

Article

Program Outcomes of Payments for Watershed Services in Brazilian Atlantic Forest: How to Evaluate to Improve Decision-Making and the Socio-Environmental Benefits

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Abstract: In 2014, the Paraíba do Sul River Basin Integration Committee (CEIVAP) established its Pilot Program of Payments for Ecosystem Services (PES), focusing on water resources. The projects from this program share the same goal: to disseminate the use of PES as a tool for land management in watersheds. Contemplating 11 municipalities, including 84 landowners, conserving 718.63 ha and restoring 188.58 ha, this program was concluded in April 2020. Reviewing its historical and contextualizing features, we have observed that the outcomes from this program extend beyond these numbers. Here, we propose an evaluation methodology comparing the efficiency, performance, and impact of the PES projects. Based on new indicators that are easy to measure, we have identified key elements that have asymmetrically affected the projects. The complexity of the project scope and the execution of high-cost, and risky interventions on rural properties, have resulted in expensive projects with little tangible outputs. Our results support the upgrade of public policy for investment in ecosystem services by CEIVAP in the Paraíba do Sul watershed. In addition, our results can be more successful by improving the decision-making processes for similar projects in other watersheds.

Keywords: water management indicators; water governance; river basin planning; nature-based solutions

1. Introduction

The concept of ecosystem services (ES) highlights the interdependence between ecosystem function and human well-being [1,2]. Since the publication of the Millennium Ecosystem Assessment [3], ES have been conceptualized as the benefits that people obtain from ecosystems, organized into four groups: supporting, provisioning, regulating, and cultural. From international initiatives on ES, such as

The Economics of Ecosystems and Biodiversity (TEEB), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), and Ecosystem Service Partnership (ESP), the concept has become the key to discussions on global environmental change and decision-making for natural resource management [4].

The valuation of ecosystem services is a strategy for natural resource conservation and the policies of Payments for Ecosystem Services (PES), defined as “a transfer of resources between social actors, which aims to create incentives to align individual and/or collective land use decisions with the social interest in the management of natural resources” [5]. PES has become an engaging policy and economic tool for many landowners, environmental managers, and public managers, as it provides an incentive-based approach to internalize the positive externalities of land use decisions [6–10]. They are also considered more efficient and more easily applicable than command and control policies [11,12].

The PES programs have become widespread in Latin America [13], addressing four main ecosystem services: biodiversity conservation, watershed services, carbon sequestration, and scenic beauty [14]. In Brazil, the evolution of PES programs is increasing [15]. In a report released by Forest Trends, 200 PES projects were accounted, most of them in the Atlantic Forest biome [16]. Most of these programs are related to water resources conservation through Payments for Watershed Services (PWS) [17]. The PWS programs are often designed to mobilize resources contributed by downstream actors to compensate upstream actors for managing landscapes [18]. In the Brazilian Atlantic Forest, all PWS programs pay rural landowners, usually by legal agreements [19].

The Brazilian National Water Resources Policy (Law. No. 9.433/1997), inserted the concept of water resources user-payer and the Watershed Committees (CBH in the Portuguese acronym) as the entities of water governance in the watersheds [20]. The adoption of PWS programs by these committees is part of a strategy that recognizes the role of the ES water conservationist, encouraging the increase of the offer of these services by the “conservator-recipients”. This is a key mechanism for integrating water resources management into land management (Figure 1), by reasoning that if upstream users receive no incentive from downstream users, the former may have no motive for considering the interests of the latter in their land-use decision making [21]. This mechanism helps to facilitate the necessary cooperation and negotiation that enable PWS programs, helping landholders realize and benefit from those values [22].



Figure 1. River Basin Committee (CBH) operation when formulating policies to recognize the role of the “conservator/provider” of ecosystem services for the water resources management in the watershed.

The Committee for the Integration of the Paraíba do Sul River Basin (CEIVAP, in the Portuguese acronym) acts as the water resources management in one of the most important watersheds in Brazil, since it supplies the metropolitan regions of São Paulo and Rio de Janeiro. In 2014, CEIVAP created the Pilot Program of PWS, with the goal of promoting the use of PWS in the land management of municipal watersheds. From this program, the CEIVAP financed conservation actions of forest remnants of the Atlantic Forest and forest restoration of degraded areas on rural properties located in the priority microbasins for water management.

