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Gaps in Colombian environmental regulations Colombian environmental regulations: The case of the El Quimbo hydroelectric*

Vacíos en la normatividad ambiental colombiana: El caso de la hidroeléctrica El Quimbo

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Abstract

Environmental issues have become of significant interest worldwide due to the negative phenomena experienced. Thus, studies have emerged that analyse various anthropogenic factors that affect the environment, including research that warns of weak regulations on environmental issues. This study evaluates the environmental regulations based on the requirements of the environmental licences that hydroelectric projects require as a mandatory condition for their implementation, addressing the case of the El Quimbo hydroelectric plant. The research was carried out from the perspective of environmental impacts and their identification in previous (ex-ante) and subsequent (ex-post) studies in order to compare the reliability of environmental licences. As a result, it was found that the ex-ante environmental impact studies, carried out in the framework of the environmental licence application, are unreliable due to their accuracy because they underestimate, overestimate or omit environmental impacts.

Keywords: Hydroelectric plants, Environmental impacts, Environmental licensing, Ex-post studies, Ex-ante studies.

Resumen

Los asuntos ambientales se han tornado de interés significativo en todo el mundo a partir de los fenómenos negativos experimentados. Así, surgen estudios que analizan diversos factores de origen antrópico que afectan el medio ambiente, entre los que sobresalen las investigaciones que advierten sobre la débil normatividad en cuestiones ambientales. El presente estudio evalúa la normatividad ambiental a partir de las exigencias de las licencias ambientales que requieren los proyectos hidroeléctricos como condición obligatoria para su implementación, abordando el caso de la hidroeléctrica El Quimbo. La investigación se realizó desde la perspectiva de los impactos ambientales y su identificación en estudio previos (ex–ante) y posteriores (ex–post) con el fin de comparar la fiabilidad de las licencias ambientales. En consecuencia, se obtuvo como resultado que los estudios de impactos ambientales ex – ante, realizados en el marco de la solicitud de la licencia ambiental, son poco fiables debido a su precisión puesto que subestiman, sobreestiman u omiten impactos ambientales.

Palabras clave: Hidroeléctricas, Impactos ambientales, Licencias ambientales, Estudios ex–post, Estudios ex–ante.

Resumo

As questões ambientais tornaram-se de grande interesse em todo o mundo devido aos fenómenos negativos verificados. Assim, têm surgido estudos que analisam diversos factores antropogénicos que afectam o ambiente, incluindo investigações que alertam para a fragilidade da regulamentação em matéria ambiental. Este estudo avalia a regulamentação ambiental com base nos requisitos das licenças ambientais que os projectos hidroeléctricos exigem como condição obrigatória para a sua implementação, abordando o caso da central hidroelétrica de El Quimbo. A investigação foi

realizada a partir da perspetiva dos impactos ambientais e da sua identificação em estudos prévios (ex-ante) e posteriores (ex-post), com o objetivo de comparar a fiabilidade das licenças ambientais. Como resultado, verificou-se que os estudos de impacto ambiental ex-ante, realizados no âmbito do pedido de licença ambiental, não são fiáveis devido à sua exatidão, porque subestimam, sobrestimam ou omitem impactos ambientais.

Palavras-chave: Usinas hidrelétricas, Impactos ambientais, Licenciamento ambiental, Estudos ex-post, Estudos ex-ante.

SUMARIO: Introduction – Research Problem – Methodology – Problem – Solving Framework – Writing Plan – 1. Environmental Licensing Management - 2. Environmental Impact and Environmental Impact Studies - 3. Scope of Environmental Impact - 4. Ex-ante and Ex-post Environmental Studies – Results and Discussion – Conclusions – References.

Introduction

Hydroelectric projects were implemented with the aim of obtaining energy benefits; however, they entail unfavorable phenomena that, according to environmental regulations, must be prevented, mitigated, corrected, or compensated (Maradin, 2021; Pérez Guedes & Arufe Padrón, 2023). In this regard, the legislation stipulates that the mechanism for determining the potential impacts of construction projects are environmental impact studies conducted prior to the construction phase, known as ex-ante studies, on which the request for the respective environmental license is based before the environmental authorities (Vargas et al., 2020).

One of the most emblematic cases in this regard was the 'Three Gorges' hydroelectric plant, the largest energy complex in the world, due to the numerous negative consequences generated by the construction and implementation of the project (Xu et al., 2020; Yang et al., 2024). The issue primarily lay in the fact that the impacts projected in the environmental impact study (ex-ante study) and, therefore, in its environmental license differed from the actual impacts that effectively emerged during the construction and operation phases (Tang et al., 2022). For this reason, there is a growing trend in environmental matters to conduct environmental impact studies ex-post, that is, after the construction and operation of hydroelectric plants.

