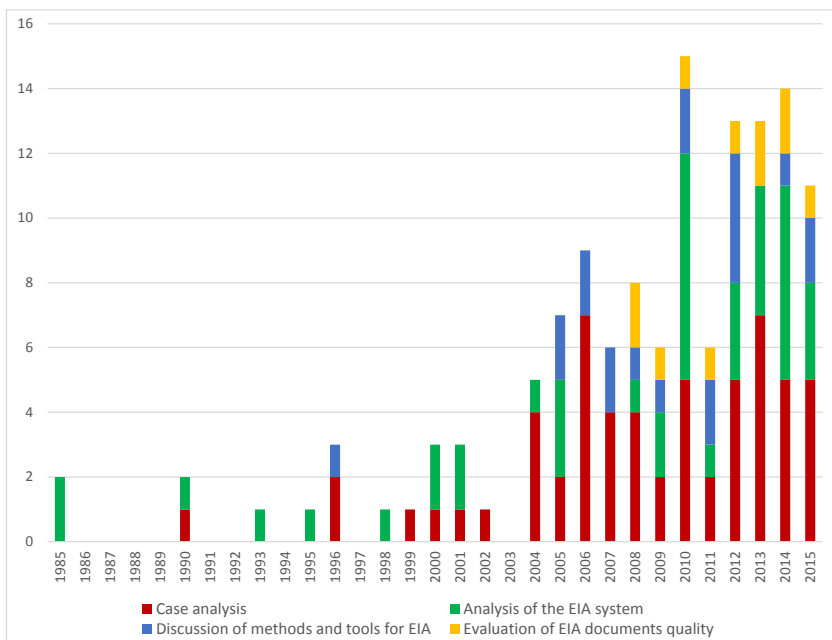


Figure 2. Number of papers related to EIA published per year and category between 1985 and 2015.

Out of the 131 papers, only 8 are simultaneously indexed in the three selected databases, 9 appear in both Scopus and Scielo databases, 17 in SciELO and DOAJ and 2 in Scopus and DOAJ. In total, 83 papers were found in Scopus (64 exclusively on this portal), 43 in SciELO (9 exclusive) and 49 in DOAJ (22 exclusive).

Hereafter, we presented the main topics, findings and/or conclusions of the selected papers, for each of the four categories described above.

3.1 Case analysis

The 59 papers in this category cover 16 types of projects (Figure 3).

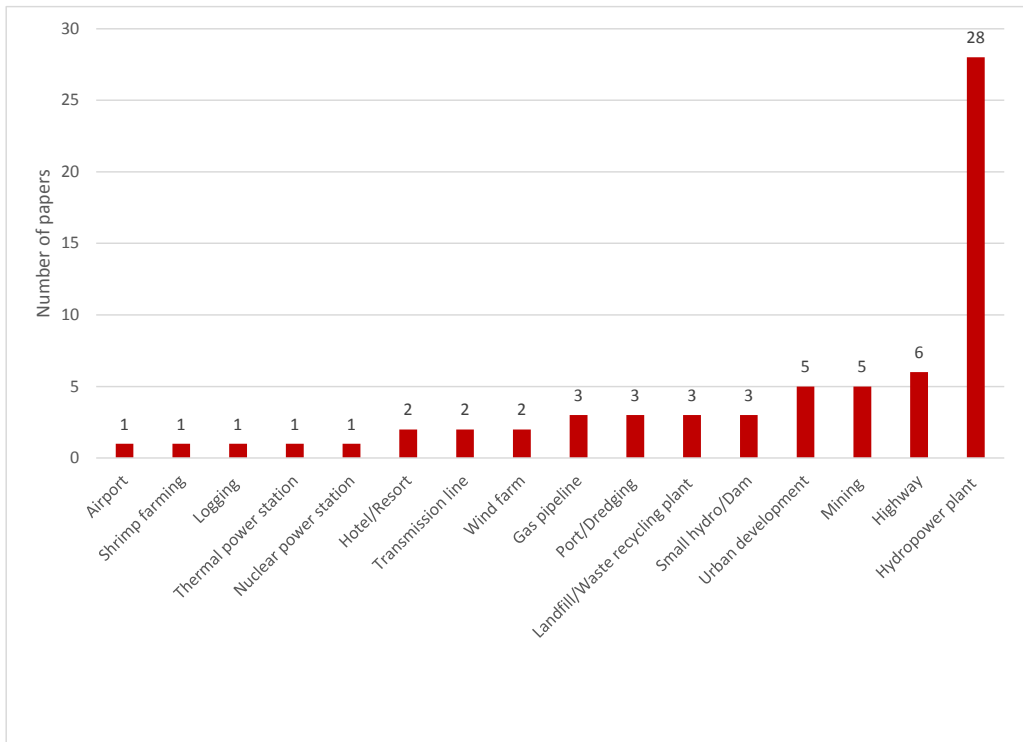


Figure 3. Types of projects covered by the papers of the category ‘case analysis’.

