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POTENTIAL ECOSYSTEM SERVICES FOR CONTINENTAL FISH FARMING ACTIVITIES

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Abstract: This article analyzes the use of environmental compensation as an economic instrument to support the conservation of natural resources (specifically water and native vegetation) integrated with fish farming in the state of Santa Catarina, Brazil. This activity faces significant challenges, especially those related to current environmental legislation, in the process of adapting the use and occupation of production structures in permanent preservation areas (APP) and Legal Reserves (RLs). The study maps out the main legal provisions that deal with legal reserve compensation, the environmental regularization of the sector and the Payments for Environmental Services (PES) programs, thereby proposing to investigate the potential ecosystem services possible in the logic of the use and occupation of this activity. The methodology involved researching secondary data, resulting in the identification of nine legal provisions relevant to the subject. The results suggest that projects to conserve water resources and recover native vegetation on properties where this activity takes place could benefit from PES programs. In addition, the compensation of legal reserves can boost new instruments for valuing the ecosystem services present in these rural properties. The study identifies challenges, including the need for a regulatory framework to encourage certain legal provisions, such as consolidating sources of funding for these public policies and the importance of effective implementation of the Environmental Regularization Programs (PRA) that were planned as a step after validation of the Rural Environmental Registry (CAR). The conclusion is that the continuous evolution of PES policies and the implementation of state and national programs reinforce the importance of sustainable practices and the valuation of ecosystem services. In order to overcome these challenges, there is a need

to strengthen an intersectoral arrangement, where sectors such as forestry, water resources and the productive sector engage in dialog in order to consolidate and implement existing public policies.

Keywords: Environmental compensation, Environmental Reserve Quotas, fish farming, Environmental services, Forest Code.

INTRODUCTION

Continental fish farming is the main aquaculture activity in Brazil, and according to data collected by PeixeBR (2023), Brazilian continental fish production reached 860,355 tons, according to the exclusive survey carried out by the Brazilian Fish Farming Association (Peixe BR). This figure represents an increase of 2.3% on the 841,005 tons produced in 2021. Tilapia continues to be the highlight of farmed fish and saw a 3.0% increase in national production when comparing the 550,060 tons of 2022 to the 534,005 tons of 2021.

Continental fish farming is predominantly carried out on private rural properties, which are subject to the Law on the Protection of Native Vegetation (LPVN, Law No. 12.651), which regulates interference with native vegetation in areas considered permanent preservation (APP) and Legal Reserve (RL) (Loureiro, et al., 2024).

Most of the areas used for fish farming in Santa Catarina are located within APPs or their boundaries, resulting in environmental liabilities (Loureiro et al., 2019). Environmental liabilities occur when an environmental asset is significantly damaged, or when human activities cause potential risks to the property. Consequently, this scenario involves the duty to invest in actions to control, prevent or recover environmental impacts (Wakim and Wakim, 2012). In the context of the LPVN, that includes damaging or suppressing vegetation in APP and RL areas and requiring the restoration of native vegetation in these areas.

Federal Law No. 12.651/2012, which establishes the updated version of the Law on the Protection of Native Vegetation (LPVN), was implemented with important instruments for compliance with this legislation, among them the Rural Environmental Registry (CAR), seen as the main tool to support the environmental regularization of rural properties in Brazil. In addition to the environmental aspects, the law provides for economic and financial instruments to achieve its objectives, such as environmental compensation for legal reserves (Article of the law).

Since fish farming is classified as an activity subject to environmental licensing and, in order for such an enterprise to be authorized, environmental regularization involves compliance with the restoration of native vegetation in a minimum strip around watercourses and springs (APPs), as well as having to have an area of protected native vegetation, known as a Legal Reserve. This compliance with the Legal Reserve requirements represents a challenge for the rural properties where continental fish farms are located, since most of them are located on small rural properties and these hardly have the minimum 20% Legal Reserve.

According to Farias et al. (2021), the deficit of native vegetation in 2008 occurred in 56% of the properties registered in the Atlantic Forest. Small properties, smaller than 4 Tax Modules, represent 90% of the number of properties with a deficit, but only 14% of the total area of estimated RL or APP deficit. Large properties, larger than 15 Tax Modules, represent only 2% of the number, but 42% of the total area of estimated RL or APP deficit. Thus, adapting only large properties would reduce 2 million ha or 42% of the deficit in the Atlantic Forest. However, small rural properties have an environmental liability to be resolved.