In this context, there are hundreds of examples of ex-post studies demonstrating their usefulness. In Brazil, home to the second and third largest dams in the world, Aledo et al. (2015) presented the results of ex-post evaluations for the Porto Primavera and Rosana dams, located in the upper Paraná River in Brazil, focusing on the population of Porto Rico. A shift was observed in the main productive activity, transitioning from fishing tourism to beach and sun tourism.

Indeed, agricultural activities shifted to service-related commercial activities; however, negative effects on the river flow and wildlife were noted. The high mortality rate of fish was highlighted as a consequence of pollution generated by tourism, sewage discharges into the reservoir, low water

levels, and contaminants used for turbine cleaning (Sanabria Martínez, 2022). Although aquatic flora supported the survival of fish, navigation for fishing purposes was hindered.

Similarly, in Europe, Santos et al (2007) conducted an ex-ante and ex-post comparative study of the impacts generated by the Alqueva dam, while in Colombia, Olaya et al (1992) conducted an ex-post study on the impacts of the Betania hydroelectric power plant located in the south of the country. Both studies showed the importance of carrying out environmental impact assessment studies, especially after the construction and operation of hydroelectric projects, since they generally result in impacts that had not been previously considered.

It should be mentioned that ex-ante studies are the most widely used because they are used to carry out environmental licensing procedures for projects, while ex-post studies are less popular and therefore rarer, having emerged more recently in order to monitor impacts, detect which of these are underestimated or overestimated, and to learn about new impacts (Qiu et al., 2020). In this way, the measures of the project's environmental management plan, land use planning or the socio-economic development of the respective area of influence can be better redirected (Higuera Carrillo, 2022).

In the case of El Quimbo, the communities that suffered displacement and experienced some level of direct or indirect impact, reached a high level of awareness and organization that allowed the emergence of formal organizations or social platforms to defend their interests, even during the construction phase of the construction works (Duque Ramos, 2024; Helmcke, 2023a).

As a result, the Association of People Affected by the El Quimbo Hydroelectric Project, Asoquimbo, was created, an organization that brings together the communities directly affected, interested citizens and academics, mainly from the Universidad Surcolombiana, who are concerned about the effects of the project on the communities and the region (Helmcke, 2023b).

Along with this pioneering organization, peasant and social organizations have emerged to defend the interests of certain sectors or interest groups, such as associations of sand makers, fishermen, farmers, transporters and day laborers, among others, who have expressed their disagreement with the compensations made by EMGESA, compensations that were formulated based on the environmental impact study and the environmental management plan prepared by the company (El Tiempo, 28 de noviembre de 2017; Semana, 14 de noviembre de 2016).

Based on the above, there have been multiple investigations and studies mainly supported from academia (González-Chavarría, 2023; Murgas Téllez et al., 2023; Sánchez Castillo et al., 2019) and, to a lesser extent, from the empiricism of the organizations in question (Dussán, 2017), which question the veracity of the impacts identified by the environmental impact study conducted prior to the construction of the hydraulic work.

The level of dissatisfaction with EMGESA's compensation actions has escalated to judicial levels, so much so that in 2013, the Fifth Chamber of the Constitutional Court ordered EMGESA, which

belongs to ENDESA, to include in the census of affected people and grant them compensation benefits to the population harmed by the project. It also ordered that a new census be carried out and that the affected population be included in the census to be compensated. In this regard, the Court recognizes that a project of this magnitude is dynamic and generates impacts over time (Portafolio, 20 de febrero de 2014).

Likewise, in 2016, the National Environmental Licensing Authority - ANLA sanctioned EMGESA through Resolution 0381 of the same year due to non-compliance with the activities associated with forest harvesting because the company in its environmental management plan estimated the removal of a smaller amount of biomass (ANLA, 2016). This represented a serious environmental problem when the filling began due to the large amount of biomass, estimated by experts at more than 20%, not removed from the reservoir, which ultimately led the Corporación Autónoma Regional del Huila - CAM to suspend the filling process (Semana, 04 de julio de 2015).

On the other hand, in 2008 the Governor of Huila on duty filed a tutela action against EMGESA, requesting the suspension of the environmental license of the El Quimbo hydroelectric project and requiring a response to doubts raised at the Environmental Public Hearing held in 2016, mainly due to the negligence and non-compliance of compensatory and mitigation measures in the area of influence. The tutela was ruled in favor of EMGESA, however, the company was ordered to answer some of the questions raised (Portafolio, 02 de abril de 2018).

In view of the above, there are multiple organizations, institutions, social and political actors, in addition to scientific and empirical material, that evidence the existence of phenomena resulting from or impacts generated by the hydroelectric plant, which were underestimated or simply not identified in the environmental impact study, and therefore their mitigation or compensation actions were not contemplated in the respective environmental management plan.