In total, 28 papers deal with hydropower plants, especially in the Amazon region (Fearnside; Barbosa, 1996a; b; Fearnside, 2005, 2006, 2013, 2014, 2015; Hernandez, 2012), including discussions on the relationship between environmental licensing procedures and infrastructure planning (Fearnside, 2002). Regarding the Belo Monte project – the latest controversial large dam in the Amazon – there are papers discussing the weaknesses in citizen participation, especially indigenous peoples (Hochstetler, 2011; Jaichand; Sampaio, 2013) uncertainties in the studies (Sousa Júnior; Reid, 2010), capacity to mitigate negative effects (Berchin *et al.*, 2005), and one paper highlighting

the positive aspects of this project (Tundisi *et al.*, 2015). The case of Tucuruí hydropower, the first very large dam build in the Amazon, is explored regarding the social costs of project implementation, such as the displacement of local and indigenous populations, fisheries collapse, and impacts on population health (Fearnside, 1999; Monosowski, 1990). The Tijuco Alto hydropower case – a dam in the Ribeira de Iguape river whose license was denied – is also analyzed in terms of public participation (Souza; Jacobi, 2011); the environmental and social issues associated with the hydropower (Bermann, 2007) and the observed divergence of information on urban infrastructure presented in the EIS of this project (Jeronymo *et al.*, 2012). Further, Zhou and Oliveira (2006), considering the Minas Gerais state context, discuss the frequent social conflicts in the construction of hydropower plants. In the follow-up phase, Massoli and Borges (2014) find that the environmental management programs outlined by the EIS of Estreito hydropower, in the Tocantins river, were not enough to mitigate the environmental impacts of the project and Aledo *et al.* (2015) explore the social impacts of Porto Primavera and Rosana dams using causal maps.

In the mining sector, studies on the operation phase in the state of Minas Gerais predominate. Fabri *et al.* (2008), in the analysis of environmental licensing processes of dimension stones quarries, found that the mitigation measures are not implemented and none of the 81 quarries investigated was, in fact, rehabilitated. In the Iron Quadrangle region, Prado Filho and Souza (2004) also conclude that not all mitigation measures proposed in the EIS were implemented, and some of them were not even scheduled for future implementation. In contrast, Viana and Bursztyń (2010) reiterate that government overseeing of mining in Minas Gerais faces difficulties regarding effectiveness and staff capacity. Fonseca *et al.* (2013) present a broad assessment of the policies focused on sustainability for the city of Itabira, and conclude that many initiatives were already implemented. Such initiatives, however, are marked by fragmentation and lack of monitoring, which does not allow to infer on the contributions to sustainability that were, in fact, implemented as a result from environmental licensing.

In the transport sector, Sánchez and Silva-Sánchez (2008) explore the São Paulo Metropolitan ringroad case, whose first EIS, prepared for its southern section, was considered insufficient for decision-making, thus, triggering a SEA to solve the issues that had not been considered in the project EIA. In the project implementation phase, the case of the Imigrantes highway (São Paulo) is highlighted as a reference of good follow-up practices during construction (Gallardo; Sánchez, 2004, 2006; Sánchez; Gallardo, 2005; Gallardo *et al.*, 2015). Cunha (2006) explores the Port of Santos case and concludes that the difficulties of environmental licensing decisions reflect the late incorporation of environmental management by the port business sector and the limitations of environmental agencies. Veçozzi and Carvalho (2013) discuss the institutional arrangements for the environmental licensing in ports, using the Porto Novo Terminal as case study (RS).

In the solid waste management sector, Prado Filho and Sobreira (2007) evaluate the context of recycling units and the disposal of domestic solid waste in Minas Gerais. These authors demonstrate that the requirements of environmental licensing, coupled with tax incentives have contributed positively to the improvement of environmental

quality. In contrast, Fulgencio *et al.* (2009) challenge the environmental licensing process for the landfill construction in Quissamã (RJ), which was conducted through the simplified EIA process, defending the need for a complete EIS instead, given the magnitude of the impacts that the project could entail.

In the tourism sector, Pinho and Santos (2013) evaluate the Tourist Complex 'Enseada de Suape' in Pernambuco, and find that there were no actions to avoid or mitigate the environmental liabilities generated by the implementation and operation of the project. Pereira *et al.* (2014) study the EIA of initiatives related to the Rio de Janeiro Pan American Games of 2007 and show that the Pan American Village EIA benefited its development and implementation - as project design and EIA were integrated from the beginning. Pereira and Conto (2014), in turn, compare the citizen participation process in the London Olympics (2012) and the Pan American Games (2007).

Citizen participation is also the topic of several papers based on case studies. A few major projects were not approved due to the action of organized citizens (Devlin; Yap, 2008; Devlin; Tubino, 2012; Rothman, 2001). Other papers report criticism and shortcomings related to the current participation model, which calls for a public hearing to be conducted only after the EIS is filed for review by an environmental agency. Human rights violations and problems in the governance model (McCormick, 2007; Piagentini *et al.*, 2014; Silva, 2009; Zhouri; Oliveira, 2012) are also discussed.

As for public hearings, Alonso and Costa (2004) concluded that in the case of São Paulo Metropolitan ringroad (western section), the process failed to guarantee effective citizen participation - although it fulfilled an educative, informative and supportive role to decision making. Stori *et al.* (2013) explored the logical action of eleven social actors involved in the environmental licensing of a port terminal in Santos, and identified the determinants world views for promoting the approval of project implementation. Moreover, Assunção *et al.* (2010) analyze citizen participation in public hearings in EIA processes in Bahia state. From these analyzes, the authors verify the existence of different degrees of participation, which vary according to the socioeconomic status of the community, which will be affected by the project.

Two studies addressed issues related to health in EIA processes and demonstrate that health has been treated superficially in the case of a logging plan in Pará (Eve *et al.*, 2000) and of a thermal power station in Ceará (Rigotto, 2009).

