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Overview of Payments for Environmental Services scientific publications in Brazil

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Abstract: The Payment for Environmental Services (PES) has become a territorial management and nature conservation tool increasingly applied in Brazilian context. Thus, this article aimed to analyze and systematize information about the evolution of PES scientific publications in Brazil. Therefore, a systematic literature review was carried out. The results indicated the predominance of research focused on case studies, with geographic limits following the administrative shape and watershed, and the most studied ecosystem service was related to water. Thematic analysis contributed to a visualization of the objectives which guide current research and possible practical applications of this instrument. Therefore, it is recommended to expand rigorous, systematic, and counterfactual evaluations, as well as studies in the Pantanal, Cerrado, and Caatinga biomes.

Keywords: Nature conservation; Economic Instruments; Payment for Environmental Services; Systematic Review; Ecosystem Services.

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São Paulo. Vol. 27, 2024

Original Article

DOI: http://dx.doi.org/10.1590/1809-4422asoc0101r2vu27L1OA

Introduction

According to the Brazilian Federal Constitution, everyone has the right to an ecologically balanced environment, being the Government and the community incumbent with defending and preserving this common good (BRASIL, 1988). To fulfill this right, a set of standards configuring environmental protection was established, and the related public policies can be applied by using command and control actions along with economic instruments (NUSDEO, 2006).

Even though regulations predominate among the Brazilian government's strategies to control the threats to environmental conservation (PICHARILLO; RANIERI, 2019), policies combining economic and command and control instruments are considered complementary (BÖRNER, MARINHO, WUNDER, 2015; EZZINE-DE-BLAS et al., 2016). The Payment for Environmental Services (PES) emerges as an increasingly popular environmental policy instrument for territorial management in favor of nature conservation (EZZINE-DE-BLAS et al., 2016) and that seeks to "match" the interests of landowners and external actors by means of financial compensations (WUNDER, 2007).

Although the terms environmental services and ecosystem services often appear as synonyms in the international scientific literature, a group of people advocates that these terms must be distinguished (e.g. MURADIAN et al., 2010; PEREIRA et al., 2020). For Muradian et al. (2010), environmental services (ES) are the benefits associated to different types of ecosystems, actively managed by human beings (e.g. sustainable agricultural practices, rural landscapes), whereas ecosystem services (EcS) are the benefits generated by natural ecosystems. They are hence considered distinct terms for corresponding to services that emerge from divergent flows; the flow of ecosystem services occurs from nature to society, whereas the flow of environmental services occurs from society to nature (PEREIRA et al., 2020).

A widely used definition for PES is that of Wunder (2015, p.241): "Voluntary transaction between service users and service providers that are conditional and agreed rules of natural resource management for generating offsite services". Therefore, one of the aims of PES is to pay for the positive externalities, that is, reward the actions of landowners that, by protecting and/or recovering certain ecosystems functions, generate benefits to third parties (SALZMAN et al., 2018).

The Millennium Ecosystem Assessment proposed classifying EcS into four categories: supporting, provisioning, regulating, and cultural (MA, 2005), being most of the recent classifications based on this publication. However, when it comes to PES, the services are usually identified as biodiversity, landscape, water, and carbon (WUNDER, 2007). For Grima et al. (2016), these classifications are interrelated, once biodiversity conservation regards supporting EcS; landscape protection encompasses the cultural EcS; improving the quality and quantity of water regards provisioning EcS; and increasing carbon sequestration or avoiding emissions refers to the regulating EcS. In turn, the "mixed" EcS regard the transactions in which various EcS are considered in the PES arrangement.

Although economic instruments are already provided in the Brazilian National Environmental Policy (BRASIL, 1981), PES can be considered formally instituted by

Federal Law No. 12,651/2012, which addresses the "Program of Support and Incentive to the Preservation and Recovery of the Environment", by which a rural landowner that does not fit into the standards for forming Legal Reserves can purchase ES from another property, thus legally compensating for the non-constituted reserves (GODECKE; HUPFFER; CHAVES, 2014). Only on January 14, 2021, was the Federal Law No. 14,119 enacted, establishing the National Policy for Payment for Environmental Services, creating an expectation for expansion and debate in the country (BRASIL, 2021).

In view of the heterogeneity of the policies related to the PES (KULL; ESTRE; CASTRO-LARRAÑAGA, 2015) and the importance of understanding the state-of-the-art of research, this work aimed to analyze and to systematize information on the evolution of scientific publications on PES in Brazil.

Methodological Procedures

It was conducted a Systematic Literature Review (SLR) of the publications related to PES in Brazil, according to CEE (2018). SLR offers a broader and more precise level of understanding than a traditional review of the literature, aiming to provide comprehensive and reproducible abstracts, with important evidence to guide policy decisions (BILOTTA; MILNER; BOYD, 2014; PATI; LORUSSO, 2018).