On the other hand, among the impacts generated by the hydroelectric power plant, one of the most neuralgic aspects was the flooding of lands dedicated to agricultural and livestock production, as evidenced above, about 5,300 ha were dedicated to the project (Salomão et al., 2024). This triggered the loss of productive capacity, as well as the loss of jobs and a decrease in the dynamics of commercial activities related to agricultural and livestock activities, such as companies that sell inputs and fertilizers, agricultural tools and livestock equipment, among other things.

In summary, there are multiple impacts, both positive and negative, of the hydroelectric power plant, specifically on the sectors that support the local economy. Likewise, there are varied perceptions about the levels of affectation, without there being any consensus on the matter so far. In this sense, it is necessary to truthfully establish the impacts in order for the municipalities to formulate growth strategies in their development plans.

In view of the divergence in the impacts associated with El Quimbo on the area of influence, there are significant issues that must be addressed, such as the apparent weakness of the environmental management plans and effectiveness in mitigating the impacts generated. In other words, the actions taken by EMGESA, owner of the project, have left many aspects unattended and

superficially addressed, as evidenced by the judicial and administrative decisions referred to in previous sections. The loss of productive land dedicated to farming, the increase of areas (water mirrors) for fish farming, the disappearance of livestock activities such as cattle raising and agricultural activities such as cocoa farming, among others, are some of the situations that have been little analyzed and intervened by the local and regional governments or by the company itself, through the different plans formulated and executed during the five years that the hydroelectric plant has been operating.

This leads to the existence of a series of phenomena, hypothetically linked to the construction and operation of the project, that are not recognized or identified from official perspectives, and consequently are not addressed. Especially when the environmental management plan and the local development plans took as exclusive reference the impacts consigned in the Environmental Impact Study presented by EMGESA (INGETEC S.A., 2008) and the Environmental License 0899 of 2009 (Autoridad Nacional de Licencias Ambientales – ANLA, 2009).

Research problem

¿What are the gaps in Colombian environmental regulations related to environmental licenses for hydroelectric plants?

Methodology

The research method used for the development of this research was the deductive-inductive method, since it allowed going from general statements to particular ones, and vice versa, until approaching the concrete reality through indicators or empirical references (Proudfoot, 2023).

In the first phase of the study, the technique of analysis of documentary sources was used to identify the environmental impacts of the El Quimbo hydroelectric power plant contemplated in the project's environmental license granted by Resolution 0899 of 2009 (Autoridad Nacional de Licencias Ambientales – ANLA, 2009). Thus, a list of identified impacts was drawn up based on the ex-ante environmental impact study that supported the respective environmental license.

On the other hand, a second list of environmental impacts was constructed based on documentary sources that appeared ex-post, that is, during and after the construction of the hydroelectric plant. Thus, a list was obtained with the impacts identified in ex-ante studies and another list with the environmental impacts identified in ex-post studies.

In the second phase of the study, the impacts identified for the El Quimbo hydroelectric plant were classified. They were classified based on their ex-ante or ex-post occurrence, in order to subsequently carry out a comparative analysis to identify the current impacts generated by the hydroelectric plant under study.

The comparative method aims at finding similarities and differences. In other words, it corresponds to the procedure of systematic comparison between cases of analysis (Baumgartner & Thiem, 2020; Niculescu et al., 2022).

The use of the comparative method makes it possible to understand unknown things from known things, to explain and interpret them, to point out new knowledge or to highlight the particularities of known things, as well as to systematize the information by emphasizing the differences (Freiberger, 2021; Lažetić, 2020).

The comparison should be made between variables or factors that have similarities and differences in order to have a valid starting point. In the particular case of impacts identified ex-ante and ex-post, it also implies the homologation of different names of impacts that have the same meaning, for an accurate comparison.

In this study, a comparison was made to determine the differences and similarities of the ex-ante and ex-post impacts generated by the El Quimbo hydroelectric power plant. The development of the comparative analysis technique was the exclusive work of the researchers. First, a list of impacts was constructed based on the criteria previously established. Then, a comparative table was established with the ex-ante and ex-post impacts in order to establish the level of coincidence between them and determine the usefulness of the ex-ante versus ex-post environmental impact studies.

Outline of the resolution of the research problem

Drafting plan

1. Environmental management and licensing

Environmental management worldwide has found in the requirement of permits or licenses for companies wishing to develop activities, projects or operations, a tool to determine their environmental viability and establish mitigation actions (De Godoi et al., 2022).

In the United States, with the enactment of the National Environmental Policy Act, standards were established for the determination of an environmental impact, requiring an environmental assessment to determine the need for and scope of the environmental impact statement (Emerson et al., 2022).

Environmental impact statements (EIS) correspond to a permit issued by the federal agency that helps to comply with environmental law, in terms of required standards (emission, environmental quality, procedural and production).