Regarding risk analysis in the environmental licensing process, few studies are dedicated to the topic. Montañó and Souza (2008) show that in undertakings considered hazardous, the risk factors are not considered properly. They suggest the adoption of acceptability standards for the design of mitigation measures. Kirchhoff *et al.* (2007) and Kirchhoff and Doberstein (2006) present reflections on the consideration of risk analysis in the evaluation of the Bolívia-Brazil gas pipeline, stating that it has not been appropriate.

Under a regional approach, Azevedo (2006) analyzes avifauna baseline studies of seven projects in different ecosystems in the Santa Catarina state. In this study, the author concludes that the studies provided new information on the distribution of 66 species, and emphasize the contribution of EISs for generating knowledge on biodiversity.

Similarly, Ribon *et al.* (2004) explore data on avifauna of an EIS of the Zona da Mata in Minas Gerais and point out the importance of monitoring reports for expanding information and knowledge about the distribution of birds of the area.

Raio and Bennemann (2010) surveyed fish species on the Tibagi River and compared the results obtained with those of the Mauá Hydropower EIS. They conclude there are failures in the EIS that do not allow the adequate design of mitigation measures.

We can mention other papers, such as Sinay *et al.* (2013), who present an analysis applied to dredging and explore the benefits achieved for the ports of Santos and Paranaguá; Prieto and Colesanti (2012), who describe the planning process of a university campus in Minas Gerais, including EIA; and Araripe *et al.* (2006), who analyze the context of shrimp farmings in the Delta do Parnaíba Environmental Protection Area, and point out a series of weaknesses detected during the EIA process.

3.2 Analysis of the EIA system

We identified 42 papers regarding the EIA system in Brazil, including analysis of the federal system, sectorial analysis, studies on the relationship of environmental licensing/EIA with other planning instruments, the role of health in the EIA process, and even, of the role played by the Federal Court of Accounts (TCU).

The papers published between 1985 and 1995 are generally more descriptive, highlighting concepts underlying EIA and show the efforts undertaken in structuring the state or federal EIA systems (Barbieri, 1995; Fowler; Aguiar, 1993; Lages, 1990; Lim, 1985), while Wandesforde-Smith and Moreira (1985) explain how EIA was introduced in the Rio de Janeiro environmental agency prior to its adoption by federal legislation.

The first critical evaluation is from Glasson and Salvador (2000), which evidence that, although the legislation is well structured, its implementation faces different problems, such as: low qualification of professionals, absence or deficient scoping and other weaknesses, in addition to gaps between procedures and practice.

In a theoretical analysis about the inclusion of EIA into Brazilian legislation, Prestupa (2009) affirms that this instrument reveals a new preventive rationality and evidence maturity and political evolution. Further, the author highlights the importance of public hearings for the democratization of information. In the same manner, Sparenberg and Sarreta (2004) reiterate the role of EIA in applying the precautionary principle, and Gurgel (2014) explores the legal and conceptual aspects of environmental licensing, highlighting the role of public authorities as being widely responsible for the licensing effectiveness. Rocha *et al.* (2005) describe the licensing systems in Mercosul countries, showing the similarities between Brazil, Paraguay and Uruguay, and that Brazilian legislation is the most complete and modern among the countries studied.

Evaluating citizen participation in the decision-making process of environmental licensing based on EIA, Coletti (2012) points out the need to improve communicative tools, techniques and processes to encourage citizen participation, Conde (2012) discusses the important inclusion of a humanistic approach into the EIA structure, so that human factors, such as traditional communities, are considered during the assessments.

The discussion regarding social impacts and the insufficient participation of affected communities in the decision-making process is present in other papers (Devlin *et al.*, 2005; Diegues, 1998; Hanna; Vanclay, 2013; Hanna *et al.*, 2014; Zhou, 2008). Positive reports in relation to participation of communities are also found in Devlin *et al.* (2005), reviewing cases in which participation led to the abandonment of large-scale, high impact development projects.

Villarroya *et al.* (2014) analyzed biodiversity offset policies in Latin American countries. In this study, the authors show that Brazil is one of the countries which has the legal requirements for such offsets, but not a mechanism to previously guarantee the application of the mitigation hierarchy (avoidance, minimization, restoration and offset). Domingues and Carneiro (2010) review the compensation history required by the National System of Nature Conservation Units Law, in its legal nature, advances and setbacks.

The importance of including health issues in environmental licensing is addressed by Cunha *et al.* (2011), which elucidate that the precautionary principle should guide health impact assessments; and by Silveira and Araújo Neto (2014), who demonstrate the low influence that the demands of the Ministry of Health have exerted in the selected studies.

The role played by TCU stands out in the EIA system control, because TCU performs operational audits on the implementation of environmental policies - including the environmental licensing, and it acts to ascertain the efficiency in the use of public resources (Lima, 2005; Lima; Magrini, 2010).

In the sectorial segment, Cardoso Júnior *et al.* (2014) describe the legal evolution of electric power transmission lines licensing. The authors show, in this study, that the new regulations of the sector addressed only some of the critical problems, and that the concession/contracting of a new project still occurs without any prior environmental analysis, leading to frequent conflicts during the EIA process.

Focusing on the demands of infrastructure to meet the needs of increased soybean production, Fearnside (2001) evidence that environmental licensing of several developments (waterways, highways, railways) have been subject to great pressure. Moreover, the author also highlight that the implementation of many of these developments can result in more significant impacts than predicted in the EIS.