The intention of this review was to outline an overview of the scientific papers addressing the economic instrument PES. This overview brings information both on bibliographic and geographic (origin) data of the paper, as well as on the characteristics of the PES case(s) studied, methodologies, and ways in which the research were conducted. For directing the search of these papers, guiding questions were formulated, namely: What was the methodological approach used for the research on PES? What institutions account for developing research on PES in Brazil? Is there a trend in the number of publications per year or in the journal chosen for publication? In which geographic area has PES been studied in these research? What are the services associated to the PES schemes studied? What subjects are the PES schemes studied related to? From these questions, the search terms were defined, as well as the eligibility criteria of the works (PULLIN; STEWART, 2006; CEE, 2018).

After establishing the protocol, the searches were made by topic (i.e., in titles, abstracts and keywords) on October 16, 2020 in the SciVerse Scopus, Web of Science and Scientific Electronic Library Online (SciELO) platforms, with no restriction on type of document, language or date. CEE (2018) recommends considering the need to search in the "grey literature", which encompasses documents not indexed to the usual scientific platforms. This stage was disregarded since the aim of this research was to analyze information on scientific publications in peer reviewed journals.

As in Perevochtchikova et al. (2021), the research sequences were developed and tested until the combinations were exhausted, considering synonyms and alternative spelling. Two terms were also considered: ecosystem services and environmental services, associated or not to the term PES. This decision was taken for capturing all the papers

connected to the theme in the search, without judging the terms used. Thus, the final search terms used were: "Brazil" AND ("payment* for ecosystem service*" OR "payment* for environmental service*"), and its version in Portuguese "*Brasil*" AND ("*pagamento* por serviços ambientais*" OR "*pagamento* por serviços ecossistêmicos*"). The asterisk (*) at the end of the words allows the system to locate derivations, increasing the research return spectrum.

The works were screened by reading the titles and abstracts for selecting those of interest to the research context (PULLIN; STEWART, 2006; CEE, 2018). Duplicated works and those that clearly did not answer the guiding questions were discarded, and the others were included for full reading (including those on which there was a doubt after reading the title and abstract). Documents that did not address PES in Brazil or those in which PES was not directly associated with the aims of the work were excluded.

The documents selected were codified and, from them, data were extracted for quantitative analysis and by theme (Box 1). For the information used in the merely quantitative analysis, the categories were pre-established according to general information of scientific publications and with the classifications of the focus of the PES studied. Note that only the information dealing with the focus of the PES were related to the schemes studied in the works surveyed by the SLR, being that the remaining information extracted and discussed is related to the scientific works identified. In turn, the data for analysis by themes were categorized by the aim and/or central subjects of the documents; the type of information extracted was organized into 7 categories, established *a posteriori*, from the reading of the selected texts and grouping of similar themes.

Box 1 - Form for codifying and extracting the elements analyzed in the documents

	Type of information	Categories for data extraction
Data for Quantitative Analysis	Bibliographic data	Title
		Year
		Means of publication (journal or book)
	Geographic area of the study area of the scientific work	Biome; Watershed (WS); Administrative area (state or municipality); Country
	Research Institution(s)	Author(s)'s affiliation
		Institution(s) location
	Approach of the scientific work	Case Study; Theoretical
	Approach of the scientific work method	Quantitative; Qualitative; Mixed
	Focus of the PES studied [1, 2]	Water; Carbon; Biodiversity; Landscape; Mixed; Non-specified [3]

Data for Analysis by Themes	Aims and/or central subjects addressed in the scientific work	Institutional arrangement
		Effects of PES on physical-biological aspects
		Effects of PES on social-economic aspects
		Motivations
		Prioritization of areas for PES
		Valuation
		PES viability

Note: [1] According to Wunder (2007).

[2] The classification related to the PES focus was made according to what was described by the authors of each paper.

[3] Documents classified as "Non-specified" were those that did not objectively describe which EcS were prioritized in the PES scheme studied or used as examples in the documents analyzed, and those not having as objects case studies or analysis of specific PES schemes.

Source: Elaborated by the authors.