Similarly, in the European Union, Community Directive 337 of 1985 established the need for an environmental impact assessment to identify, describe and evaluate the direct and indirect effects of projects (Council of the European Communities, 1985). Subsequently, Directive 11 of 1997

included that projects for which an environmental impact assessment is required must be subject to an authorization for their implementation, and such assessment should be carried out before the authorization was granted (Council of the European Union, 1997). In addition, Directives 42 of 2001 (European Parliament and Council, 2001) and 35 of 2003 (European Parliament and Council, 2003) were issued with specific modifications on the assessment of the impacts of plans and programs affecting the environment (Council of the European Union, 1997).

On the other hand, as mentioned, environmental management in Colombia began to consider environmental impact studies and environmental licenses since the issuance of Decree Law 2811 of 1974 in its article 28, which considers "necessary the previous ecological and environmental study and, in addition, to obtain a license" (Sleman-Chams y Velásquez-Muñoz, 2016, p.487).

However, this provision was never regulated, so no licenses were required for the industries and/or activities that took place during that period. The situation began to change with the issuance of the 1991 Political Constitution, in its articles 79 and 80, which created the right to enjoy a healthy environment, on the one hand, and incorporated the mandate to plan the management and use of natural resources (Sleman-Chams and Velásquez-Muñoz, 2016). However, prior to Law 99 of 1993, some companies were required to conduct environmental impact studies, as was the case with the Betania hydroelectric power plant in the department of Huila.

The aforementioned articles were regulated with Law 99 of 1,993, which completely dedicated title VIII (articles 49 to 62), to the environmental license, in which each of the formal and operational aspects of the instrument are established (Sleman-Chams and Velásquez-Muñoz, 2016). Similarly, the implementation of the environmental license is configured by means of Article 50, which establishes (Munévar, 2014):

An environmental license is understood as the authorization granted by the competent environmental authority for the execution of a work or activity, subject to compliance by the beneficiary of the license with the requirements established therein in relation to the prevention, mitigation, correction, compensation and management of the environmental effects of the authorized work or activity (p.28).

It should be mentioned that Law 99 of 1993 has been regulated on several occasions in relation to the license. The first one by means of Decree 1753 of 1.994 and the most recent with Decree 2041 of 2.014, whose text was incorporated to the Sole Regulatory Decree 1076 of 2.015 of the Environment and Sustainable Development Sector. In this sense, it establishes that the activities, works or projects that potentially generate environmental deterioration must process their respective environmental license, within the framework of which they must carry out the respective environmental impact study.

In this regard, it should be noted that Decree 2041 of 2014 has been generally referred to by experts, critics and academics as the decree that institutionalizes the "Express Licenses", since it reduces the process from almost 20 months to 183 days. Likewise, Law 1753 of 2015, in its article 179,

established a new modification in the procedure times and determined a duration of 120 working days, 63 working days less than Decree 2041 of 2014 (Zárate et al, 2016).

Another definition of environmental license is contemplated in article 3 of Decree 1220 of 2005, which suggests the environmental license as:

(…) authorization granted by the competent environmental authority for the execution of a project, work or activity that, in accordance with the law and regulations, may cause serious deterioration of renewable natural resources or the environment or introduce considerable or notorious modifications to the landscape, subjecting the beneficiary to compliance with the requirements, terms, conditions and obligations established therein in relation to the prevention, mitigation, correction, compensation and management of the environmental effects of the authorized project, work or activity (p.2).

In general, the law provides that the National Environmental Licensing Authority (ANLA) and the Regional Autonomous Corporations and Sustainable Development Corporations are competent authorities to grant or deny environmental licenses, in accordance with the law and the decree in question.

2. Environmental impact and environmental impact studies

Environmental management as we know it today has been developing for several decades around the world as a result of the interaction of economic, social, cultural and political factors (García, 2004). In the 1970s, with the first environmental events (Stockholm Earth Summit in 1972), it was recognized as a necessity to include the environmental variable in the analysis of development (De la Maza, 2007).

The objective of environmental impact assessments (hereafter EIAs) was the systematic identification and evaluation of the potential impacts of proposed projects, plans, programs or legislative actions with respect to the physicochemical, biological, cultural and socioeconomic environment. EIAs also provide mechanisms for amending development proposals when it is necessary to mitigate potential adverse impacts (Nita et al., 2022).

The legal origin of the environmental impact study dates back to January 1, 1970, in the United States with the National Environmental Policy Act (NEPA) (Bas and Herson, 1993), and in December of the same year, when the Environmental Protection Agency (EPA) was created as an environmental regulatory institution (De la Maza, 2007).

The regulations issued by the United States had a great impact on the world level due to their level of dissemination, so much so that Israel in 1973 developed a procedure for evaluating human environmental impacts in different parts of its geography, with special concern for water resources. Subsequently, other countries formulated their own environmental impact assessments, generally based on NEPA (De la Maza, 2007; García, 2004).

By 1976, Australia, Canada, France, Ireland and New Zealand had environmental impact assessments in place; however, the greatest expansion came in 1985, when the European Union (then the European Community) adopted it as a requirement for its member countries (Cave et al., 2021).