On the spatial planning of hydropower plants, Moretto *et al.* (2012) present a broad reflection on the history and trends in this area, where the role of EIA has fundamental importance. Piagentini and Favareto (2014), in turn, undertake a comparative analysis of EIA process of hydropower plants in Brazil, United States, Canada and China. This study has the purpose to identify lessons that could be useful to improve Brazilian practices and suggests more controls on the quality of EIS (such as independent reviews) and incrementing public participation. Andrade and Santos (2015) present a critical analysis of the environmental licensing of hydropower plants, and point out possible solutions to the identified problems, and highlighting the importance of integrating SEA in the energy planning.

In the mining sector, Mechi and Sanches (2010) analyze the current licensing process in São Paulo, which does not fully achieve the objectives of the National Envi-

ronmental Policy Law, nor does it conform to the Federal Constitution. Silva *et al.* (2001) describe the impacts of kaolin mining and emphasize the importance of EIA for planning its mitigation.

Kaiser *et al.* (2013), in turn, analyze the environmental policies for navigation and port management in São Paulo, and indicate that, despite efforts to simplify environmental licensing, the process is still complex – in fact, in their view, it delays the development of infrastructure in the country.

In the oil sector, Malheiros and La Rovere (2000) ponder in respect to current command and control instruments and propose improvements in the environmental licensing, which may meet the increasing demands for project analysis.

Almeida and Montaña (2015) analyze how the EIA system has been developed in Minas Gerais comparing it with international best practices and identifying the positive aspects, such as the decentralization of the licensing process; participative decision to be taken by the State Environment Council - and also its deficiencies - such as the absence of participation of directly affected citizens and the comparison among alternatives. Rodrigues (2010) analyzes the integration mechanism and the interdisciplinary approach in the environmental licensing process, elucidating the contributions and the difficulties faced by adopting this model for EIA. At the municipal level, Valinhas (2009) presents proposals to improve the process of environmental licensing in the municipality of Macaé (RJ).

Pizella and Souza (2012), in turn, explore the possibility of commercial release of genetically modified crops to undergo the EIA process, documenting divergent opinions from representatives of different sectors.

On the relationship of EIA with other instruments, we found two papers in the energy sector. The first is from Vilani and Machado (2010), that environmental licensing applied to the exploration and production of oil and gas should dialogue with planning instruments. These instruments need to be adequate to reorienting the exploration of reservoirs over time, aiming to extend the use of oil and gas reserves. The second study, from Fearnside and Laurance (2012), critically review the pluri-annual plans of the federal government showing scant consideration of social and environmental impacts of infrastructure projects, turning EIA into an add-on procedure carried out after the decision about project construction had been made.

Regarding knowledge and learning, Bond *et al.* (2010) show a deficient understanding about interdisciplinary work and sustainability in EIA processes among consultants in Rio Grande do Sul. Costanzo and Sánchez (2014) inform that knowledge socialization practices in EIS development are adopted in most of the eight environmental consultancies firms analyzed. Despite this, there are few mechanisms to capture the lessons learned from experience. Milanez (2015) discusses the potential of advancing collaboration between social and natural sciences in the context of EIA, exploring existing challenges.

Only one paper on education was found, which portrays EIA teaching at the University of São Paulo and presents a reflection on the lived experience with Environmental Engineering course (Sánchez, 2010).

3.3 Discussion of methods and tools for EIA

The 19 papers classified in this category include the procedures, methods and the more comprehensive aspects related to the design and preparation of the environmental studies.

On alternatives analysis, Montaña *et al.* (2012) present a methodology for selecting areas to landfills siting, which is based on the integration of environmental, social and economic factors established from the citizen participation. The method presented has three steps of refinement/approximation of potential areas and aims to minimize the environmental impacts based on the selection of an area which meets the pre-established criteria. Boclin and Mello (2006), in turn, present a method for the identification and the comparison of highway routing alternatives, based on fuzzy logic and on inclusion of criteria related to the biological, physical and socioeconomical issues.

For the sand extraction industries, Torresan and Lorandi (2008) propose a methodology to analyze alternative locations for project implementation, aiming at reducing impacts and costs of environmental compensation. The method is based on the spatial analysis of vulnerability indicators related to erosion, water resources and loss of biodiversity.

Mouette and Fernandes (1996) discuss the use of the hierarchical analysis method in the EIA of urban transport systems, which is: a multicriteria procedure that groups characteristics of the alternatives under study in a hierarchical form, aiming to assist decision-making processes. Eler and Milani (2007) present a proposal for designing aquaculture projects, which includes elements that are required for the environmental licensing.

For scoping and impact analysis, Lelles *et al.* (2005) propose the adoption of a checklist to identify environmental impacts of sand extraction activities in watercourses.

Regarding baseline studies, Nogueira *et al.* (2011) present a geoprocessing tool for regional analysis that makes possible to identify and assess the critical areas and associated conflicts in mining, by densification, environmental degradation, water resources impairment, proximity to urban areas and protected areas.

As for studies related to the biological system, in the oil and gas sector, Silveira *et al.* (2010) analyze methods of surveying terrestrial fauna for mammals, reptiles, amphibians and fish. Further, the authors point out problems ranging from the formation of human resources to the experimental design, the selection of methods, and the absence of standardization for conducting inventories. In this study, it is also proposed longer terms than of those practiced in inventories and monitoring programs. Ferraz (2012) presents twelve guidelines for the development of studies related to the biotic systems, and recommends procedures to select a sample.