Assessment of PWS programs or projects should not be restricted to the quality-quantitative handover of the contracted ecosystem service, but should address the entire arrangement, through stakeholder engagement, the effectiveness of contractual instruments, social externalities generated by the implementation of the PWS, and the effectiveness of this mechanism itself for forest conservation/recovery. The evaluation of PWS programs does not aim only to produce numbers, but to improve of public policies and guide decision-makers [23]. In the universe of 42 PES programs and projects underway in Brazil, 71% use indicators related to forest cover, and that less than 30% use multiple indicators that contemplate both the delivery of services and socio-environmental aspects [24].

Indicators must be based on four criteria: relevance (importance of the indicator for evaluation), feasibility (obtaining the measure of the indicators), clarity (ability to communicate the indicator), and sensitivity (ability to detect change) [25]. In addition, indicators should comprise four aspects: program costs, additionality, leakage, and spillovers, and actual provision of environmental services [26]. Although this is extremely necessary, the Pilot Program of PWS by CEIVAP, completed in April 2020, lacked a comprehensive assessment methodology and no support for continuous improvement of this public policy.

In this paper, we aim to overcome this gap, to contribute to a critical analysis of the outcomes achieved, and to support the upgrading of investments in nature-based solutions for water supply. This strengthens the connection between science and practice by highlighting the evidence from both areas [27]. Therefore, we regard that the assessment of a program requires the joint use of indicators of the costs of using resources to implement it (efficiency), the achievement of the proposed objectives (performance), and the extent of impact or social changes promoted by it (impact) [28]. From a case study of the Pilot Program of PWS by CEIVAP, we proposed a set of new indicators to evaluate PWS projects, regarding the dimensions of efficiency, performance, and impact. Furthermore, we suggested a strategic planning methodology to be used by decision makers in the process of continuous improvement of the policy of investment of public resources in ecosystem services in the Brazilian Atlantic Forest.

2. Material and Methods

2.1. Case Study and Context

The Paraíba do Sul river basin (BHRPS) has a drainage area of 62,185 km², with territories belonging to the states of São Paulo, Rio de Janeiro, and Minas Gerais (Figure 2) [29]. BHRPS is in one of the most developed regions of the country, with more than 6000 industries, responsible for approximately 11% of the national GDP [30] and has more than 8.5 million inhabitants [31]. The BHRPS region preserves less than 20.0% of the original coverage of its Atlantic Forest biome, recognized as a global biodiversity hotspot [32,33].

At BHRPS, two important aspects for the water resources management stand out: the two water transposition systems for the public supply of the two biggest Brazilian metropolises. Through the Guandu System, two thirds of the volume flow of the Paraíba do Sul river is deviated to the Guandu river basin, which supplies 80% of the metropolitan region of Rio de Janeiro [34]. Recently, through the transposition of the Jaguari reservoir to the Atibainha reservoir, the BHRPS waters supply the metropolitan region of São Paulo [35]. Besides supplying the municipalities, industries, and agriculture, which causes a lot of pressure on water resources, the waters of the basin also serve the hydraulic

power use in at least 120 small, medium, or large hydroelectric stations [30]. This indicates the need to strengthen the instruments for the conservation of ecosystems and to provide ecosystem services.