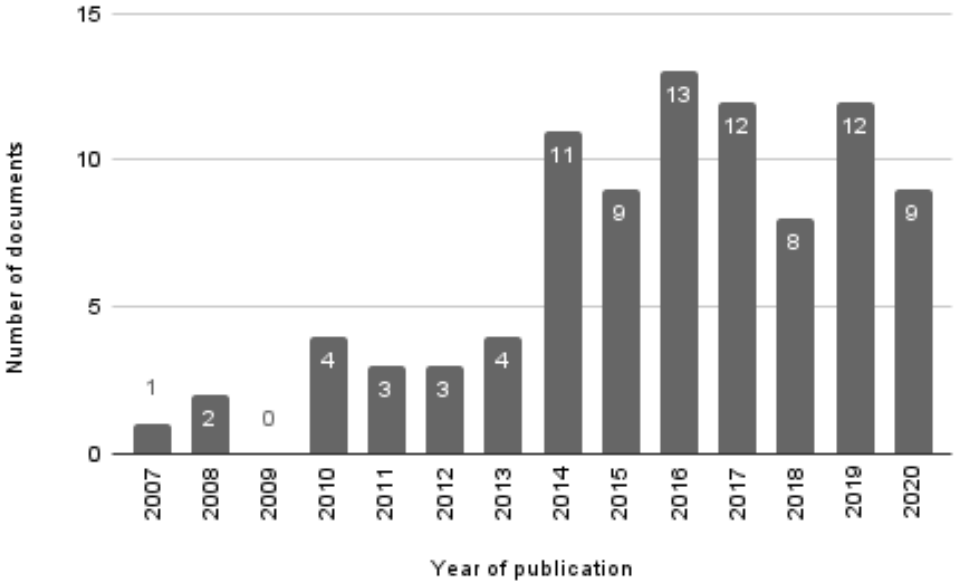
Results and Discussion

The search in the scientific platforms resulted in 147 publications, after excluding the duplicated ones. After the screening, 91 documents were selected for analysis and data extraction. The presentation of results was divided according to the quantitative analysis and by theme.

Quantitative analysis

Figure 1 allows observing that the publications on PES in Brazil started in 2007, soon after the publication of the Millennium Ecosystem Assessment (MA, 2005), when the theme began to gain prominence. Also at that time (as of 2006), the first PES initiatives in Brazil emerged (PAGIOLA; VON GLEHN; TAFFARELLO, 2013). However, until 2013, the number of documents did not exceed 4 a year. As of 2014, a substantial increase was observed in the number of publications regarding the previous years, 2016 (n=13; 14.3%) standing out.

Figure 1 - Number of scientific documents selected by SLR, considering the year of publication



Source: Elaborated by the authors.

These numbers converge with the increase in publications in the international ambit, as of 2012, and reflect the scientific community's interest in the theme (PEREVOCHTCHIKOVA et al., 2021). In Brazil, the earliest scientific studies found in the SLR consist of the assessment of policies and programs implemented at local level as of 2006 (e.g. BÖRNER; MENDOZA; VOSTI, 2007; HALL, 2008; ZOLIN et al., 2011). One of the first initiatives to systematize the results and experiences of the Brazilian PES programs occurred in the "*Workshop sobre Pagamentos por Serviços Ambientais: Experiências no Brasil*" (Workshop on Payments for Environmental Services: Experiences in Brazil), promoted by the State of São Paulo Secretariat for the Environment in 2011 (PAGIOLA; VON GLEHN; TAFFARELLO, 2013). The pressure of the local PES initiatives culminated in the national implementation of the economic instruments (including PES), introduced by Federal Law No. 12,651/2012 (GODECKE; HUPFFER; CHAVES, 2014). This legislative apparatus may also have contributed to the growth in publications.

The documents analyzed were published as 89 papers in 55 scientific journals and 2 chapters in 2 books. The papers were found in journals of different areas of knowledge, the Ecological Economics journal (n=15) standing out, especially as of 2016. The higher concentration of papers published in that journal coincides with the results attained by Grima et al. (2016). The journals Ecosystem Services and *Engenharia Sanitária e Ambiental* ranked second and third, with 7 and 5 papers, respectively. Four papers were found in the *Revista Ambiente & Água* journal, and 3 in Ambiente & Sociedade. Five other journals

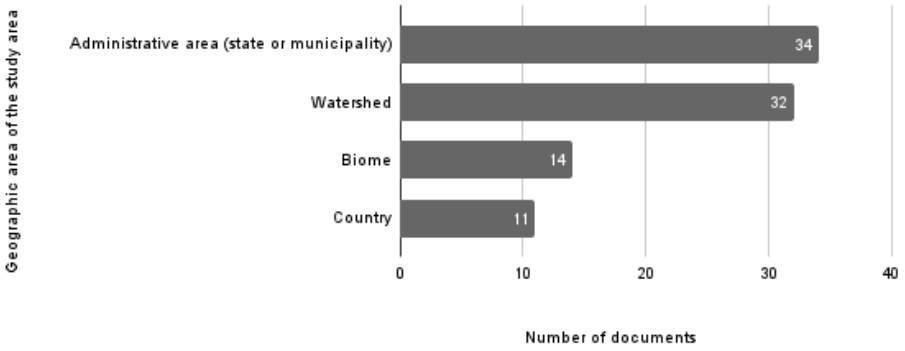
had 2 papers each, and the remaining journals had 1 document only.

One hundred and thirty-eight research institutions, in which the studies were developed, were identified. The University of São Paulo stood out with at least one author in 29 documents. Next, the São Paulo State University appeared (at least one author in 13 documents), followed by the Federal University of São Carlos (at least one author in 8 documents) and the Federal University of Minas Gerais (at least one author in 7 documents). Five other institutions appeared in 5 publications, 2 in 4, 8 in 3, 23 in 2, and 96 in 1 publication.

The Brazilian public universities stood out among the research institutions in which the studies were developed (n=27). This fact highlights the importance of those universities for the research on PES in Brazil, as occurs in other areas of knowledge (WEB OF SCIENCE GROUP, 2019).

Regarding the geographic area of the study area of the scientific documents analyzed, most (n=34; 37.4%) focused on areas delineated by administrative areas (Figure 2).