Koblitz *et al.* (2011) suggest the adoption of Landscape Ecology in the preparation of environmental studies, as it can help to understand the effects of spatial heterogeneity on the occurrence and maintenance of populations, communities and/or processes.

Barbosa *et al.* (2012) present a method for analysing the human health aspects in the EIS of oil and gas projects. This procedure is based on established legal parameters and the adaptation of a validated matrix for the hydropower sector. Oliveira and Medeiros (2007), in turn, propose an interaction matrix to synthesize impacts characteristics

already adopted in other studies. Sandoval and Cerri (2009) and Moreira (2015) present a procedure to assess the significance of environmental impacts on EISs.

Mayer-Pinto *et al.* (2012) suggest a method for impact assessment of effluents on intensity variation and temporal variability, which considers budget and logistical constraints and the absence of pre-project data. The procedure was tested for effluents from a nuclear power plant in Ilha Grande Bay (RJ).

Broetto *et al.* (2015) propose geospatial indicators to analyze the environmental impact of the swine activity, which can subsidize the environmental licensing at municipal level.

Costa and Sánchez (2010) propose a procedure to carry out environmental performance evaluation for highway rehabilitation works. This process involves surveys, environmental supervision, ranking nonconformities and also provides performance indicators.

To go beyond what environmental licensing can offer as an instrument of command and control, Padula and Silva (2005), suggest that environmental control should also include economic instruments, based on the following environmental management model: the monitoring environmental quality by the users and the target of the mitigation actions in a shared manner. The process would be applied in the air and water quality management, and it would be present since the earliest steps of environmental licensing.

In the context of interdisciplinarity present throughout the EIA process, Kirchhoff (2006) introduces a proposal of continuous training of EIA professionals, which aims to improve the quality of processes and the relationship of EIA with other instruments.

3.4 Evaluation of EIA document quality

This category includes 11 papers that evaluate the quality of EIA documents, mostly environmental impact studies, based on the systematic application of evaluation criteria.

In the analysis of 37 Environmental Control Reports - a simplified version of an EIS - for the dairy industry and slaughterhouses licensing processes in Minas Gerais -, Almeida *et al.* (2014) concluded that the studies have deficiencies related to the quality of baseline and impact analysis.

Landim and Sánchez (2012) evaluate the evolution of the scope and content of EISs in 9 mining projects, between 1987 to 2010, and show that: (1) studies have become longer; (2) studies have become more comprehensive; (3) there was no evolution over time in the analysis alternatives; (4) baseline studies feature more primary data in more recent EISs; (5) impact identification establishes clearer cause-effect relationships; and (6) more recently, mitigation and environmental management set linkages with management systems.

Scherer (2011) analyzes fauna studies of five EISs of projects in the Atlantic Rainforest. The author concludes that these studies present only a list of species, and do not specify the relationships, the distribution, and the abundance of key species, or the community structure of the area and its surroundings. Moreover, it concludes that the EISs do not present a sufficiently detailed baseline of the biological system, impairing impact analysis.

Mazzolli *et al.* (2008) analyze the errors and omissions related to mastofauna in 15 environmental studies of hydropower plants in the Santa Catarina highlands, including two EISs. They found nomenclature errors, undocumented records, species unlikely to occur in the study area and incomplete identifications. Moreover, they warn that a flawed baseline harms impact analysis and designing mitigation.

Silva *et al.* (2013a) evaluate three oil refinery EISs on issues of sustainable development and workers' health, showing their weaknesses. Silva *et al.* (2013b) ponder the of workers' health indicators in three petroleum sector EISs, and conclude that this issue is insufficiently addressed. Therefore, the authors suggest, also, the adoption of health care programs monitoring, use of risk monitoring indicators and biomarkers sensitive to the prevention of benzene, as a strategy for health surveillance and risk control.

Exploring the use of EIA methodologies in 152 Non-Technical Summaries in Ceará state, Oliveira and Moura (2009) point out as weaknesses of the process the cost calculation incurred as a result of the environmental impacts; the wide use of matrices as a technique for assessment of the impacts without the combination of evaluative techniques; as well as the repetition of techniques by the same consulting companies. Omena and Santos (2008) evaluate the SE-100/South highway project, and conclude that the EIS did not present an interdisciplinary analysis involving the relationships of biotic, physical and anthropic systems, and an integrated analysis of the impacts resulting in insufficient evidence to propose preventive measures.

Analyzing the quality of socioeconomic information in 17 EISs of sugarcane industry projects in Mato Grosso do Sul, Paiva *et al.* (2015) observed the absence of a consistent theoretical and methodological framework to satisfactorily assess the impacts on human population and the social, cultural and economic dynamics of affected communities.

Gallardo and Bond (2010), in turn, analyze 32 EISs and Preliminary Environmental Reports (PERs) of sugarcane mills in São Paulo regarding the comprehensiveness of sustainability issues. The authors show that the EISs cover impacts on water, air and soil, but do not consider important issues related to the sugarcane industry expansion, such as food security and greenhouse gas emissions. Montañó *et al.* (2014) review the quality of three EISs of small hydro plants and conclude that none of them met the established quality criteria, noting that the studies do not allow to support a conclusion on the environmental viability of the projects, recommending that the competent environmental agency should review its requirements and guidance presented to the proponents.