Environmental compensation through Environmental Reserve Quotas (CRAs) can offer a viable alternative for producers who do not have enough areas of native vegetation on their properties to make up the Legal Reserve. The CRAs allow producers to compensate for the lack of LR by acquiring quotas from preserved areas in other locations, as long as they are in the same biome, respecting the particularities of the ecological identity of the area to be compensated.

In addition to the legislation protecting native vegetation, the state government of Santa Catarina implemented the Payments for Environmental Services Program (PSA) to encourage the protection of natural resources. This program aims to pay rural landowners and traditional communities who adopt environmental conservation practices, recognizing and encouraging the maintenance of essential ecosystem services (Pagiola, 2008).

The National PES Policy aims, among other things, to foster the conservation and recovery of ecosystems, promote sustainable development, and contribute to mitigating climate change. The law also defines the sources of funding for PES programs, which include public and private resources, donations, and carbon credits (Brasil, 2021).

The effective implementation of PES programs, aligned with the adoption of CRAs, represents an integrated approach to important public policy instruments for environmental conservation and development.

In this context, the aim of this study was to map the main legal provisions that deal with legal reserve compensation and Payment for Environmental Services (PES) programs, identifying their potential as conservation tools and economic instruments that integrate with policies aimed at continental fish farmers.

METHODOLOGY

The methodology adopted consisted of an exploratory review, related to the proposed theme, following the following steps.

- Definition of the Problem: Based on the central object of this study, the relevant research questions were formulated about the implementation of ecosystem services on properties where fish farming is developed, what the potentials, opportunities and challenges are.

- Review of scientific literature and regulations: A review of existing literature on the topic was carried out in order to understand the current state of knowledge and identify gaps. To do this, we used the following keywords: Payment for Environmental Services (PES) programs, environmental compensation, LPVN, forestry code, Law 12.651, fish farming licensing and environmental suitability of rural properties.

- Data Collection: A search was carried out in the SciELO, Web of Science, Scopuse Google Scholar and google databases, using the keywords; Payments for Environmental Services (PES) Programs, Environmental Compensation, Law on the Protection of Native Vegetation (LPVN), Forest Code, Fish Farming Licensing and Environmental Adequacy.

- Data Analysis: Qualitative analysis techniques such as thematic coding and content analysis were used to identify emerging patterns, themes and insights in the literature surveyed.

- Interpretation and Synthesis: Interpreting the main points obtained in the light of the context and objectives of the research, seeking to formulate recommendations for future studies. The data was organized into two topics.

In the first, it aims to provide a clear understanding of legal environmental obligations and the procedures required to comply with environmental laws in the context of fish farming.

The second explored the existence of implemented cases of Payments for Environmental Services and Legal Reserve Compensation, assessing the challenges faced in practice in moving these initiatives forward. This topic includes examples of successful projects, as well as the difficulties encountered in implementing and operationalizing these mechanisms, offering a critical view of their effectiveness and the associated obstacles.

The first topic covers current regulations, including a detailed description of current standards and an analysis of how these regulations can be associated with continental aquaculture activity.

The second topic deals with case studies of possible environmental compensation mechanisms.

RESULTS

The results of the interpretation and synthesis will be presented below, as outlined in the methodology. Table 1 consolidates the information relating to the mapping of the main provisions surveyed. They were then divided into four descriptive topics: Mapping the Legal Provisions, the Potential of the Legal Provisions, the Challenges and Opportunities and a general analysis.

1. mapping of legal provisions: A detailed mapping of the main legal provisions related to environmental compensation and Payments for Environmental Services (PES) Programs in the context of continental fish farming was carried out. This analysis included Federal Law No. 14.119/2021 (National Policy on Payments for Environmental Services), State Law No. 15.133/2010 (State Policy