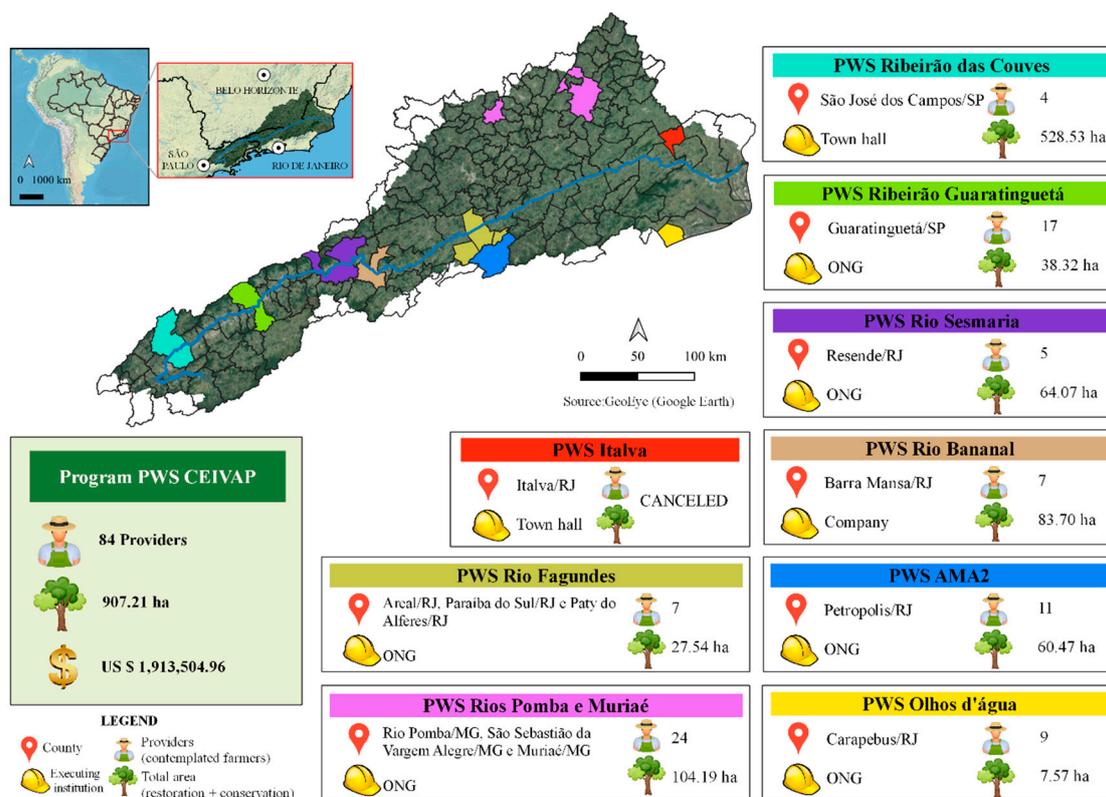


Figure 2. Basin of Paraíba do Sul river’s region and the distribution of Payments for Watershed Services (PWS) projects of the Paraíba do Sul River Basin Integration Committee (CEIVAP) Pilot Program in the Paraíba do Sul river basin.

2.2. Pilot Program of PWS by CEIVAP

The Pilot Program of PWS by CEIVAP was established in 2014, when nine municipal projects were selected to finance its implementation (Figure 2). All projects aimed at implementing PWS demonstration units, while financing forest conservation and restoration actions on rural properties, with payments profits of up to \$30.00 ha⁻¹.year⁻¹ to the landowners. The projects are financed with the resources raised from the users-payers by the charging mechanism for the use of water resources in the BHRPS, and alternatively co-financed by the municipality concerned. The execution of the projects is the responsibility of the municipal government or a contracted executing institution (NGO or private company). All projects followed the same scope defined by the Association for Pro-Management of Waters of the Paraíba do Sul river basin (AGEVAP) [36] and the same institutional arrangement represented in Figure 3. The effective Management Board (UGP) had a main role for projects development, since in this institutional arrangement all stakeholders have been participated in several steps for projects implementation and follow-up. It was a space for the alignment of stakeholders’ efforts in avoiding degradation agents to excel in maintenance efforts in areas with low forest restoration performance (Figure 3).

Implemented in 2015 and planned to be concluded in April 2020, only the PWS project of Italva/RJ was suspended. Of all the projects that continued, only for the municipality of Muriaé/MG were no actions were carried out on rural properties. Table 1 presents the goals obtained in the PWS projects of CEIVAP.

