

Management of the Impacts of Hydroelectric Power Plants about Ichthyofauna: A Case Study about Cemig's Activity

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Abstract: This article analyzes the impacts of hydroelectric plants on the ichthyofauna, with a description of the socioenvironmental damages and their causes, as well as the identification of the management methods used by CEMIG for their mitigation in the Três Marias, Minas Gerais unit. From harmful events for the ichthyofauna occurred in the Três Marias hydroelectric power plant, Minas Gerais, in the years 2006 and 2007, new methods of environmental management were adopted by CEMIG and studied in this article. This study was based on the analysis of documents provided by CEMIG and interviews that allowed us to conclude that efficient management methods are linked to the companies' perception of the importance of complying with environmental legislation, meeting the society's wishes to protect the natural environment, and preservation of income generation and employment, with repercussions on the corporate image. A recent analysis of more recent reports produced by CEMIG, 2012-2013 revealed that the management plans have an even more efficient profile and an innovative vision for the four-year period 2014-2018.

Key words: environmental management, environmental impacts, hydroelectric plants, ichthyofauna, environmental protection

1. Introduction

The Law on Environmental Crimes (Law 9605/98) brought important innovations in the scope of environmental protection, since it has become a strong influence in the environmental management of companies that have increasingly sought to achieve the so-called social responsibility through the elaboration and execution of projects that integrate the environment at all levels. This is a “normative pressure of established standards”, according to Dias [1] and directly interferes with the decision-making process of companies. According to a report published in 2008 by IBAMA (2008) [2], CEMIG was responsible for two serious accidents, classified as a crime, which resulted in the death of 8.3 tons of fish in 2006 and 2007 during

operational maneuvers carried out at the Três Marias Plant, Minas Gerais. Based on these facts, a study aimed at understanding how these and other impacts of hydroelectric plants reflect negatively on the ichthyofauna and the local population, with a description of these damages and their causes, has led to the change in their environmental management system. The objective of this work is to analyze the influence of the Law of Environmental Crimes on the environmental management of companies, as well as their methods and the reflections in the socio-environmental context, so that the scientific community can consider the environmental punitive system as an external factor that induces a response positive in relation to the minimization of environmental degradation through Management Systems.

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2. Material and Methods

For the accomplishment of this work, a descriptive study was carried out, using a focus group, interviews and non-participant observations, with the objective of obtaining information that contribute to the analysis of the management methods employed in minimizing the social and environmental impacts caused by the installation of hydropower and accidents.

Through a focus group with Cemig managers, it was tried to understand if there was modification of its management methods aiming at the prevention and repair of damages caused by its hydroelectric plants on the ichthyofauna, as well as in relation to those generated in the anthropic environment, such as the income generation of the riverside communities of the municipality of Três Marias.

Data were also collected on Cemig's environmental management in hydroelectric plants, in documents provided by the company. This information pointed to the creation and implementation of a project called Program Fish Vivo, which basically constitutes the environmental action plan of CEMIG in the Três Marias plant, after the accidents of 2006 and 2007, which has been constantly improved over the years. years, reinforcing the initial idea of preservation of the ichthyofauna, as we could see in the reports produced in the years 2009, 2010-2011 and 2012-2013, the latter with projections for the 2014-2018 quadrennium.

These data were analyzed based on the revised literature and with the constant verification of the influence of the Law of Environmental Crimes on the adoption of methods necessary to mitigate impacts of hydroelectric plants on the ichthyofauna and its social consequences.

Considering that the damages caused to the aquatic fauna in the years 2006 and 2007, in Três Marias, constitute, in thesis, environmental crimes, it was also sought, through the Public Prosecutor's Office of the State of Minas Gerais, information about the filed cases, having as answer of that body the document called the Term of Adjustment of Conduct, which aims to create

commitments to the cause of environmental damage so that it is free of a possible criminal conviction, signed with CEMIG, where it undertakes several commitments.

The commitments made in the Term of Adjustment of Conduct were compared in this work with the actions developed by CEMIG, based on documents maintained by the company itself, which report the impacts of hydroelectric plants on the ichthyofauna, in accordance with those described in the specific literature.