Key words	Legislation	Description
Payments for Environmental Services (PES) programs	Federal Law No. 14.119/2021	Establishes the National Policy on Payments for Environmental Services, defining mechanisms to encourage preservation.
	State Law No. 15.133, of January 19, 2010.	Establishes the State Policy for Environmental Services and regulates the State Program for Payment for Environmental Services in the State of Santa Catarina
Environmental Compensation	Federal Law No. 9.985/2000 (SNUC)	It establishes environmental compensation as a measure to mitigate environmental impacts, especially in large projects.
	Federal Decree No. 4.340/2002	Regulates articles of Law No. 9.985/2000, which provides for the National System of Nature Conservation Units - SNUC, and makes other provisions.
Law on the protection of native vegetation (LPVN), Forest Code	Federal Law No. 12.651/2012	It regulates the protection of native vegetation, permanent preservation areas (APP) and legal reserves (RL).
Fish Farm Licensing	CONAMA Resolution No. 413/2009	Regulates specific environmental licensing for fish farming enterprises.
	Federal Law No. 12.651/2012	-
Environmental suitability	Law No. 12.651/2012	It requires the environmental regularization of rural properties through the Rural Environmental Registry (CAR) and the restoration of degraded areas.
	Decree No. 7.830/2012	Regulates CAR provisions
	Federal Law No. 9.605/1998	Environmental crime law
	State Law No. 16.342, of January 21, 2014.	Establishes Santa Catarina's state environmental code.

Table 1. Legal provisions analyzed in this study.

on Environmental Services), Federal Law No. 9.985/2000 (SNUC), the Forest Code (Federal Law No. 12.651/2012) and CONAMA Resolution No. 413/2009 (specific environmental licensing for fish farming).

2. Potential of legal provisions: The results indicated that environmental compensation and PES programs can offer financial incentives and market mechanisms for the maintenance and preservation of native vegetation areas on fish farmers' properties. The Forest Code and environmental regularization through the CAR are essential for adapting properties with fish farming, guaranteeing compliance with the legal requirements for protecting APPs and RLs. In addition, specific environmental licensing for fish farming is essential for regularizing the activity and mitigating its environmental impacts.

3. Challenges and Opportunities: The research also identified potential challenges and opportunities in the effective implementation of these compensation mechanisms and PES programs in the context of continental fish farming. The main challenges include adapting fish farms to legal requirements, operationalizing PES programs and overcoming barriers to implementing environmental compensation. On the other hand, the main opportunities include access to financial incentives, the conservation of natural areas, the mitigation of environmental impacts and the integration of public policies aimed at the sustainability of continental fish farming.

4. General analysis: Payment for Environmental Services (PES) programs are economic instruments that aim to encourage environmental conservation through financial compensation to landowners who adopt sustainable practices. Federal Law 14.119/2021 defines the principles, objectives and guidelines for the implementation of PES at a national level. It stipulates that environmental services can include biodiversity conservation, water quality maintenance, soil conservation and climate change mitigation.

Article 3 of the Law establishing the National Policy on Payments for Environmental Services lists the modalities that are considered for ecosystem services, which are: I - direct payment, monetary or non-monetary; II - provision of social improvements to rural and urban communities; III - compensation linked to a certificate for reducing emissions from deforestation and degradation; IV - *green bonds*; V - lending; VI - Environmental Reserve Quota (CRA), established by Law No. 12,651 of May 25, 2012.

With regard to environmental compensation, this is considered to be a mechanism provided for in Brazilian legislation to mitigate the negative environmental impacts of projects. The main regulations dealing with this issue include Law No. 9.985/2000 and Decree No. 4.340/2002.

Law No. 9.985/2000 introduces the need for environmental compensation for projects that cause significant environmental impact, as well as establishing that compensation should preferably be directed towards the creation and maintenance of conservation units. Decree No. 4.340/2002, which regulates Law No. 9.985/2000, details the procedures for applying environmental compensation and defines criteria for calculating the amounts to be earmarked for compensation and provides guidance on how to apply these funds.

Environmental licensing for fish farming activities is governed by specific rules aimed at ensuring the environmental sustainability of the activity. Among the main regulations are the resolutions of the National Environment Council (CONAMA) and state legislation. But in general, CONAMA Resolution No. 413/2009 is considered the landmark for regulating the activity. This resolution sets out the criteria and guidelines for environmental licensing of aquaculture, establishes that undertakings must adopt sustainable management practices and prevent environmental impacts and defines the licensing classes (Preliminary License, Installation License and Operation License) and the respective requirements for each phase, which will be a guide for states and municipalities to define their rules and specificities.