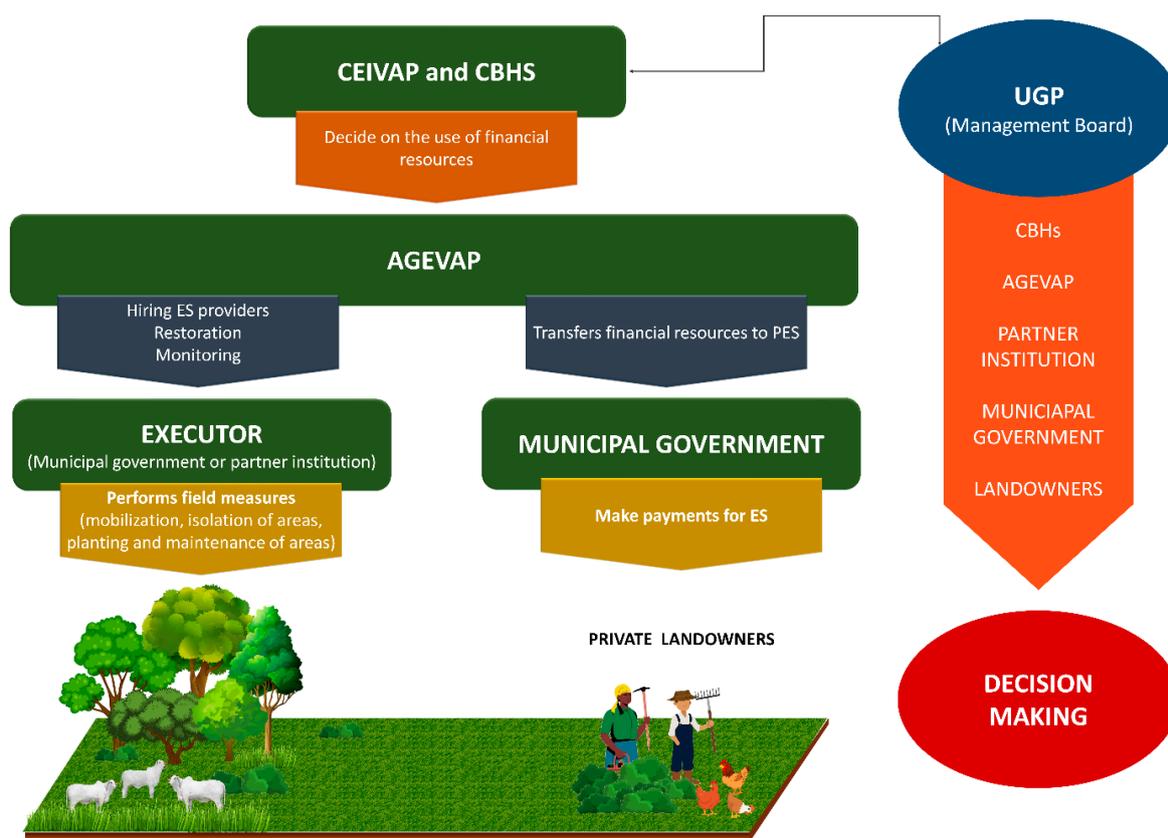


Figure 3. Institutional arrangement of Pilot Program of PWS of CEIVAP.

Table 1. Project description of the Pilot Program of PWS by CEIVAP for the Paraíba do Sul river basin.

PWS Name	PWS Code	Implementing Institution	Municipality	Providers		Rest. (ha)	Conserv.(ha)
				Hired	Assisted **		
AMA2	PWS1	NGO *	Petrópolis/RJ	11	11	30.47	30.00
Olhos D'água	PWS2	NGO	Carapebus/RJ	27	9	3.51	4.06
Ribeirão das Couves	PWS3	Municipal government	São José dos Campos/SP	4	4	33.22	495.31
Ribeirão Guaratinguetá	PWS4	NGO	Guaratinguetá/SP	17	17	38.32	0.00
Rio Bananal	PWS5	Private company	Barra Mansa/RJ	7	7	18.15	65.55
Rio Fagundes	PWS6	NGO	Areal/RJ, Paraíba do Sul/RJ, and Paty do Alferes/RJ	1 2 6	1 2 4	5.63 7.77 1.34	8.37 2.28 2.15
Rio Sesmaria	PWS7	NGO	Resende/RJ	5	5	22.68	41.39
Rios Pomba e Muriaé	PWS8	NGO	Rio Pomba/MG, São Sebastião Vargem Alegre/MG, and Muriaé/MG	12 12 12	12 12 0	20.69 6.80 0	40.04 29.48 0
TOTAL			12	116	84	188.58	718.63

* Non-Governmental Organisation (NGO) ** Landowners assisted who received projects interventions on the rural property.