The papers in this group sum an analysis effort of 266 environmental studies, as follows: 57 EISs, 152 Non-Technical Summary, 17 PERs, 37 Environmental Control Reports, 2 integrated environmental assessment reports and 1 "simplified environmental assessmentⁱⁱ". These papers show weaknesses, strengths and present recommendations. A synthesis is presented in Table 1.

Table 1. Synthesis of weaknesses, strengths and recommendations of the papers discussing quality of EIA documents.

Step	Weaknesses	Strengths	Recommendations
Scoping	<ul style="list-style-type: none"> • Identical ToR used for projects in different contexts, not directing the studies to the deepening of regional particularities [1] • Lack of indication of theoretical and methodological approaches to guide socioeconomic studies and define areas of influence [1], and also to study the biotic system [2] 	<ul style="list-style-type: none"> • Improvement in the ToR preparation may have contributed to the content evolution of the EISs [3] 	<ul style="list-style-type: none"> • The preparation of ToR must have qualified professionals in the area of ecological sciences [2]
Analysis of Alternatives	<ul style="list-style-type: none"> • EISs often describe the selected alternative and justify it, without presenting an alternative comparison study [3] [4] 	<ul style="list-style-type: none"> • Over time, the baseline in mining EISs present a more comprehensive scoping, with description of more topics [3] • In relation to older studies, the most recent ones feature more primary data and use of maps and graphic editing features. Geographic information is used as both an analytical tool and for presentation purposes [3] 	<ul style="list-style-type: none"> • Some recurrent weaknesses of EISs, such as alternatives study, can only be adequately addressed in strategic assessments [5]
Baseline	<ul style="list-style-type: none"> • Insufficient fauna baseline (distribution, abundance, habitat etc.) presented with data errors and omissions [2] [6] • Deficiencies related to the quality of baseline [7] • Definition of study areas without consideration of key characteristics of potential impacts [1] • Essentially descriptive studies that do not adopt new analytical approaches such as landscape ecology, ecosystem services or community vulnerability [3] • Reduced number of professionals and unskilled professional qualification contribute to deficiencies in addressing socioeconomic impacts [1] • No identification of vulnerable groups or of exposure to hazardous substances [9] [10] 	<ul style="list-style-type: none"> • It is necessary to define in legislation the methodologies for field procedures, requiring recommendations based on the scientifically criteria established [6] 	
Impact Analysis	<ul style="list-style-type: none"> • EISs do not consistently address the relationships between society and natural resources, in which it interacts [1] [2] • Synergistic, indirect and cumulative impacts are not adequately considered nor are there mitigation proposals for these [5] [7] • In sugarcane industry EISs, socioeconomic impacts are broadly ignored [5] or there is omission or insufficient description of the methodologies used to assess socioeconomic impacts • There is no costs calculation incurred as a result of the environmental impact caused by the use of a natural resource or damage to the environment due to pollution [11] • The importance and magnitude of impacts are determined with a high degree of subjectivity [11] 	<ul style="list-style-type: none"> • In more recent studies, impact identification demonstrates cause-and-effect relationships more clearly [3] • Sugarcane industry EISs deal comprehensively with impacts on water, air and soil [5] 	<ul style="list-style-type: none"> • The approach to assess socioeconomic impacts needs to be carried out with greater-scientific rigor and theoretical and methodological depth [1] • It is necessary to incorporate adequate cumulative and synergistic impact assessment [4] • Include impacts of the decommissioning phase [4] • Impact prediction should account for losses by modeling the density of vulnerable species that will be affected; suggest areas for offset. lists of probable species should not be accepted [6]
Mitigation Measures	<ul style="list-style-type: none"> • Environmental management measures that do not minimize or avoid impacts [1] [8] [10] • Adequate monitoring is not proposed to ascertain the effectiveness of mitigation measures [2] • Absence of emergency plans for accidents [10] 	<ul style="list-style-type: none"> • More recent studies in the mining sector present proposals for mitigation programs and environmental management related to environmental management system [3] 	<ul style="list-style-type: none"> • It should present a health care program with a proposal for monitoring, application of risk monitoring indicators and use of biomarkers sensitive to benzene, identifying early damage to health [10]

Sources: [1] Paiva *et al.* (2015); [2] Scherer (2011); [3] Landim and Sánchez (2012); [4] Montañó *et al.* (2014); [5] Gallardo and Bond (2010); [6] Mazzoli *et al.* (2008); [7] Almeida *et al.* (2014); [8] Omena and Santos (2008); [9] Almeida *et al.* (2013a); [10] Siva *et al.* (2013b); [11] Oliveira and Moura (2009).

4. Discussion

The papers classified as *case analysis* are the most numerous and explore an array of issues pertaining to EIA. Several papers in this group demonstrate deficiencies that were overlooked or ignored in licensing decision-making, approving undertakings whose impacts are very significant and do not offset adverse residual impacts. Few papers explore projects whose license was denied. Most papers discuss highly complex projects, such as hydropower and mining.

The contribution of these case analysis to a reflection about the EIA system in Brazil is certainly relevant: in the case of projects with great impact potential, it would be expected that proponents and consultants would adopt high quality standards to respond to the demands of media visibility, engagement of local actors, nongovernmental organizations, academia and Public Ministry. Nevertheless, the literature predominantly reports deficiencies in the EISs and in the EIA process, evidencing a gap between planning and execution.