In Latin America, the institutionalization of environmental impact assessment corresponded at first to the demands made by multilateral financial entities such as the Inter-American Development Bank - IDB or the World Bank - WB (Garcia, 2004). Colombia was the pioneer in including environmental impact assessment in its natural resources code in 1973, followed by Mexico in 1978, Brazil in 1988, Venezuela in 1992, Bolivia in 1992, Paraguay in 1993, Chile in 1993, Honduras in 1993, Uruguay in 1994 and Argentina in 1994 (Coria, 2008; García, 2004).

As mentioned, in Colombia, environmental impact was included in Law 23 of 1973 - Natural Resources Code - (Hernández, 1994); the details of which were established by Decree Law 2811 of 1974, requiring environmental impact studies as a condition for the granting of the license, but the lack of regulation of the process prevented this instrument from fully complying with its prevention and control objectives. Subsequently, with the approval of Law 99 of 1,993, the environmental licensing process acquired greater relevance and environmental impact studies became basic instruments for making decisions on projects, works or activities that significantly affect the environment (Toro et al, 2013).

In turn, Law 99 of 1993 has been regulated on several occasions in relation to the aforementioned license. The first one through Decree 1753 of 1994 and the most recent one with Decree 2041 of 2014. Finally, the regulations were consolidated, including the text of this legal provision in Decree 1076 of 2015, also known as the Sole Regulatory Decree of the Environment and Sustainable Development Sector (Sleman-Chams y Velásquez-Muñoz, 2016).

In this regard, Article 18 of Decree 2041 of 2014 provides that prior to the environmental impact studies, the applicant shall send to the Competent Environmental Authority the request to evaluate whether the project, work or activity requires an Environmental Diagnosis of Alternatives. The purpose of this is to provide information to evaluate and compare the different options presented by the petitioner, under which it is possible to develop a project, work or activity.

Likewise, Law 99 of 1993 and its respective decrees regulating the environmental license require that the Environmental Impact Study include a section called Environmental Management Plan, which aims to mitigate, compensate or progressively eliminate in rational terms, the negative environmental impacts generated by a work or activity under development.

3. Scope of environmental impact

In the national regulations, environmental impacts are outlined as the modifications on the biotic, physical and/or socioeconomic environments derived from anthropic activity (Ministry of Environment and Sustainable Development, 2015). Similarly, the International Organization for

Standardization (ISO) considers environmental impacts as a positive or negative alteration of the environment as a consequence of the management and interaction of an organization with its environment (ISO, 2015).

Weathern (1988) considers that the concept of environmental impact accumulated a negative reputation because it was interpreted as a negative consequence on the environment and natural issues due to human activity in a given space and time. Therefore, environmental impact is seen as a set of harmful phenomena discharged on ecosystems, the climate and society by human actions such as the indiscriminate use of natural resources, waste generation, dumping of polluting substances, among other things (Baloch et al., 2023).

Pardo (2002) documented that on many occasions the environmental impact is positive for the environment; nevertheless, the great affectations caused by multiple projects have historically focused attention on preventing or mitigating the damage caused to the environment and the population, underestimating the benefits or positive impacts of these projects. This is due to the fact that environmental licenses are designed to mitigate the effects and not to take advantage of the opportunities generated, just as the interest of project owners is more focused on seeking authorization and less on contributing to social and ecological wellbeing (Pardo, 2002).

André et al (2004) mention that impacts on the environment occur directly and indirectly, that is to say that some impacts appear as a kind of "domino effect" derived from an initial impact. Consequently, a biotic impact can cause a second socioeconomic impact because many communities base their economy on natural resources such as fish, timber or hunting. In this sense, Pardo (2002) considers that many secondary impacts are perceived with greater force by the communities precisely because their well-being and survival are threatened.

4. Ex-ante and ex-post environmental studies

The term ex-ante, also written ex ante or exante is a Neo-Latin word meaning "before the event" or "before the fact"; while the term ex-post, also written ex post facto means "after the event" or "after the fact". These terms have been used to refer, respectively, to environmental impact studies carried out before and after the construction phase of a project (Qiu et al., 2020).

In general, environmental authorities in almost all countries request the issuance of an environmental license to companies wishing to develop projects that potentially cause environmental damage or deterioration, for which they require an environmental impact study or assessment prior to the start of works or activities (De la Maza, 2007; García, 2004).

Some authors refer to this type of assessment as an ex-ante environmental impact study (Fonseca & Gibson, 2020), which is carried out in order to project potential impacts or the probability of their occurrence. In contrast, environmental impact studies conducted after the construction phase of a project are called ex-post studies.

For example, Renssnature & Consulting (2017, p.1) express that "The ex-ante Environmental Impact Study is a multidisciplinary technical study that provides background for the prediction and identification of environmental impacts that could originate from the operation of an activity".