2.3. Data Collection

This study was conducted by exploratory research [37]. Part of the data collection was performed during our previous research about this Pilot Program of PWS [38]. Three main techniques were used: participant observation [39,40], field observation [41], and documentary analysis [42]. Participant observation is an appropriate technique for qualitative research, especially when it requires field research. The method is distinct because the researcher addresses participants in their own environment, rather than making them come to the researcher [43]. The participant observer participates in daily situations common to people belonging to the research environment while collecting information about

what is observed [44]. For this study, the participating observation technique proved to be adequate, since the first author is a member of the PWS project management team, enabling the analysis process in the field of observation and participation in the activities [43].

Documental analysis technique refers to the analysis of documents that contain information about the “phenomenon” we want to study [42]. We reviewed more than 400 documents produced and published from 21 July 2000 to 31 December 2019; presented as reports and technical notes, minutes of meetings, measurement bulletins of works in PWS projects, schedules, and budgets. All documents are public data, available for open access at the Association for Pro-Management of Waters of the Paraíba do Sul river basin (AGEVAP) (www.agevap.org.br), CEIVAP (<https://www.ceivap.org.br/>) and the portal of the Geographic and Geoenvironmental Information System of the Paraíba do Sul river basin (SIGA/CEIVAP) (www.sigaceivap.org.br) (more details in Supplementary Materials).

Additionally, the first author participated in the first and second workshop of the Pilot Program of PWS by CEIVAP, held at the AGEVAP headquarters, on the 8th of March and the 23th of May, 2018, respectively. In these workshops, stakeholders met to discuss the challenges, goals, results expected, and past accomplishments in PWS projects. Here, we conducted informal discussions focused on opinions on PWS project management, such as individual experiences and views on the scope and rules of the current PWS project. The field observation was through technical visits to rural properties, all by using a field notebook and photographic records.

2.4. Data Analysis

We used a set of indicators to assess PWS projects under three dimensions of management process evaluation: efficiency, performance, and impact [23]. Five indicators were proposed per dimension (Tables 2–4). For comparative analysis, the indicators were standardized by score ranging from 0 to 1. From the standardized values of the indicators, partial scores were determined for the dimensions Efficiency ($S_{\text{Efficiency}}$, Equation (1)), Performance ($S_{\text{Performance}}$, Equation (2)), and Impact (S_{Impact} , Equation (3)). The final score (S_{Final}) was obtained by Equation (4), which assumes that the Pilot Program of PWS aimed: (i) to install PWS demonstration units, and (ii) to disseminate the PWS strategy as a municipal environmental management tool. Therefore, equation (4) associates a higher degree to the impact scores (multiplication factor equal to 3), than to the performance scores (multiplication factor equal to 2) and to the efficiency scores (multiplication factor equal to 1). Finally, a principal component analysis (PCA) was performed to correlate the scores of each indicator in the three dimensions analyzed using the CANOCO statistical package [45].

$$S_{\text{Efficiency}} = (E_{\text{Mob}} + E_{\text{Plan}} + E_{\text{Iso}} + E_{\text{Planting}} + E_{\text{Maint}}) \quad (1)$$

$$S_{\text{Performance}} = (P_{\text{Goal}} + P_{\text{Rem}} + P_{\text{Prev}} + P_{\text{Surv}} + P_{\text{Rest}}) \quad (2)$$

$$S_{\text{Impact}} = (I_{\text{Paym}} + I_{\text{Eng}} + I_{\text{Leg}} + I_{\text{Pub}} + I_{\text{Par}}) \quad (3)$$

$$S_{\text{Final}} = (S_{\text{Efficiency}}) + 2(S_{\text{Performance}}) + 3(S_{\text{Impact}}) \quad (4)$$

where E_{Mob} = social mobilization; E_{Plan} = planning; E_{Iso} = land area isolation; E_{planting} = seedling planting; E_{Maint} = project maintenance; P_{Goal} = goals reached; P_{Rem} = remaining providers; P_{Prev} = prevent land degradation; P_{Surv} = seedling survival; P_{Rest} = forest restoration; I_{paym} = payments of PWS installments; I_{Eng} = joint engagement; I_{Leg} = legal framework; I_{Pub} = knowledge generation and dissemination; and I_{Par} = network partnerships.