Figure 2 - Geographic area of the study area used by the scientific works selected in the SLR



Source: Elaborated by the authors.

Of the 34 scientific works that adopted an administrative area, the study areas located in the north of Brazil (n=16) stand out. Next, areas focusing on the southeast (n=13), south (n=4), mid-west, and northeast (n=1 each) appeared. It is worth highlighting that one document could encompass more than one region in the country as the study area.

In second place, works using WS as the study area (n=32; 35.2%) appeared, of which 25 involved areas in the southeast of Brazil. Seventeen works involved the Paraná WS, 14 the Southeast Atlantic WS, 3 works involved the South Atlantic WS, 1 the Paraguay WS, and 1 the Amazon WS. Note that one work could involve more than one WS. Of the works that adopted biomes as the study area, 9 were developed in Amazon, 3 in Atlantic Forest, 1 in *Pantanal*, and 1 in *Cerrado*. Lastly, 11 studies analyzed PES

considering the country as a whole.

The choice of scientific works by the WS area is justified by an established context: seeing that water is considered an increasingly endangered good, the PES schemes directed to WS protection have stood out in Latin America (GRIMA et al., 2016; PEREVOCHTCHIKOVA et al., 2021). The conduction of scientific studies in Brazil has been observed, especially on the southeast region. The increase in the scarcity of water in high-consumption areas triggered the search for alternative ways to increase supply, which has favored managing strategies based on PES (JARDIM; BURSZTYN, 2015; GRIMA et al., 2016). Furthermore, people can easily assess the direct and short-term damages that can be caused by a bad-quality management of the water resources and of the WS they belong to. Legally, the PES appeal in the water management arrangements can be based on charging for the use of water resources, as instituted by the National Policy on Water Resources, or even on the National System of Nature Conservation Units, which refers to the financial compensation for the use of water resources originating in Conservation Units.

PES can also be adopted as a strategy for riparian areas conservation, in compliance with Federal Law No. 12,651/2012 (STABILE et al., 2020). However, studies suggest that only the payment may not be enough for landowners to preserve or to recover those areas (SALOMÃO; LIMA; RAJÃO, 2022), and there are evidence that a number of programs pay for the conservation that would have occurred anyway, instead of stimulating real changes in land use (BÖRNER et al., 2017; MARTINO; KONDYLIS; ZWAGER, 2016).

The approach of the works shows that 83.5% (n=76) of the documents surveyed by the SLR involved specific case studies, generally seeking to evaluate the results and effectivity of a program selected under economic, social and environmental aspects, to validate a methodology under development, to understand the motivations leading landowners to adhere to PES or to assess the viability of implementation of these programs. In turn, the theoretical scientific documents represented 16.5% (n=15) and sought to discuss the political dimensions of the PES programs, the relations and the influences on the local economy and the population, besides addressing the factors that may influence its implementation.

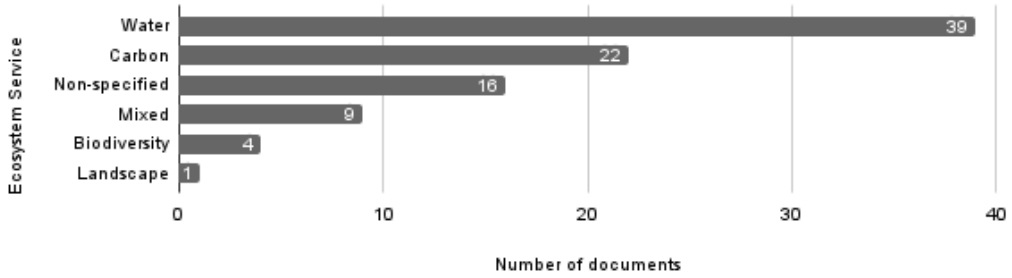
The fact that the largest proportion of the research analyzed involves case studies, in regional or local scales, reaffirms what was discussed and converges with Grima et al. (2016). The authors pointed out that 90% of the documents resulting from a systematic search for research related to PES in Latin America direct the research to local or regional case studies.

Nevertheless, the literature shows weaknesses in the impact assessment of PES programs that are often mere monitoring indicators. The approach may therefore produce ambiguous and biased results (FERRARO, 2009). More appropriated methodological alternatives thus emerge, detaching strict, systematic assessments and with a contrafactual approach. For Ferraro (2009), elucidating causal relationships by contrafactual thinking and experimental or near-experimental designs is essential for an environmental policy.

In the methodological approach of the documents surveyed by the SLR, the

quantitative works present a larger number (n=36; 39.6%), followed by qualitative ones (n=32; 35.2%) and by those combining both approaches (n=23; 25.3%). Most of the scientific works that adopt the theoretical approach (n=11; 73.3%) are observed to have used a qualitative approach of analysis. In turn, quantitative (n=32; 42.1%) and mixed (n=23; 30,3%) approaches predominate in the case studies. According to Arriagada et al. (2009), the qualitative evidence of case studies are useful to extract the social and institutional context in which the PES program operates. With regard to the focus of the PES studied in the documents surveyed by the SLR, Water appears in first place (42.9%), followed by Carbon (24.2%), Non-specified (17.6%), Mixed (9.9%), Biodiversity (4.4%), and Landscape (1.1%) (Figure 3).