To better support the work, twelve interviews were conducted with people from the local community, involved with the Peixe Vivo Program. The fishermen interviewed were chosen among the oldest and engaged in the Colony of Fishermen of Três Marias, following information passed on by the members that compose it. It was understood as relevant, also, to know the opinion of the Municipal Secretary of the Environment of Três Marias on the actions of CEMIG. A researcher from the São Francisco and Paranaíba Valley Development Company — CODEVASF was consulted for being responsible for Cemig's fish farming and fishery studies.

The interviews were recorded and transcribed in their entirety, trying to keep dialects, slang forms of communication and expression private and own the interviewees. The questions were elaborated aiming to understand the opinion of the interviewees about CEMIG's Live Fish Program, its actions, community participation in its development, reduction of fish death after its implementation, preservation of native species of fish in the Três Marias region and the impacts of the power plant on the income generation and employment of the local community.

Those responsible for the Peixe Vivo Program, three in number, presented the guidelines of the program. During a visit to the Três Marias hydroelectric power plant, the general operation and the maneuvers that caused the accidents of 2006 and 2007, as well as the new procedures to mitigate damage to the ichthyofauna

were known. Among these methods, two biologists demonstrated the functioning of the monitoring systems for the abundance of fish downstream of the plant.

Through the General Reports of the Peixe Vivo Program, released by CEMIG, 2009, 2010-2011 and 2012-2013, it was possible to analyze the continuity of the process of preservation of native fish species in the Três Marias region and the impacts of the mill on income generation and employment of the local community.

Três Marias is a city located in the central region of the State of Minas Gerais. It has an area of 2,675 square kilometers, bathed by the Boírio São Francisco River, in the São Francisco river basin (Municipal City of Three Marias, 2011). It has a population of 49,354 inhabitants, according to the Census 2013 (IBGE, 2013). It became an urban center in the 1950s, when the first dam of the São Francisco River was installed there, generating a number of jobs, both direct and indirect, that settled there with the completion of the works, starting to perform typical activities such as fisheries and agriculture [3].

Its economy was amplified by the potential tourism created with the formation of a large lake resulting from the dam, known by its residents as "Mar Doce" (Municipal City of Three Marias, 2011), but conserves traditional populations that live from fishing in São Francisco, from which they derive their own food, in addition to marketing the surplus to tourists and merchants in general.

According to the General Report of the Peixe Vivo Program [4], Cemig's operations are coordinated by a holding company, Companhia Energética de Minas Gerais-Cemig, and two subsidiaries: Cemig GT and Cemig Distribuição SA (Cemig D), in addition to holding interests in 120 companies and 16 consortiums and a participation fund, with assets in 23 Brazilian states and Chile. Cemig, through its wholly-owned subsidiaries, subsidiaries and generation affiliates, has

63 hydroelectric plants, three thermoelectric plants and four wind farms with 7,038 MW of installed capacity.

Cemig, a publicly-held company controlled by the Minas Gerais State Government, has 117,000 shareholders in 40 countries. Its shares are traded on the Stock Exchanges of São Paulo, New York and Madrid. Today the Company is a reference in the global economy, recognized for its sustainable performance. For 13 consecutive years, it is part of the Dow Jones Sustainability World Index (DJSI World). The Cemig Group is recognized for its size and technical competence, being the largest integrated company in the Brazilian electric power sector. In Minas Gerais, it accounts for 96% of the concession area, with approximately 6.8 million consumers in 774 municipalities. It is also the largest energy supplier to free customers in the country, with 25% of the market. Cemig's operations extend to 22 Brazilian states, in addition to the Federal District, and to Chile, with the operation of a transmission line in a consortium with Alusa. She became the controlling shareholder of Light, increasing its participation in the distributor that serves Rio de Janeiro and other cities of Rio de Janeiro. It also has a stake in electricity transmission companies (TBE and Taesa), investments in the natural gas segment (Gasmig), telecommunications (Cemig Telecom) and energy efficiency (Efficientia).

3. Results and Discussion

Although the phenomenon of environmental devastation is not current, its perception is of recent explanation [5]. In this sense, Wainer [6] reports that "the first legislative formulations that discipline the environment are to be found in the Portuguese legislation that was in force in Brazil until the advent of the Civil Code in 1916."