Table 2. Characterization and description of the indicators for “efficiency dimension”.

Indicator	Formula	Description	Measure Unit	Standardisation
Social mobilization	$E_{\text{Mob}} = \frac{V_{\text{Mob}}}{P_{\text{h}}}$	V_{Mob} = Investment in social mobilization: Total cost for planning, publication of the public notice, registration, selection and hiring of providers (landowner) P_{h} : = Hired providers: Total landowners effectively hired	* R\$/Hired providers	(Lowest E_{Mob} between projects)/(E_{Mob} of project itself)
Planning	$E_{\text{Plan}} = \frac{V_{\text{Plan}}}{P_{\text{incl.}}}$	V_{Plan} = Investment in planning: Total cost of preparing the project work-plan P_{incl} = Rural properties included: Total number of rural properties with projects adequately elaborated	R\$/Rural properties included	(Lowest E_{Plan} between projects)/(E_{Plan} of project itself)
Land area isolation	$E_{\text{Iso}} = \frac{V_{\text{Iso}}}{Q_{\text{Iso}}}$	V_{Iso} = Investment in the land area isolation: Total cost of installing fences to isolate the areas under protection. Q_{Iso} = Quantity of installed fences: Total number of installed fences.	R\$/Quantify of fences	(Lowest E_{Iso} between projects)/(E_{Iso} of project itself)
Seedling planting	$E_{\text{Planting}} = \frac{V_{\text{Planting}}}{Q_{\text{Seedling}}}$	V_{Planting} = Investment in the seedling planting: All costs related to the planting in the areas destined for forest restoration. Q_{Seedling} = Quantity of planted seedlings: Total number of seedlings planted	R\$/Quantity of planted seedlings	(Lowest E_{Planting} between projects)/(E_{Planting} of project itself)
Project maintenance	$E_{\text{Maint}} = \frac{V_{\text{Maint}}}{Q_{\text{rest}}}$	V_{Maint} = Investment in the maintenance area to forest restoration process: All costs related to maintenance Q_{Rest} = Quantity of area in forest restoration: Total area of forest restoration in the projects.	R\$/ha of maintenance area	(Lowest E_{Maint} between projects)/(E_{Maint} of project itself)

* R\$ is Brazilian currency. However, for discussion, the figures were converted to US\$.

Table 3. Characterization and description of the indicators for “performance dimension”.

Indicator	Formula	Description	Measure Unit	Standardisation
Goals reached	$P_{\text{Goal}} = \left(\frac{\text{Hired prov.}}{\text{Assisted prov.}} \right) + \left(\frac{\text{Planned fences}}{\text{Installed fences}} \right) + \left(\frac{\text{Planned planting area}}{\text{Carried out planting area}} \right) + \left(\frac{\text{Planned conservation area}}{\text{Designated conservation area}} \right)$	<p>Hired prov. = Number of project hired providers Assisted prov. = Number of project assisted providers “Planned fences” and “Installed fences” = Quantity of fences (meters) “Planned planting area” and “Carried out planting area” = Area used for planting (hectares) “Planned conservation area” and “Designated conservation area” = Area of conservation (hectares)</p>	%	(Percentage of area reached in project)/(Highest percentage reached between projects)
Remaining providers	$P_{\text{Rem}} = \frac{\text{Hired prov.}}{(\text{Hired prov.} - \text{Quitting prov.})}$	<p>Hired prov. = Number of project hired providers Quitting prov. = Number of providers who dropped out of the project</p>	%	(Percentage of area reached in project)/(Highest percentage reached between projects)
Preventing land degradation	$P_{\text{Prev}} = 1 - \left(\frac{\text{Events at the properties}}{\text{Total of events}} \right)$	<p>Events = Records of invasion in the area by cattle, fire outbreaks and soil erosion</p>	adimensional	(Number of events in project)/(Higher quantity of events recorded between projects)
Seedling survival	$P_{\text{Surv}} = \frac{\sum \text{seedlings}}{\text{Project area}}$	<p>\sum seedlings = Total number of live seedlings Project area = Size of the planting area (ha)</p>	%	(Percentage reached in project)/(Highest percentage reached between projects)
Forest restoration	$P_{\text{Rest}} = \frac{\text{Score from "Restauradora"}}{\text{Project area}}$	<p>Average scores from “Restauradora (To access this digital tool: https://www.restauracaoflorestalrj.org/copia-restauradora-1), a digital tool to assessment of forest restoration grade by State Institute of the Environment (INEA, 2019).</p>	adimensional	(Value reached in project)/(Highest value reached between projects)