Figure 3 – Focus of the PES studied in the scientific works



Source: Elaborated by the authors.

The prevalence of case studies on PES focusing on the water theme converges with Grima et al. (2016) on the Latin American context. The authors highlight that half of the cases studied in Latin America are on water PES programs. This trend was also verified by Wunder et al. (2018) in an assessment of these schemes at a world scale.

Works studying PES schemes focusing on carbon appear in second place, aiming to reduce illegal burnings and deforestation. As illustrated by Wunder et al. (2018), the papers on PES schemes focusing on carbon were mostly related to the Amazon region (n=17; 77.3%). This concern may be linked to the fact that Brazil has been one of the major sources of global loss of vegetation cover, as well as the deforestation and degradation in tropical regions being the primary drivers of anthropic emissions of carbon dioxide (HANESN et al., 2013; BÖRNER; MARINHO; WUNDER, 2015; SIMONET et al., 2018).

By focusing on a single EcS, PES schemes may conceal other services and influence recommendations on policy and management, so as to maximize the EcS studied, bringing possible negative consequences (KULL; ESTRE; CASTRO-LARRAÑAGA, 2015). According to those authors, the ecosystems provide an infinity of EcS, but the need of specific evidence and of valuation usually constrains researchers and policy-makers to one or few EcS.

In this context, only 9 scientific works brought discussions based on PES schemes classified as Mixed, be it from a case study, using PES as a tool to prove the models or

simply as an example of application. Silva et al. (2016), for example, analyzed the future implementation of a PES scheme in a municipality of the sugarcane belt of the state of São Paulo. For this, they included the mapping of the EcS related to the major types of land use in the region as the main source of data, compiling the EcS potentially offered in the area studied. Farley et al. (2010) studied the PES programs designs as an incentive tool and the hindrances to developing a scheme at a global level; their work states that, independently of the approach adopted, the payments must have a set of services as a focus.

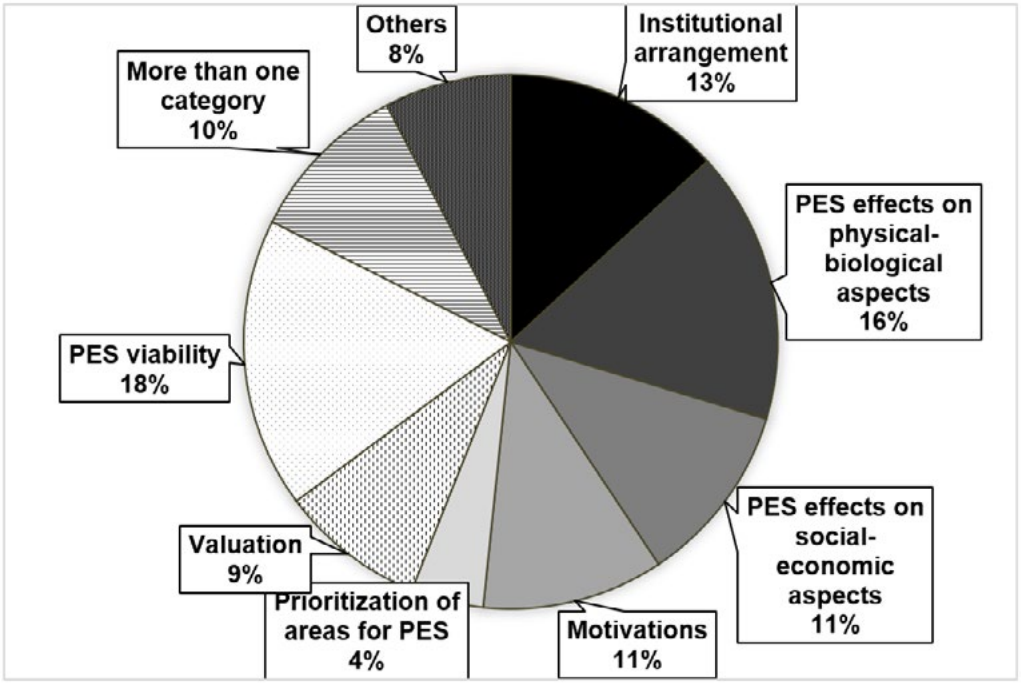
The PES schemes related to EcS understood as public goods, such as those of biodiversity, may face difficulties in identifying and delimiting the users (ENGEL; PAGIOLA; WUNDER, 2008). The non-excludability allows users to have strong incentives to benefit from the EcS without paying for them, a concept known in the literature as free riding and used by the mentioned authors. Of the 4 works found dealing with PES schemes focusing exclusively on this EcS, 3 had the PES scheme related to the conservation of marine species (BEGOSSI, 2011; 2014; LOPES; VILLASANTE, 2018), whereas the other used PES as a tool to estimate the cost of conservation in the biodiversity hotspots of the Atlantic Forest (BANKS-LEITE et al.; 2014). These results converge with Grima et al. (2016), who identified and analyzed only 1 PES scheme on biodiversity in Latin America.