Several papers approach EIA not as a purely technical instrument, but as a process subject to political pressure and also as a place for dialoguing and strengthening democracy (Fearnside, 2014; Moretto *et al.*, 2012; Zhouri; Oliveira, 2012).

The **analysis of the EIA system** show papers that describe the system; evaluations at federal and state level for Minas Gerais, besides a case at municipal level; analysis of public participation, compensation and offsets, TCU's role; sectoral analysis (transmission lines, hydropower plants, mining, ports and oil & gas); the relationship of EIA with other planning instruments and papers on knowledge management and education. There is evidence of the fragile consideration of social and health impacts and insufficient citizen participation. Otherwise, there is recognition of the good structure of Brazilian legislation, reports of the contributions of EIA in avoiding the approval of some projects considered as environmentally unacceptable, emphasis on the importance of advancing in including public participation in decision-making processes and reports of successful experiences in the follow-up phase. Literature sources not included in this review (for instance, Banco Mundial, 2008; Ferrer, 1998; Lima *et al.*, 1995; Sánchez, 2013b) also generally agree in acknowledging such contributions of EIA to decision-making. It is important to note that only one paper concludes EIA is excessively time-consuming, delaying the development of infrastructure in the country (Kaiser *et al.*, 2013).

In the set of papers on **discussion of methods and tools for EIA**, four papers address locational alternatives, four deal with methods that aid baseline studies, and five apply to impact analysis. Such aspects are considered as areas of poor practice in many papers in the three other categories. This survey enables to note that there are efforts to produce scholarly contributions to overcome such gaps, but they are a minority when compared to the set of papers reviewed.

The majority of the papers that feature **evaluation of document quality** point to their shortcomings, and similar findings indicated by MPF (2004), which analyzed 80 EISs. A synthesis of the results in those papers is presented in Table 1, showing the most frequent weaknesses and a number of strengths and recommendations. Although some

positive aspects are featured, only one paper explored the evolution of the studies' content over time, observing advances in issues such as: broader scoping, greater use of primary data and environmental management programs presented in a more integrated manner.

In the categories **document quality** and **case analysis** there is a predominance of single case analysis, and few papers dealing with multiple cases. This result suggests that many licensing processes are complex, requiring individual treatment and in-depth attention to their context. Otherwise, it may also suggest that there is still low maturity in this research field, since multiple case studies require a more consolidated knowledge about the research subject. This assumption is corroborated by the finding that, throughout 253 authors, only 5 published at least 5 papers, whereas 224 authors published only one paper. Another confirmation comes from the statement of Montaña and Souza (2015) that there are few research groups working systematically in the area of EIA in Brazil.

Some topics often cited as fragile in EIA both in the national public debates and the international literature (SAE, 2009; Banco Mundial, 2008; Morgan, 2012) were not explored or not dealt with in detail in the selected set. Those topics include: (1) the effectiveness of EIA, and its influence in the decision-making process; (2) the process costs or cost-effectiveness; (3) the institutional and technical capacity of environmental agencies and consultants; (4) the prevention of impacts through project change and effective mitigation; (5) the delays in the EIA process; (6) the technical responsibility and legal uncertainty for the consultants and government analysts involved; (7) the balance between procedural standardization and professional judgment of officers at environmental agencies; (8) the weakness or absence of cumulative impacts consideration; and (9) judicialization of conflicts.

Only TCU is subject of two papers regarding the role of external control bodies. Given the role of the Public Ministry in licensing processes, it is surprising the lack of publications regarding its role and corresponding result. Possibly, papers on the topic can be found in the law literature, not indexed in the databases used in this research. The performance of the Public Ministry is indicated by some protagonists as being excessively strict (Banco Mundial, 2008, CNI, 2013); however, according to the results obtained here, it is evident that there are no peer-reviewed papers that prove or contend such assertion.

Compared to the overview of EIA in the world provided by Morgan (2012), it is noticeable that, while international research in EIA is more focused on practices analysis, in new areas of application and new forms of impact assessment, the Brazilian studies mainly deal with case studies - individual, sectoral or regions. The author also emphasizes that research on public participation not only critically review current practices in selected cases, but also provide new ideas for improving the practice. In contrast, papers dealing with public participation in Brazil reinforce the importance of existing consultation mechanisms and show the fragilities in citizen participation. Also, unlike international research, there is little emphasis on proposing ways to improve practice in Brazil. Another point addressed in the international literature is the research and practice of cumulative impact assessment, which is considered as underdeveloped in relation to other EIA topics. This was also verified for Brazil, since the set of papers deals with the topic only generically, although a recent paper (Neri *et al.*, 2016) develops an approach to deal with the cumulative impacts of several projects proposed for a small area.

Surveys of EIA research in other countries indicate some differences with the results found about the Brazil. In Germany, Koepfel and Geissler (2015) point out that there is little incentive for independent academic publications aimed at developing methods and approaches to advance practice, since most of the funding available is used for the development of guidelines and handbooks detailing legal requirements. In Brazil, the situation seems to be opposite, as there have been incentives for research in this area, but neither governments nor businesses ask academics to develop technical guidance.

In Ireland and Spain, del Campo (2015) considers the fact that EIA is not appropriately included in the undergraduate curriculum, reflecting in low interest in postgraduate courses, where most research is conducted. In Brazil, this survey found only one paper dealing with EIA teaching (which is in line with international teaching, according to Sánchez and Morrison-Saunders, 2010), but also showed that the scientific production has been increasing, although there are still a small number of authors continuously dedicated to EIA research.