Table 4. Characterization and description of the indicators for “impact dimension”.

Indicator	Formula	Description	Measure Unit	Standardisation
Payment of PWS installments	$I_{\text{Paym}} = \frac{\text{Total annual installments paid}}{\text{Number of project municipalities}}$	Assessment of the quantity of PSW annual payment installments paid to the implementing institutions of projects.	Unit	(Value reached in project)/(Highest value reached between projects)
Joint engagement	$I_{\text{Eng}} = \text{Number of meetings}$	Record of meetings attended by the implementing institution, the financial technical agent and the providers.	Unit	(Value reached in project)/(Highest value reached between projects)
Legal framework	$I_{\text{Leg}} = \text{Number of legal documents}$	Quantity of legal documents instituted after the publication of Notice AGEVAP 004/2014	Unit	(Value reached in project)/(Highest value reached between projects)
Knowledge generation and dissemination	$I_{\text{Pub}} = \text{Number of published scientific papers and other documents}$	Quantity of technical-scientific papers published after the publication of Notice AGEVAP 004/2014 related to research/studies developed in the areas of the pilot program.	Unit	(Value reached in project)/(Highest value reached between projects)
Network partnerships	$I_{\text{Par}} = \text{Number of partnerships established}$	Quantity of partnerships for scientific production and project support (funding and scale-up).	Unit	(Value reached in project)/(Highest value reached between projects)

3. Results

3.1. Efficiency

The indicators of mobilization (E_{Mob}) and planning (E_{plan}) were directly related to the preliminary activities (structuring component) of the projects, which include the stages of stakeholder's mobilization and conception of executive projects (PERs). The indicators of isolation (E_{iso}), planting (E_{planting}) and maintenance (E_{maint}) are related to final activities in the field (structural component). The main distinction between the components is the complexity and high cost of structural activities compared to structuring activities, while the latter requires greater competence for institutional interlocution. By associating these two components in the same project scope, the PWS program of CEIVAP required from project implementers multidisciplinary expertise and financial prudence.

All our project efficiency indicators correlate the financial investment with the obtained goals (hired providers, projects executed, seedlings planted, and maintenance performed). The highest efficiency is obtained when the great goal is executed with lower cost. The reduction of physical targets by maintaining a high cost with a multidisciplinary technical team characterized the low efficiency ($S_{\text{Efficiency}}$) of PW5, PW6, PWS2, and PWS8 (Table 5) projects. For these projects, the achievement of the targets would favor the reallocation of expenses for the multidisciplinary technical team from "fixed costs" to "variable costs" during the initial planning.

Table 5. Efficiency indicator values of each project of the PWS pilot program of CEIVAP.

PWS	Scores					
	E_{Mob}	E_{plan}	E_{iso}	E_{plantio}	E_{manut}	$S_{\text{Efficiency}}$
PWS3	1.00	1.00	0.49	1.00	1.00	4.49
PWS4	1.00	0.50	0.61	0.70	0.95	3.76
PWS8	0.48	1.00	1.00	0.59	0.63	3.70
PWS2	0.21	0.48	0.48	0.27	0.97	2.40
PWS1	0.23	0.27	0.51	0.52	0.50	2.04
PWS6	0.15	0.14	0.57	0.54	0.62	2.02
PWS5	0.14	0.26	0.46	0.31	0.77	1.93
PWS7	0.07	0.21	0.40	0.47	0.61	1.75

The values of the indicators correspond to scores from 0 to 1 based on the standardization used.