Lastly, the PES schemes related to landscape also face difficulties for involving non-quantifiable concepts and EcS, rooted in human experience (KULL; ESTRE; CASTRO-LARRAÑAGA, 2015). There are considerably fewer works dedicated to studying PES schemes focusing on landscape and there are, therefore, different issues with a deficit of depth related to the participation and to the compensation that could be claimed by forest owners for making voluntary agreements to supply landscape and recreational values (MÄNTYMAA et al., 2018). The Latin American scenario also indicated a low occurrence of schemes focused on this EcS (GRIMA et al., 2016), even there being methodologies available for contingent valuation, capable of assessing the willingness to pay for and to receive from potential participants (MÄNTYMAA et al., 2018; MOORE; HOLMES; BELL, 2011). However, the difficulties of economically valuing cultural and landscape services in monetary language may pose hindrances for furthering research on this EcS within the PES theme.

Analysis by theme

Besides the quantitative analysis, it was also presented the major themes, aims, and methods used by the authors to develop their scientific works, respecting the way in which information was presented in the original documents. Such information is presented as follows according to the categories established, as described in the methodology (Figure 4). Note that one work may have been included in more than one category.

Figure 4 - Synthesis of the results of the analysis by theme



Note: Others - Scientific works not fitting in any of the categories established.
Source: Elaborated by the authors.

The importance of the institutional arrangement of the PES schemes was studied in 16 documents. The major themes approached in these research were related to governance issues, programs scale, partnerships established by government authorities (e.g. RICHARDS et al., 2015), legal aspects related to the instrument (e.g. LEITE; ANGUITA, 2017), the importance of the institutional and social context (e.g. PEREIRA, 2010), and distribution of benefits among the suppliers of the services (e.g. BÖRNER et al. 2010).

Other themes approached were: the characteristics of the political and administrative organizations (e.g. ROSA DA CONCEIÇÃO; BÖRNER; WUNDER, 2015); the use of PES to pollution control (e.g. LIBANIO, 2016); and studies on the institutional arrangements needed and hindrances to implement and to develop efficient PES schemes (e.g. FARLEY et al., 2010; FIORE; BARDINI; CABRAL, 2020). These studies were mainly based on qualitative methodologies, such as document analysis, literature review, and interviews.

From the reading of the works on this theme, the main highlights refer to the difficulty in identifying, indicating, and distributing the financial benefits to the ES providers (e.g. BÖRNER et al. 2010; LEITE; ANGUITA, 2017), and the importance of the local governments to implement the schemes studied (e.g. JARDIM; BURSZTYN, 2015; FIORE; BARDINI; CABRAL, 2020).

The analysis of the effects on the physical-biological aspects was the subject of 19 studies. The major theme addressed was the assessment of the effectiveness of the Brazilian PES schemes. It was identified studies that aimed to assess the PES efficiency in reducing burnings and deforestation as compared to the traditional command and control policies (e.g. BÖRNER; MARINHO; WUNDER, 2015; CAMMELLI; ANGELESN, 2019), as well as for incrementing the vegetation cover (e.g. FIORINI et al., 2020) and the synergy among the different EcS generated (e.g. VIANI et al., 2018).

Standing out is the lack of studies adopting an analysis of contrafactual scenarios, since international scientists have recommended this approach to assess systematically and based on evidence the PES programs effectiveness (BÖRNER et al., 2017). This lack is confirmed in the review of Wunder et al. (2020) on the past performance and the perspectives for the PES schemes, in a global ambit, in which only Ruggiero et al. (2019), Simonet et al. (2018) and Fiorini et al. (2020) appear as Brazilian studies analyzing scenarios with control groups formed from a contrafactual approach.

Research related to the importance of the Amazon to mitigate global warming, in which the PES programs and for Reducing Emissions from Deforestation and Forest Degradation (REDD+) are studied as ways to compensate for the carbon emissions and to preserve forests. They were also highlighted in the literature analyzed on this theme (e.g. FEARNSIDE, 2012). Other studies with varied themes were found, namely: assessment of the losses of soil and analysis of scenarios of land use and land cover to maximize the provision of EcS, mainly the water ones (e.g. PAVANI et al., 2020); and phytosociological assessment of areas where PES schemes are implemented (e.g. MELO et al., 2016).

The main methodologies used in the studies surveyed by the SLR on the physical-biological aspects involved mathematical modeling (e.g. BÖRNER; MARINHO; WUNDER, 2015) and scenarios, based on the landscape ecology and using Geographic Information Systems (e.g. VIANI et al., 2018). Also performed were quantitative analysis of physical, chemical, microbiological and/or biodiversity variables (e.g. MELO et al., 2016; KLAMT et al., 2019; PAVANI et al., 2020). Some studies in this category employed document analysis (e.g. PAGIOLA; PLATAIS; SOSSAI, 2018), interviews (e.g. FIORINI et al., 2020), and application of the game theory with rural landowners (e.g. CAMMELLI; ANGELESN, 2019).