However, after the 1960s, advances in environmental legislation occurred with the reformulation of the Forest Code (Law 4.771/1967), the Law on Protection of Wildlife (Law 5,197/1967) and the Fisheries Code (Decree-Law 221/1967).

However, it was only in the 1980s that there was a boost in environmental legislation, becoming more comprehensive, in light of the issues posed at the Stockholm Conference in 1972.

This broader scope of environmental legislation began with the emergence of Law 6.938/1981, which legally conceptualized the environment and instituted the National Environmental System, representing a milestone in environmental protection in Brazil. Next, Law 7,347/1985 (Law of Public Civil Action) created specific procedural instrument for the defense of the environment and other diffuse and collective interests.

The Federal Constitution of Brazil, enacted in 1988, consolidated environmental protection in Brazil, bringing provisions relating to the subject in several titles and chapters, serving as the basis for the edition of Law 9,605 of February 12, 1998, which provides for criminal and administrative sanctions applicable to conducts harmful to the environment. Constitutional provisions also include the elaboration of laws, decrees, regulations and other legal norms for the protection of the environment at the state and municipal levels, and these governmental entities are responsible for supervising the activities carried out within the framework of their political and administrative activities.

Law 9605/98 gave more adequate contours to the question of the commission of conduct that is extremely harmful to the environment, because by applying the penalty defined in the legal system that was not observed, the State eliminates the dissatisfaction and social discomfort generated, reaffirming the authority of the legal order. This is the great juridical modification of the environmental protection occurred by the promulgation of Law 9.605/98, because “the stigma of a criminal proceeding generates effects that other forms of repression do not reach” [7].

In accordance with the provisions of the Federal Constitution, Milaré [5] emphasizes that the environment is of common interest, regardless of the

existence of property guarantees and geopolitical limits. For this reason, according to Silva (2017) [8], environmental law aims to protect the quality of the environment as a function of quality of life, and there are two objects of protection, in this case: an immediate one — that is the quality of the environment, and the other mediate — that is the health, well-being and security of the population, which is being synthesized in the expression quality of life.

The occurrence of several ecological phenomena, all tending to unbalance the environment, causing damages that were sometimes irreparable, aroused environmental awareness, drawing the attention of the authorities to this problem [8].

Article 225, §3 of the 1988 Federal Constitution establishes three spheres of protection of the environment: civil, criminal and administrative. The civil protection of the environment is related to the nature of the environmental damage and its extension, generating the obligation to indemnify the damages caused to the environment in itself and to affected third parties, being the cause of the damage the integral risk by the exercise of its activity. Administrative protection of the environment, as recommended in art. 225 of the CF/1988, it is the duty of the public authority to preserve the environment. Accordingly, it must, through police power and regulatory power, use administrative measures in environmental matters, in order to meet the public interest, in order to repress any action or omission that violates the legal rules of use, enjoyment, promotion, protection and recovery of the environment, under the terms of art. 70, caput, of Law No. 9,605/98. Criminal protection is that which comes from criminal law, which has been a useful and important instrument in the protection of the environment, resorting to it whenever administrative and civil repressions prove unsatisfactory in order to combat successive aggressions to the environment. It is the duty of the State to punish those who commit offenses defined by law as criminally relevant, being a generic and impersonal right, since it is not directed

specifically to a person, but to the community as a whole [9].

It is important to note that Law No. 9605/1998 — Law on Environmental Crimes — consolidated in a single legal document the sparse documents that contained the description of conduct considered as crimes against the environment, facilitating its application. This Law is divided into different sections and provides for crimes against fauna, flora, urban planning and cultural heritage, as well as a part that deals with pollution and other environmental crimes and has brought important innovations in the ambit of environmental protection, among them the possibility of the corporate entity being condemned for the practice of crimes against the environment.

Philippi Jr. et al. [10] conceptualize environmental management as the act of administering, directing or governing the natural and social ecosystems in which man is inserted and with him seeks an interaction with the activities that he exercises. To do this, it is necessary to establish quality standards that focus on the preservation, maintenance or recovery of the natural environment.

Dias [1] defines environmental management as being the business management that is oriented to avoid, as far as possible, problems for the environment. In other words, it is the management that aims to achieve that the environmental effects do not exceed the carrying capacity of the environment where the organization is located, obtaining a sustainable development. This author complements that the process of environmental management in companies is deeply linked to the legal norms elaborated by public institutions that discipline the legal order of the environment, being the main instrument to obtain a sustainable industrial development.