Likewise, the Instituto Latinoamericano y del Caribe de Planificación Económica y Social – ILPES (1993, p.1) defines ex-post evaluation as follows:

Ex-post evaluation is the evaluation of the project during its operation phase, once the investments have been completed. That is, the project is in its full operational phase and the benefits can be measurable. In ex-post evaluation, the implementation, results, beneficiaries and goals obtained from a project are analyzed in detail.

In accordance with the above definition, González (2000) considers that ex-post or ex post facto environmental assessment is an analysis of the effects and consequences of a project after it has been executed and completed.

Ex-post studies are evaluations based on actual situations that have occurred, as opposed to ex-ante studies, which are predictive in nature, relying on the prediction and projection of likely scenarios.

Generally, ex-post studies are conducted to verify that the projected impacts did indeed occur and that the actions taken helped to mitigate them. Their purpose, in addition to identifying failures to implement necessary corrections, is to highlight the lessons learned (Departamento Nacional de Planeación – DPN, 2004).

One of the advantages of ex-post studies is the opportunity to identify impacts that were not observed before the construction of a project. The usefulness of the evaluation comes from understanding the differences between what was planned and what was achieved, in order to improve management quality, ensure the appropriate allocation of resources, and derive lessons from the experience (Ministerio de Economía y Finanzas del Perú– Agencia de Cooperación Internacional de Japón, 2012).

Despite the importance of ex-ante studies, as they allow for projecting and anticipating the impacts that a project may generate with a certain level of certainty, it is important to highlight that evidence shows a significant margin of inaccuracy regarding the impacts observed during the construction and operation phases.

Results and Discussion

Environmental impacts are generally identified in ex-ante environmental impact studies because regulations stipulate that, for the granting of an environmental license, the identification of environmental impacts must be conducted in advance at the physical, biotic, and socioeconomic levels. However, much of the issue lies in the forecasting capacity of these types of studies. In

contrast, ex-post studies identify environmental impacts during or after the construction of the project.

In the case of El Quimbo, a comparison was made between the environmental impacts identified in ex-ante studies (environmental impact study and environmental license) and those identified in ex-post studies (see Table 1). In this regard, the impacts that coincided in both types of studies were highlighted, as well as those that were found in one type of study but not mentioned in the other, and vice versa.

On the other hand, for each area of impact (physical, biotic, and socioeconomic), the impacts were categorized based on whether they occurred before or after the project became operational. In other words, there are impacts that arose from the start to the end of the construction of the hydroelectric plant, while others emerged only after it began operating. In any case, some impacts arose and then disappeared, while others still persist in the environment.

In the comparison, it should be highlighted that, evidently, the number of impacts identified ex-post is greater than the number identified in the ex-ante documents. As shown in Table 1, fifty-nine (59) impacts were identified in the ex-ante analysis, while eighty-eight (88) were established in the ex-post analysis, a difference of twenty-nine (29) impacts, with the most significant discrepancy in the socioeconomic sphere.

In the physical domain, there was a high level of agreement between the impacts identified in both the ex-ante and ex-post analyses, where thirteen (13) impacts were established in both types of analysis: reduction of river flow, increase in air pollution, rise in noise levels, reduction of vegetation cover, flooding of land, decline in river water quality, decrease in reservoir water quality, alteration of the area's microclimate, rise in groundwater levels, increase in geological instability, rise in unpleasant odors, reduction in the area's scenic appeal, and loss of river connectivity.

In the ex-ante studies, five impacts were identified that had no equivalent in the ex-post studies: increased soil degradation, increased generation of construction waste and debris, increase in erosion downstream of the reservoir, decrease in groundwater quality, and increased sedimentation in the reservoir. Conversely, the ex-post studies identified three impacts that had no equivalent in the ex-ante studies: increased availability of water for crop irrigation, increased availability of water for industrial use, and reduction of reserve areas.

Similarly, in the biotic domain, a high level of agreement was observed between the impacts identified in the ex-ante and ex-post analyses, with six impacts established in both analyses: reduction of terrestrial habitats, increase in displacement of terrestrial fauna, rise in mortality of terrestrial plant species, rise in mortality of native terrestrial fauna species, expansion of aquatic ecosystems, and disruption of fish reproduction cycles.

In the ex-ante studies, one impact was identified that had no equivalent in the ex-post studies: reduction in biodiversity. Conversely, in the ex-post studies, one impact was identified that had no equivalent in the ex-ante studies: increase in mortality of native aquatic fauna species.

Finally, in the socioeconomic domain, there was a relative level of agreement between the impacts identified in the ex-ante and ex-post analyses, which established the following impacts in both types of analysis: reduction of agricultural and livestock activity areas, decrease in fertile land area, increase in human displacement, rise in temporary employment due to the project, loss of regional communication and connectivity, loss of cultural practices, reduction in agricultural employment, increase in cost of living, decline in infrastructure, loss or deterioration of archaeological sites, increase in emigration of the local population to other regions, population growth in the area, reduction in fishing sites, increase in immigration to the area of influence, rise in public health issues, increase in drug addiction and alcoholism, loss of material cultural heritage, increase in general social conflicts due to the project, heightened pressure on public services in the area, rise in the creation of bars and restaurant businesses, loss of social and community interaction spaces, increase in revenue for territorial entities due to transfers, decrease in land value around the reservoir, growth in tourism-related economic activities, and increase in respiratory diseases.