Runhaar and Arts (2015) point out that EIA surveys in the Netherlands do not deal with uncertainty, complexity, adaptive management, or political aspects of decision-making processes, to show the value of EIA as a tool to improve governance. The contribution of EIA to decision-making and its role in protecting the environment and communities is also largely absent of the academic production about EIA in Brazil.

5. Conclusions

The 131 papers published between 1985 and 2015 addressing EIA in Brazil were grouped in four categories: case analysis, analysis of the EIA system, discussion of methods and tools for EIA, and evaluation of quality of EIA documents. The conclusions in each category can be summarized, respectively, in the following points: (1) mostly, cases of high complexity are explored, with concentration in hydropower projects; (2) weaknesses are noted in the EIA system, alongside the recognition of certain positive outcomes and advances; (3) studies on methods, a small part of the total, aim at addressing weaknesses of different steps of the EIA process; (4) evaluations of quality of EIS show recurrent deficiencies, in addition to temporal evolution.

By mapping the scientific production related to EIA in Brazil, we hope to contribute to the debate about the main problems and solutions for improving environmental licensing. We argue that science-based evidence is necessary for policy reform in this area, alongside a broader participatory debate, capable of expliciting the diversity of views and interests.

It should be emphasized that before proposing reforms, it is fundamental to develop a robust knowledge of the EIA system so as not to compromise successful practices while seeking to fighting the weaknesses of the process. The reviewed papers address a number of the most important shortcomings, but not the broad array of concerns expressed in the public debate on environmental licensing in Brazil or in the international literature. This research field is at an initial stage of development. The growth in publications over the last decade indicates an increased interest and the existence of a community of researchers.

In the future, they may deepen the debate and ground proposals based on a more robust set of scientific evidence.

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Notes

- i The order is as follows, beginning by the author that published more papers: Fearnside, P. M.; Sánchez, L. E.; Souza, M. P.; Gallardo, A. L. C. F.; Montaña, M.
- ii The PER and this simplified assessment are equivalent to the US environmental assessment.

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WHAT DOES THE ACADEMIC RESEARCH SAY ABOUT IMPACT ASSESSMENT AND ENVIRONMENTAL LICENSING IN BRAZIL?

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Abstract: Scholarly papers on Environmental Impact Assessment (EIA) in Brazil were reviewed aiming at surveying the state of research in this field. Searches in three databases identified 131 papers published between 1985 and 2015. They were classified under: case analysis (45%); analysis of the EIA system (32%), discussion about methods (15%) and evaluation of quality of EIA documents (8%). It was found that those papers: (i) deal with highly complex cases; (ii) identify several weaknesses in the EIA system, but also some achievements and improvements; (iii) address a number of weaknesses identified in other studies; and (iv) show recurrent deficiencies, as well as temporal evolution in the quality of EIA documents. Some topics often pointed as weaknesses in the national debate and the international literature were not addressed in this set of papers. This research field is at an early development stage in Brazil, but features a growing number of publications.

Keywords: Environmental impact assessment; Environmental licensing; Scientific research; Systematic review.

Resumo: A produção de artigos científicos sobre licenciamento ambiental com base em Avaliação de Impacto Ambiental (AIA) no Brasil é analisada, visando identificar os principais enfoques e conclusões apresentados. Buscas em três bases de dados bibliográficos identificaram 131 artigos de 1985 a 2015, que foram classificados em: análise de casos (45%), análise do sistema de AIA (32%), discussão de métodos (15%) e avaliação de qualidade de documentos (8%). Nesses artigos: (1) são explorados casos de alta complexidade; (2) são apontadas diversas fragilidades no sistema de AIA, com reconhecimento de certos avanços; (3) estudos sobre métodos abordam algumas fragilidades identificadas em outras pesquisas; e (4) avaliações da qualidade dos estudos mostram deficiências recorrentes e evolução temporal. Alguns temas frequentemente citados, no debate público nacional e literatura internacional, como fragilidades não foram explorados nesses artigos. O campo de pesquisa está em fase inicial de desenvolvimento no Brasil, mas registra um número crescente de publicações.

Palavras-chave: Avaliação de impacto ambiental; Licenciamento ambiental; Pesquisa científica; Revisão sistemática.

Resumen: La producción de artículos científicos sobre el licenciamiento ambiental basado en la Evaluación del Impacto Ambiental (EIA) en Brasil se analiza para identificar los principales enfoques y conclusiones. Las búsquedas en tres bases de datos identificaron 131 artículos publicados entre 1985 y 2015, clasificados como análisis de casos (45%), análisis del sistema de EIA (32%), discusión de nuevos métodos (15%) y evaluación de la calidad de los documentos (8%). En estos artículos: (1) son explorados casos de alta complejidad; (2) varias debilidades se identifican en el sistema, asimismo hay reconocimiento de los avances; (3) estudios sobre métodos están en línea con los puntos débiles identificados en otros estudios; (4) las evaluaciones de calidad de los estudios muestran debilidades recurrentes al lado de evolución temporal. Algunos temas a menudo citados como debilidades en el debate público y en la literatura nacional e internacional no se han explorado en estos artículos. El campo de investigación está en una etapa temprana de desarrollo en Brasil, pero dispone de un número creciente de publicaciones.

Palabras clave: Evaluación del impacto ambiental; Licenciamento ambiental; Investigación científica; Revisión sistemática.