Environmental management is therefore the tool used by man to make rational use of the environment, with the best use of his resources, not to cause damages, as well as to mitigate those that were generated by his exploitation. The legal norms are mandatory references

for companies that intend to implement an Environmental Management System (EMS), and the violation of these legal norms, or their ignorance, significantly affects the companies' investments, as well as their capacity to intervene in the market [1].

Dias [1] conceptualizes the Environmental Management System as being: 1) Set of organizational responsibilities, procedures, processes and means that are adopted for the implementation of an environmental policy in a given company or productive unit. 2) Systematization of environmental management by a given organization. 3) It is all employed to lead an organization to achieve and keep functioning according to establish norms, as well as to achieve the objectives defined in its environmental policy.

The adoption of effective methods of environmental management is a competitive differential that, within its strategy, a company can achieve by improving its image in the market. This trend has been increasingly observed by society in general, considering that every day increases the environmental awareness of people. In this way, there is a new paradigm of environmental management, which seeks to prioritize systems that allow companies to anticipate negative environmental impacts resulting from the installation and operation of their activities.

The interruption of the natural course of a river results in the formation of a reservoir that causes a change in the predominant species upstream of the dam, due to changes in temperature and dissolved oxygen in the water, reduction of water flow, flow velocity and habitat diversity, as well as a decrease in the small fish population due to lack of shelter and easy catching by predators [11].

Another problem related to the construction of dams is the displacement of fish as a function of reproduction, search for food or shelter, which is severely impaired, causing the interruption of the reproductive migration of the species, which can be extinguished. In addition, several species become easy prey for predators or they can still suffer the damaging actions of the hydraulic

turbines, considering that they remain for long periods at the foot of the dams. The causes of death of fish can also occur when individuals move upstream or downstream of suction pipes, where the opposite course of movement occurs at machinery stops [12].

For the coastal populations, artisanal fishing is a means of subsistence, where the product is withdrawn for its own food and for the sale of its surplus to the other nuclei and cities that make up a certain hydrographic region [13]. Regarding the socio-environmental impacts caused by hydroelectric power plants, we highlight Silva (2007), who states that the formation of dams may lead to the reduction or extinction of fish species, which ultimately negatively impacts fishery activities in regions. According to Godinho and Godinho [14], "hydroelectric dams have a strong negative impact on fishing and are among the main causes of the decline in fishing in rivers in many countries."

Launched by CEMIG in June 2007, the Peixe Vivo Program was created to develop actions to preserve the ichthyofauna in the hydrographic basins where its hydroelectric power plants were installed, seeking to mitigate the impacts generated during the implementation and operation of the hydroelectric generating units electricity.

Its creation came after two consecutive accidents that resulted in the death of 1.3 tons of fish in 2006 and 7 tons in 2007 during operational maneuvers at the Três Marias Plant located on the São Francisco River.

According to information provided by one of the engineers responsible for the operation of the plant, one of the turbines needed maintenance, which could only be performed with the machine out of operation. For this maintenance, it was necessary to deplete the water in the escape channel, where large concentrations of fish occur. In order that the exhaustion could be accomplished, the descent of a sealing door began. At this moment, a large volume of fish was trapped in the suction tube, killing the thousands of fish that were there, due to lack of oxygenation.

The operation was aborted when it was found that a large volume of fish had entered the suction area, but at this moment, it was not possible to equate the internal and external pressures to reopen the sealing door, which eventually stuck, keeping the fish confined.

In another event, also in 2007 occurred the death of a large quantity of fish in the spillway of the plant, specifically in the dissipation basin, which receives the water flow from the dam, when it reaches levels that if exceeded can cause flooding. This is because the volume of the dispersion area dropped sharply, imprisoning large quantities of fish that exceeded the containment wall, in search of a place with greater oxygenation, due to the flow of water generated by the descent of the drained water.

The death of fish in hydroelectric plants makes CEMIG the target of civil and criminal actions, which aim to punish those responsible for the damages caused to biotic and anthropic media, in addition to the application of severe fines and turbine shutdown.