Seventeen studies had their aims directed to PES effects on social-economic aspects. Among the themes addressed in those works, the following can be pointed out: planning and future opportunities for implementing PES programs (e.g. BÖRNER; MENDOZA; VOSTI, 2007; TREVISAN et al., 2016), assessment of the effectiveness of PES already implemented (e.g. YOUNG; BAKKER, 2014; SANTOS et al., 2020), and improvement in environmental health by employing PES (e.g. FAVARO; ROSSIN, 2014). For developing those studies, the authors used various methodologies, from the creation of predictive models or of simulation (e.g. BÖRNER; MENDOZA; VOSTI, 2007; YOUNG; BAKKER, 2014) and the use of efficiency indicators (e.g. SANTOS et al., 2020), up to the application of interviews (e.g. TREVISAN et al., 2016) and literature review (e.g. FAVARO; ROSSIN, 2014).

The scientific works on this theme analyzed evidenced that a large portion of the Brazilian PES is related to the most socially vulnerable populations, especially in the case studies located the Amazon biome (e.g. PEREIRA, 2010; ALVES-PINTO et al., 2018). This context stresses the importance of continuing the research on this theme.

Twelve scientific works with objectives directed to motivations to participate in the PES schemes were identified. The main themes of those research were related to: understanding the factors influencing rural landowners to participate in PES schemes (e.g. MOTTA; ORTIZ, 2018; ALMEIDA; SILVA; SANTOS, 2019); difference in willingness to participate in conservation programs as compared to restauration ones (e.g. ALARCON et al., 2017); construction of the contract contents for them to be advantageous and interesting to the potential participants in the scheme (e.g. RICHARDS et al., 2017); and the necessary volume of financial resources for the actors involved to adhere (e.g. RICHARDS et al., 2020). The main methods used by the authors were interviews (e.g. TREVISAN et al., 2016), questionnaires (RICHARDS et al., 2020), document analysis (e.g. SILVA et al., 2016), literature review (e.g. RICHARDS et al., 2017), and contingent valuation (e.g. MOTTA; ORTIZ, 2018).

Four works had their aims connected to studying ways to prioritize areas for implementing PES schemes. Of these, 2 analyzed the interactions necessary for implementing a PES program. Rosa et al. (2014) verified the interactions among the landscape structure, relief and hydrography of a micro basin, by the classification and cross-tabulation of information on declivity, land use and land cover. This resulted in a thematic map of priority areas. Eloy et al. (2012) analyzed the integration of agricultural activities and areas directed to PES schemes, by document analysis and interviews. The two other works aimed to develop methodologies to determine priority areas for implementing PES schemes by elaborating indicators and indexes, based on information on land use and land cover (FERNANDES; BOTELHO, 2016; MONTEIRO et al., 2018).

In eight studies identified in the SLR, the aims regarded the economic valuation category of the PES schemes and/or of the services involved. Among the themes addressed in those works, the economic analysis (e.g. MACEDO et al., 2014; OLIVEIRA JUNIOR; REIS, 2020) stand out; they are useful for providing robustness to the ongoing programs, to support the planning of new proposals and monitoring the results of ongoing schemes. There were studies on this theme to estimate the necessary financial resources for PES schemes (e.g. MACHADO et al., 2016), the environmental impacts related to soil erosion and to the silting of water courses (e.g. MACEDO et al., 2014), the value of the ES rendered to preserve water sources and the value of EcS themselves (e.g. GIANNETTI et al., 2011).

The methods used in these valuation studies were assessment of opportunity cost (e.g. GREENLEAF, 2020), contingent valuation (e.g. OLIVEIRA JUNIOR; REIS, 2020), use of software for spatial analysis (e.g. RIBEIRO et al., 2015), "emergy synthesis" (e.g. GIANNETTI et al., 2011), interviews, historical and conceptual analysis (e.g. GREENLEAF, 2020).

Lastly, the objectives of 18 studies identified in the SLR were directed to PES vi-

ability. Among the themes approached, can be detached: assessment of the environmental and socioeconomic characteristics of the area intended for the PES scheme and the consideration of these characteristics when implementing the schemes, aiming to contribute to the sustainability of the policy regarding the conservation of the resources available (e.g. CORRÊA; TONELLO; FRANCO, 2016; ALMEIDA; SILVA; SANTOS, 2019); the role of local governance, by an agreement that seeks to redirect the land use activities and forest management in areas where PES schemes are going to be implemented (e.g. CENAMO; CARRERO, 2012); assessment of the implementation of REDD+ interventions, also seeking to improve the design of these initiatives (e.g. WEST et al., 2018); and historical review of the economic/cultural activities in the area devised for the PES scheme, for thus assessing its implementation and reach of the conservation objectives (e.g. BEGOSSI, 2014). Those types of works have been used to also show the areas in which the scheme is not viable (e.g. LIMA et al., 2013), as well as the importance of combining the payment with other environmental policy instruments, so that social and environmental targets are met (BEGOSSI et al., 2011; BÖRNER; MARINHO; WUNDER, 2015).