As a result, environmental compliance becomes essential for the activity, since it refers to the measures adopted to ensure that fish farming activities comply with environmental legislation, minimizing negative impacts on the environment. To this end, the producer must respect both the Forest Code (Law No. 12.651/2012) and, if it is located in the Atlantic Forest biome, consider the issues related to Federal Law 11.428/2006, which provides for the use and protection of native vegetation in the Atlantic Forest Biome, and makes other provisions.

Regarding environmental compensation mechanisms, this was established in the form of article 36 of Law No. 9.985, of July 18, 2000, and regulated by articles 31 to 34 of Decree No. 4.340, of August 22, 2002. The aim of environmental compensation by means of environmental adaptation is to comply with the recovery requirements in the APPs and RL areas, in accordance with the forestry code in force, which may become more applicable to the context presented by the work.

Legal Reserve Compensation (CRL) is provided for in Art. 66, which stipulates that the owner or possessor of rural property who, on July 22, 2008, had a Legal Reserve area smaller than that established in Art. 12, may regularize their situation, regardless of adherence to the PRA, by adopting the following alternatives, individually or jointly:

- I - restore the Legal Reserve;
- II - allow the natural regeneration of vegetation in the Legal Reserve area;
- III - compensate for the Legal Reserve.

Paragraph 5 of the Forest Code states that compensation can be; I- acquisition of an environmental reserve quota (CRA), II- leasing of an area under easement or Legal Reserve; III- donation to the public authorities of an area located within a conservation unit with pending land regularization and IV- registration of another area equivalent to and exceeding the Legal Reserve, on a property owned by the same person or acquired from a third party, with established native vegetation, in regeneration or recomposition, as long as it is located in the same biome.

DISCUSSION

The results obtained in this study highlight the importance of legal provisions related to environmental compensation and Payment for Environmental Services (PES) programs in the context of continental fish farming. These regulatory and economic instruments have great potential for integrating public policies aimed at the sustainability of this activity.

Identifying the main legal provisions, such as Federal Law No. 14,119/2021, which establishes the National PES Policy, Federal Law No. 9,985/2000, which establishes legal reserve compensation, and the Forest Code, reveals the legal framework that can be used to promote the conservation of natural resources on rural properties with fish farming. This

understanding of the rules is fundamental for guiding fish farmers through the obligations and opportunities that exist. As Loureiro et al. (2019) argue, “compliance with legal requirements, such as the maintenance of permanent preservation areas and legal reserves, represents a significant challenge for fish farmers, given the location of their activities in environmentally sensitive regions”.

The analysis shows that environmental compensation, especially through the acquisition of Environmental Reserve Quotas (CRAs), can be a viable alternative for fish farmers who do not have sufficient areas of native vegetation on their properties. This possibility of compensation helps to comply with the legal requirements for legal reserves, making it possible to bring the rural property where the fish farm is located into environmental compliance, since there is a combination of maintaining the activity, through the concept of a consolidated rural area, plus compensating for the RL on another property. Ideally, RL compensation on another property should take place within the same river basin, in order to contribute to the conservation of water resources in the basin affected by the end activity. In addition, RL compensation should preferably promote the conservation of intact ecosystems (e.g. existing forests), helping to increase the extent of protected forests in the region.

The National Policy on Payments for Environmental Services could help promote the conservation of ecosystems on properties that have surplus RL and environmental reserve quotas, as well as environmental restoration (Article 66, provision I, Law 12.651/2012) on properties that choose to restore the native vegetation in the RL on the property itself.

PES programs, such as the Santa Catarina State Program, offer financial incentives for the conservation and recovery of ecosystems,

in line with the interests of fish farmers in reconciling production with environmental preservation. Pagiola (2008) points out that “PES programs have become an important tool for promoting the adoption of conservation practices on rural properties, benefiting both landowners and society as a whole”.

However, the effective implementation of these instruments faces some challenges. Adapting rural properties with fish farming to legal requirements, such as regularization by the Rural Environmental Registry (CAR) and recovery of degraded areas, represents an obstacle that demands effort and investment on the part of fish farmers. Wakim and Wakim (2012) argue that “environmental liabilities on rural properties impose the need for actions to control, prevent or recover impacts, which represents a significant burden for producers”.

In addition, the operationalization of PES programs and overcoming bureaucratic and access barriers to these incentive mechanisms are also challenges to be faced. In this sense, Sattler and Mattos (2020) point out that “the complexity and lack of clarity in the procedures for accessing PES programs has been an obstacle to effective adoption by rural landowners”.