After the accidents, the Public Prosecutor's Office of the State of Minas Gerais initiated three civil investigations (ICPs n°0058.07.000003-7, n°0058.07.000004-5 and n°0058.06.000002-1) to investigate responsibilities, Bulletins of Occurrence of the Military Police, requesting measures to the Police Authority due to the commitment, in theory, of environmental crime, infraction notices issued by the IEF and FEAM, indicating the administrative infractions found, technical opinions issued by the Technical Support Center of the Public Prosecutor's Office.

The aforementioned inquiries culminated in a Conduct Adjustment Agreement entered into between the Minas Gerais State Attorney General's Office and CEMIG Geração e Transmissão SA in April 2010, where the latter undertook several commitments aimed at the conservation of the ichthyofauna and prevention of new accidents, in addition to the payment of fines.

After implementing the program, an evaluation carried out in the year 2013 pointed to the achievement

of the goals established in the creation of the Program, and the need for a new vision for the program to expand its strategic actions for the conservation of the native fish of the basins where it operates and in the promotion of public environmental policies, through a process of integration of several sectors involved.

According to surveys, there was a significant reduction in fish death due to the implantation of the Peixe Vivo program, and there were no deaths such as those of 2006 and 2007, which can be evidenced by the analysis of the reports of environmental accidents reported by IBAMA.

CEMIG's Live Fish Program operates on three fronts, namely the conservation programs of the ichthyofauna and hydrographic basins, the production of scientific knowledge to subsidize these programs and the promotion of community involvement in the activities planned.

Since 1976, CEMIG has carried out the repopulation with native species of fish in reservoirs and rivers, seeking the preservation of biodiversity, by releasing fingerlings to restore fish stocks, especially those species that are threatened with extinction by natural impacts, or by anthropic action. According to data from the Environmental Premium Report Brazil, 2009, in the first harvest in the scope of Peixe Vivo, almost 1.5 million fingerlings were released in the 154 fishings in 97 municipalities of the hydrographic basins of Minas Gerais. Production in captivity was 34.7 tonnes. In 2007, fishings were also carried out in the Paraíba do Sul and Jequitinhonha river basins, which in the 2008/2009 harvest alone received more than 1.5 tons.

In 2011, the researcher interviewed at CODEVASF described the methods of repopulation, emphasizing that the partnership with CEMIG has guaranteed the maintenance of native species in the region of Três Marias, considering that there are investments in the order of R \$ 450,000.00 in research for the production of fingerlings and studies of repopulation, which brings improvement of the quality of life for the local

communities that sustain themselves with the fishing. The following words subsidize this statement:

Cemig actively participates in the preservation of the native species of fish of Três Marias fomenting actions for the production of fingerlings and researches in ichthyology (Edson V. Sampaio, Researcher of CODEVASF).

Due to a period of renovation at the Três Marias Integrated Center of Fisheries and Aquaculture Resources, the station returned with its production in the 2010-2011 harvest, when a new contract was signed between CODEVASF and CEMIG. Currently the center has a total area of 20 hectares, where are installed about 2.46 hectares of water mirror, with several nurseries, an Effluent Treatment Station composed of a lift station and two stabilization ponds, where it is guaranteed maintenance of matrices and nursery, which contribute to the preservation of native species.

In order to guarantee greater safety to the fish fauna, CEMIG prepared normative instructions on the operational procedures in the plants, establishing more efficient patterns and methods of operation. All the work of planning and execution of the operative maneuvers are carried out through reports, which are accompanied by the Peixe Vivo Program team and evaluated by a committee, decisive tasks to avoid the death of fish, especially in departures and drains of machines, which are riskier operations.

Based on a survey of records of environmental occurrence from 2000 to 2009, the Peixe Vivo Program team was able to elaborate a diagnosis of the impacts of the operations of the Cemig hydroelectric power plants, where improvements were suggested for the rescue work of fish in the suction tubes of the machines, considering the efficiency and quantification of the volume rescued. New procedures and studies have been carried out to ensure the continuity of operations without any damage to the fauna. With these procedures there was a significant reduction of fish

deaths, with a rescue of live fish of the order of fifteen tons.