The main methodologies applied by the authors addressing the PES viability theme varied from historical reviews, SLR (e.g. BEGOSSI, 2014), content analysis (e.g. SOUZA et al., 2016), interviews, workshops, and political meetings (e.g. CENAMO; CARRERO, 2012), up to the application of mathematical models (e.g. WEST et al., 2018).

Final Considerations

Scientific research on PES considerably increased in the last decade and Brazil kept up with this evolution, with more publications as of 2014. The largest proportion of research analyzed involved case studies in regional or local scales. The high incidence of studies on administrative areas may be linked to the fact that, when the search was conducted, the Brazilian federal legislation still did not effectively had specific directives approved for institutionalizing the instrument, leaving PES implementation on the hands of municipalities and states.

The results also showed that the research are concentrated in the Southeast region, both regarding the institutions in which they were developed and the geographic area studied. In this aspect, the public universities stood out, stressing the importance of these institutions.

The analysis per theme contributed to understanding the complexity of the PES instrument from the research carried out. Focus was observed on the themes: institutional arrangement; PES effects on the physical-biological aspects; PES effects on the social-economic aspects; motivations to participate in the PES schemes; prioritization of areas for PES; economic valuation of the PES schemes and/or of the services involved; and PES viability. These themes demonstrate the concerns directing the current research and possible practical applications of the instrument.

It is necessary to acknowledge that there is much to be improved regarding research

on PES in the Brazilian context, requiring rigorous and systematic assessments, and with a contrafactual approach. Moreover, following the international trend, no studies were found that specifically addressed cultural services. Therefore, incentives should be promoted for developing studies that fill these gaps, mainly regarding the states not belonging to the Brazilian southeast region. The volume of studies on the *Pantanal*, *Cerrado,* and *Caatinga* biomes can be expanded due to the ecological relevance and the relative area they occupy in Brazil. The results of the present work are thus expected to contribute to the development of new research on PES in Brazil and that future studies are conducted assessing the possible changes in the trend of publications and in the use of PES after the enactment of Federal Law No. 14,119/ 2021.

Acknowledgements

The authors thank the National Council for Scientific and Technological Development (CNPq) and the Coordination for the Improvement of Higher Education Personnel (CAPES) for financial support.

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Submitted on: 21/09/2021
Accepted on: 14/10/2023

2024;27:e01012

AMBIENTE & SOCIEDADE 25 anos 25 años 25 years

SciELO

Panorama das publicações científicas sobre Pagamentos por Serviços Ambientais no Brasil

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Maria Rita Raimundo e Almeida
Victor Eduardo Lima Ranieri

Resumo: O Pagamento por Serviços Ambientais (PSA) tem se tornado uma ferramenta para gestão territorial e conservação da natureza cada vez mais aplicada no contexto brasileiro. Diante disso, esse artigo teve por objetivo analisar e sistematizar informações acerca da evolução das publicações científicas sobre PSA no Brasil. Para tanto, foi realizada uma revisão bibliográfica sistemática. Os resultados indicaram a predominância de pesquisas voltadas a estudos de caso, com limites geográficos que seguem os recortes administrativos e bacias hidrográficas, e o serviço ecossistêmico mais estudado foi aquele relacionado à água. Já a análise por temática contribuiu para uma visualização dos objetivos que norteiam as pesquisas atuais e possíveis aplicações práticas deste instrumento. Portanto, recomenda-se ampliar as avaliações rigorosas, sistemáticas e com abordagem contrafactual, bem como estudos nos biomas Pantanal, Cerrado e Caatinga.

Palavras-chave: Conservação da Natureza; Instrumentos Econômicos; Pagamento por Serviços Ambientais; Revisão Bibliográfica Sistemática; Serviços Ecossistêmicos.

São Paulo. Vol. 27, 2024

Artigo Original

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São Paulo. Vol. 27, 2024
Artículo Original

Resumen: El Pago por Servicios Ambientales (PSA) se ha convertido en una herramienta de gestión territorial y conservación de la naturaleza que se aplica cada vez más en contexto brasileño. De este modo, este artículo tuvo como objetivo analizar y sistematizar informaciones sobre la evolución de las publicaciones científicas sobre PSA en Brasil. Para eso, se realizó una revisión sistemática. Los resultados indicaron el predominio de investigaciones centradas en estudios de casos, con límites geográficos que siguen los cortes administrativos y cuencas hidrográficas, y el servicio ecosistémico más estudiado fue el relacionado con el agua. El análisis temático contribuyó para una visualización de los objetivos que orientan las investigaciones actuales y las posibles aplicaciones prácticas de este instrumento. Por lo tanto, se recomienda ampliar las evaluaciones rigurosas, sistemáticas y con enfoque contrafactual, así como estudios en los biomas Pantanal, Cerrado y Caatinga.

Palabras-clave: Conservación de la naturaleza; Instrumentos económicos; Pago por Servicios Ambientales; Revisión sistemática; Servicios ecosistémicos.