In the ex-ante studies, nine impacts were identified that had no equivalent in the ex-post studies: increased pressure on local employment, heightened expectations regarding project benefits, rise in insecurity and crime, increase in road accidents in both urban and rural areas, increase in the creation of transportation service companies, loss of territorial references, reduction in land value around the reservoir, and increase in aquaculture economic activity.

On the other hand, in the ex-post studies, forty impacts were identified that had no equivalent in the ex-ante studies: reduction in agricultural income, increase in local commercial networks, rise in teenage pregnancies, increase in prostitution, increase in infrastructure projects in the area, rise in grassroots community organizations, reduction in river material extraction sites, decline in agro-industrial establishments, reduction in industrial establishments, increase in human rights violations, rise in forced land expropriations, increase in social discontent, increase in the closure of agricultural input businesses, reduction in labor available for agricultural activities, generalized wage increase in the area, rise in the abandonment of agricultural activities, increase in the creation of small businesses, appearance of foreign cultural practices, reduction in smallholdings, decline in traditional economic activities—such as mining, increase in destruction of third-party properties, rise in illegal invasion of third-party lands, increase in cases of wild animal attacks on people, rise in the number of divorces and dysfunctional families, increase in the stigmatization of social and environmental movements, rise in corruption within public institutions, decrease in income of relocated populations, decline in income of displaced populations, increase in fish farm mortality downstream of the reservoir, increase in demand for goods and services, decrease in agricultural producer community organizations, reduction in fishing resources, drop in regional productivity, increase in land prices, increase in flood risk downstream of the reservoir, rise in recreational boating, increase in reforestation activities, increase in drowning deaths, rise in informal and illegal tourism businesses, and increase in land invasions around the reservoir (Moreira & Reis Fonseca, 2024).

Tabla 1. Comparación de impactos

Scope of impact	Impact	Identified impacts *ex–ante*	Identified impacts *ex–post*	Stage
Physical	Increase in soil degradation	☑		Before construction
	Decrease in river flow downstream of the reservoir	☑	☑	
	Increase in air pollution	☑	☑	
	Increased noise level	☑	☑	
	Decrease in vegetation cover	☑	☑	
	Flooding of land	☑	☑	
	Increase in unpleasant odours	☑	☑	
	Increased generation of waste and construction debris	☑		
	Decrease in reserve areas		☑	
	Increased erosion downstream of reservoir	☑		After construction
	Decrease in groundwater quality	☑		
	Increased availability of water for crop irrigation		☑	
	Increasing the availability of water for industrial use		☑	
	Increased sedimentation of the reservoir	☑		
	Decrease in river water quality	☑	☑	
	Decrease in reservoir water quality	☑	☑	
	Rising water tables	☑	☑	
	Increased geological instability	☑	☑	
	Alteration of the microclimate of the area	☑	☑	
	Diminishing the scenic attractiveness of the area	☑	☑	
	Loss of river connectivity	☑	☑	
Biotic	Decline of terrestrial habitats	☑	☑	Before construction
	Increased movement of terrestrial wildlife	☑	☑	
	Increased mortality of terrestrial plant species	☑	☑	
	Increased mortality of native terrestrial wildlife species	☑	☑	
	Biodiversity decline	☑		
	Increased mortality of native aquatic fauna species		☑	
	Increase of aquatic ecosystems	☑	☑	After construction
	Disruption of fish reproductive cycles	☑	☑	
Socioeconomic	Increased pressure on local employment	☑		Before construction
	Increased expectations of project benefits	☑		
	Increased insecurity and criminality	☑		
	Decrease in agricultural income		☑	