In relation to the local community Cemig has been working to preserve the fish of the region, source of sustenance of the fishermen, besides realizing projects that enable the society of Três Marias. The Versol Project, conducted by CEMIG in partnership with the Instituto Rumo Náutico/Grael Project, teaches students from local public schools in sailing practices, environmental education and motors for stern engines, so that these students can use these in the future. knowledge to develop professionally.

In a follow-up visit to one of the classes of the Versol Project, it was possible to perceive the great interest of the local community for the courses offered, where it was verified the presence of all the participants who made a relay between sailing and canoeing classes, Praia de Minas, an artificial "beach" that was built on the banks of the São Francisco River, in the Tres Marias dam.

In an interview with the president of Colony Z5 of Fishermen of Três Marias, it was verified that the fishing community in the locality does not exceed two thousand people, being sure that there is no stimulus for its continuity. "Fishermen who still remain in this activity do so because they have not had other job opportunities, the majority of them being semi-illiterate, with no other qualifications, which makes it difficult to enter the labor market" (Marco Aurélio de Lima, President of Colônia Z5 of Três Marias Fishermen).

For the fishermen's colony, the fishing activity has suffered a lot with the risk of extinction of the native species and proliferation of exotic species, which are predators of the former, being the main causes of this phenomenon the lack of implementation of conservation actions. The decline in fishing activity in the Três Marias region causes the citizens of the community to seek new forms of employment and income, many of them migrating to other cities in search of a job opportunity, reinforcing the hypothesis

highlighted by Godinho and Godinho (2003) [14], cited in the theoretical framework.

Even acknowledging that CEMIG damages the class, the fishing community seeks to understand the need for the presence of the bus in the region, seeking to adapt to this reality, modifying its methods and techniques, increasing the fishing of exotic species, so that the activity continues giving them the necessary to live worthily.

The work of environmental education is also part of the actions developed by the Program in relation to the community, especially with the children and riverside, who receive information and participate in some activities, such as fishings, where they can better understand preservation work. The community also participates in field days for planting seedlings and receives information material such as folders and the virtual book Peixinho Dourado.

CEMIG presents in its latest program report, 2014, the indicators related to the work fronts, the conservation programs of the fish fauna and river basins, the production of scientific knowledge to subsidize these programs and the promotion of community involvement in the activities planned, where it is possible to observe the increase in investments in research projects and management of the fish fauna in the order of R \$ 8,000,000.00 between 2007 and 2013, reduction of the biomass affected, sum of the entire mass of dead fish as a result of the impacts caused by the maintenance and operation in hydroelectric power plants, 77% in house, maintenance of the students' frequency in the Versol and Pescadores do Saber projects, in addition to a significant participation of the community in fishings.

4. Conclusion

Efficient management methods are linked to companies' perception of the importance of complying with current environmental legislation, as well as meeting the society's desire to protect the natural

environment, with significant impacts on the corporate image.

The Law on Environmental Crimes, as well as other legal provisions directly influence decision making within an environmental management process, but for some companies such as CEMIG, it is not exclusively the preponderant factor for the adoption of methods aimed at conservation.

Issues related to the image of companies in the market, certifications and sustainability indexes have been decisive factors for the adoption of environmental management methods appropriate to the business reality, which reinforces the hypothesis that it is a competitive differential increasingly observed by society in general, considering that every day increases the environmental awareness of people. It is, therefore, the aforementioned new paradigm of environmental management, where it is sought to prioritize systems that allow companies to anticipate the negative environmental impacts resulting from the installation and operation of their activities.

The fear of companies being known to society as "criminals" has become a major concern in the exploitation of natural resources. In this measure, we emphasize that the legal norms obligatory references in the implementation of an Environmental Management System (EMS), so that the investments of companies are not significantly affected, as well as their capacity to intervene in the market.

Another important conclusion, based on CEMIG's post-accident actions of 2006 and 2007, which had extremely negative impacts on the aquatic fauna of the Três Marias dam, is that in the past, corrective methods for solving environmental impacts predominated, but continuity of the operations of the ichthyofauna management program reveal a new scenario of preventive actions.

Hydroelectric power plants, due to their operational nature, are responsible for significant environmental impacts, where they can highlight the side effects on aquatic fauna, demanding efficient measures to prevent

and repair damages. Environmental management in hydroelectric systems has significant impacts on local communities, with important socio-environmental impacts to be observed by companies.

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