Despite these challenges, the integration of environmental compensation and PES programs is a promising approach to reconciling aquaculture production with the conservation of natural resources. This synergy between regulatory and economic instruments can encourage the adoption of sustainable practices in continental fish farming, contributing to the mitigation of environmental impacts and the preservation of aquatic and terrestrial ecosystems. As emphasized by Loureiro et al. (2024), “the adoption of an integrated approach, with the use of legal and economic instruments, is fundamental to achieving the sustainability of continental fish farming”.

In this sense, it is essential to step up efforts to train and guide fish farmers on the existing

legal framework, as well as to facilitate access to and effective implementation of these instruments for compensation and payments for environmental services. In this way, it will be possible to make progress in building a sustainable development model for continental fish farming.

Environmental compensation in rural areas is still in its infancy in Brazil. There are still isolated cases and initiatives, or some government initiatives, but these generate discontinuity in the programs. According to Silva et al. (2024), the potential for using CRA to comply with the provisions of Law No. 12,651/2012 in Brazil is broad, since according to estimates, the country has a Legal Reserve (RL) deficit of 103 million hectares (Mha).

Soares-Filho et al. (2016) argue that state policies should be aligned with preservation objectives, based on the criteria of ecosystem importance and environmental services of the area being protected. For example, parameters and compensation rates can be adopted in the areas, as well as financial incentives applied to CRAs issued in priority areas (Brancalion et al., 2019; Young; Castro, 2021).

In Santa Catarina, one of the initiatives to pay for the protection of forests and associated environmental services is the Ecological Corridors Project, implemented by the Environment Institute (IMA), in partnership with the Santa Catarina Agricultural Research and Rural Extension Company (Epagri) and the State Secretariat for Sustainable Economic Development (SDS), under the SC Rural program. However, it was not possible to identify any recent advances in this area.

However, it was possible to see a lack of continuity in projects and actions aimed at PES. According to Rodrigues et al. (2020), the implementation of these mechanisms faces significant challenges, such as a lack of financial resources and resistance on the part of some landowners to adopting new practices.

In relation to the integration of PES programs and the carbon market, these can be seen as strategic drivers for small rural properties. The 2017 Agricultural Census recorded that of the 5,072,152 agricultural establishments in the country, 77% are run by family farmers, but despite the predominance of this configuration, an analysis by Souza and Almeida (2023) shows that only 15% of Brazilian family farmers have access to rural credit policy.

In addition, according to the study by Cazella et al. (2020), the rate of “non-recourse” to the National Program for Strengthening Family Farming (PRONAF), the main public rural credit policy aimed at family farming, is 64%, which shows that it is a limited and unequal policy. This scenario highlights the strong tendency for the carbon credit market to also become a public action that excludes the majority of family farming units.

According to a study carried out by Guedes and Seehusen (2021) on PES initiatives in the Atlantic Forest Biome, a concentration of PES initiatives was found in the Southeast region, especially in the states of Minas Gerais, Espírito Santo and São Paulo. Of the 40 water PES initiatives mapped, 28 are located in this region, seven in the South and only five in the North, Northeast and Center-West.

The same authors highlight an extremely important point as a driving force behind this policy, which is the relationship between this issue and the National Water Resources Policy Law, Law No. 9.433/97, which established the

legal framework for charging for water use. This is due to its potential to be one of the main sources of funds for PES.

For most of the systems underway, the sources of funds for the payments are mainly from the River Basin Committees (CBHs), through charging for the use of water, from the companies that supply water to the population and, more timidly, from private initiative.

CONCLUSION

Environmental compensation for legal reserves could be an important tool to start applying environmental services to rural properties where fish farms are located, giving those who preserve their green areas access to economic valuation instruments.

The state of Santa Catarina has the potential to strengthen actions that have already been implemented, but it is important to ensure that actions that have already begun are not discontinued.

Continental fish farming can take on a strategic role as a productive sector that produces and conserves, being an example of properties with different ecosystem services to offer.

As a result of the analysis of the scenario presented, the future prospects are that the continuous evolution of PES policies needs to be stimulated through the implementation of state programs and the integration of sectors that can strengthen actions, allowing the programs to be continuous and permanent, so that it becomes a consolidated policy.

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