Scope of impact	Impact	Identified impacts *ex–ante*	Identified impacts *ex–post*	Stage
	Decrease in the area of agricultural and livestock economic activities	☑		
	Decrease in fertile land area	☑	☑	
	Increased human displacement	☑	☑	
	Increase in temporary employment in the project	☑	☑	
	Loss of intra-regional communication and connectivity	☑	☑	
	Losses of cultural practices	☑	☑	
	Decline in agricultural employment	☑	☑	
	Cost of living increases (zonal inflation)	☑	☑	
	Declining infrastructure (roads, bridges, housing, etc.)	☑	☑	
	Loss or deterioration of archaeological sites	☑	☑	
	Increased out-migration of the local population to other regions	☑	☑	
	Increase in road accidents in the urban and rural areas	☑		
	Increase in the creation of companies providing transport services	☑		
	Population growth in the area	☑	☑	
	Decrease in fishing sites	☑	☑	
	Increased in-migration of people to the catchment area	☑	☑	
	Increase in public health diseases	☑	☑	
	Increase in drug and alcohol addiction phenomena	☑	☑	
	Loss of tangible cultural heritage	☑	☑	
	Increased social conflicts generated by the project	☑	☑	
	Increased pressure on public services in the area	☑	☑	
	Increase in the creation of bar and restaurant service businesses	☑	☑	
	Loss of spaces for social and community interaction	☑	☑	
	Loss of territorial references	☑		
	Increasing commercial networks in the area		☑	
	Increase in teenage pregnancies		☑	
	Increase in prostitution		☑	
	Increased infrastructure works in the area		☑	
	Growing grassroots community organisations		☑	
	Decrease in sites for extraction of materials from the river		☑	
	Decrease in agro-industrial establishments		☑	
	Decrease in industrial establishments		☑	
	Increase in human rights violations		☑	
	Increase in compulsory land expropriations		☑	

Scope of impact	Impact	Identified impacts *ex–ante*	Identified impacts *ex–post*	Stage
	Increasing social unrest		☑	
	Increase in farm input business closures		☑	
	Decrease in available labour for agricultural activities		☑	
	Wage increases across the board in the area		☑	
	Increase in the abandonment of agricultural activities		☑	
	Increase in the creation of small businesses (neighbourhood shops, fast food, clothing and shoe shops, etc.).		☑	
	Emergence of foreign cultural practices		☑	
	Decrease in smallholdings		☑	
	Decline in traditional economic activities - mining		☑	
	Increased destruction of third party property		☑	
	Increase in illegal encroachment on third party land		☑	
	Increase in cases of attacks on people by wild animals		☑	
	Increase in divorce and dysfunctional families		☑	
	Increased stigmatisation of social and environmental movements		☑	
	Increasing corruption in public institutions		☑	
	Decrease in income of relocated population		☑	
	Decrease in income of the displaced population		☑	
	Increased mortality of fish crops downstream of the reservoir		☑	
	Increased demand for goods and services		☑	
	Decline of community-based agricultural producer organisations		☑	
Socioeconomic	Increased economic activity in fish farming	☑		After construction
	Decrease in the value of land around the reservoir	☑		
	Increase in disease vectors	☑		
	Decline of the fishery resource		☑	
	Sub-regional productivity decline		☑	
	Increase in land prices		☑	
	Increased flood risk downstream of the reservoir		☑	
	Emergence of yachting		☑	
	Increased reforestation activity		☑	
	Increase in deaths of people by immersion		☑	
	Increase in informal and illegal tourism businesses		☑	
	Increased encroachment on land around the reservoir contours		☑	
	Increase in local authorities' transfer revenues	☑	☑	
	Increase in economic activities associated with tourism	☑	☑	
	Increase in respiratory diseases	☑	☑	

With regard to the comparative evaluation between the ex-ante and ex-post impacts generated by the El Quimbo hydroelectric power plant, it is mentioned that the available information allowed the comparison to be carried out successfully in two moments: the first in relation to all the established environmental impacts, which resulted in the identification of fifty-nine (59) impacts in the ex-ante analysis, while eighty-eight (88) impacts were determined in the ex-post analysis.

Evidently, the number of impacts identified in ex-post studies was higher and the difference was concentrated in the socio-economic sphere, which leads to focus the analysis on the limitations of the actions - corrective, preventive, compensatory or mitigating - taken to manage the consequences caused by the construction of hydroelectric projects.

Based on the analysis carried out, it can be seen that the environmental impact studies previously carried out when applying for environmental licences, a requirement requested by national regulations for the construction of hydroelectric projects, are insufficient and unreliable for the identification of biotic, abiotic and socio-economic impacts, as they are based on the projection and probability of occurrence of events.

For this reason, national regulations should include, within the granting of the environmental licence, the commitment to carry out ex-post environmental impact studies, i.e. after the construction and operation of the hydroelectric power plant, in order to establish the impacts and their magnitude, since environmental impacts may have been omitted, underestimated or overestimated.

Conclusions

The objective of this research was to establish the gaps in environmental regulations related to environmental licenses granted in the framework of the construction of hydroelectric dams in Colombia. In this regard, a comparison was made between the environmental impacts identified in ex-ante environmental impact studies and the environmental impacts identified in ex-post studies and investigations, finding significant differences between the two. Indeed, it was established that the ex-ante studies contain high levels of inaccuracies, making the current regulations insufficient for the management of environmental impacts, especially in the case of negative impacts.

Finally, it is important that the Colombian environmental regulations are complemented by the obligation of the companies applying for environmental licenses to carry out ex-post environmental impact studies, that is, after the construction of the hydroelectric projects, since this type of studies contain a high level of reliability since they identify and evaluate the magnitude of the impacts after their occurrence.

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