The PWS1 and PWS7 projects were the only ones to meet their respective original targets fully. In these projects, the greater control also required a higher investment of financial resources which, when compared to lower cost projects and similar targets, resulted in lower efficiency on the E_{Mob} , E_{plan} , E_{iso} , E_{planting} and E_{manut} indicators for the PWS1 and PWS7 projects. The best efficiency was obtained by the projects that: (i) presented low cost of the technical team to manage the project, (ii) contracted isolation, planting and maintenance services for a lower price, and (iii) did not significantly reduce isolation, planting, and maintenance targets.

3.2. Performance

The proposed indicators for evaluating project performance aimed to focus on quality-quantitative results as a direct benefit of the activities carried out in the projects. These results include the achievement of quantitative goals (providers assisted in relation to the total number of hired providers, fences built, seedlings planted, area conserved in relation to the total planned) (P_{Goal}), the permanence of the providers after being contemplated (P_{Rem}), the degradation of the areas contemplated (P_{Prev}), the success of planting activities for forest restoration with survival of seedlings in the post-planting (P_{Surv}), and the progress of forest restoration of the areas (P_{Rest}).

As we showed, the PWS7 project presented the highest cost of mobilization (alignment with the municipal government, dissemination of the project to the local community, selection of providers, field visits, etc.), as well as significant costs in planning, planting, and maintenance, consequently resulting in the lowest efficiency ($S_{\text{Efficiency}}$). However, this project was also the one with the highest performance

($S_{Performance}$), as shown in Table 6. In other words, the highest investment was compensated with effective results for the actions undertaken in the project.

Table 6. Performance indicator values of each project of the PWS pilot program of CEIVAP.

PWS	Scores					
	P_{Met}	P_{Per}	P_{Prev}	P_{Sob}	P_{Rest}	$S_{Performance}$
PWS7	0.39	1.00	1.00	0.98	1.00	4.37
PWS1	0.39	1.00	0.96	1.00	0.58	3.93
PWS4	0.38	0.65	0.93	0.90	0.95	3.80
PWS3	1.00	0.75	0.93	0.75	0.35	3.78
PWS5	0.44	1.00	0.70	0.90	0.63	3.66
PWS2	0.09	0.89	1.00	0.74	0.76	3.48
PWS6	0.22	1.00	0.70	0.76	0.69	3.37
PWS8	0.29	0.92	0.78	0.90	0.42	3.31

The values of the indicators correspond to scores from 0 to 1 based on the standardization used.

It is possible that the mobilization strategy adopted in PWS7 (e.g., use of booklets, video documentation, and other means of dissemination of information) ensured greater engagement of providers with the implementation phases of the project and consequently lower rates of occurrence of degrading events. The engineering solutions and the technical quality control of the outsourced services resulted in the outstanding survival performance of the post-plant seedlings and the progress of forest restoration. The latter measured based on the forest restoration evaluation protocol adopted by the program.

The control of the target plan was also effective in PWS1 and PWS4 projects. For the PWS1, it highlighted the importance of the providers' maintenance and the low occurrence of degradations to the areas contemplated. However, PWS1 encountered difficulties in the response of the forest restoration process, demonstrating that the engineering solutions were not sufficient for the rapid recovery of the contemplated areas. Conversely, PWS4 succeeded in the process of restoration, but registered the withdrawal of providers and largest number of occurrences of degrading events (e.g., access and permanence of cattle in the areas intended for forest restoration).

The PWS3 project, which achieved the highest level of efficiency, significantly increased the forest conservation goal, and served all hired providers. However, it registered the withdrawal of some providers, occurrences of cattle access in delimited areas and, mainly, presented a low quality in forest restoration efforts, with a high rate of post-plant mortality. We relate these results to the low quality of the services contracted in the public bidding process, although they were less costly.

For the PWS8, PWS6, PWS5, and PWS2 projects, besides the reduction of targets, providers' withdrawal, and reports of occurrence of degradation agents, the contracted services were not accompanied by the effective quality control, resulting in losses of seedlings after planting and delays in the forest restoration process of the areas. In many of these projects, the significant reduction of the target plan and the low quality of the interventions carried out on rural properties may justify the lack of perception of tangible results of these projects for the stakeholders. In the absence of project monitoring methodologies, the identification and communication of results is hindered or even appropriated by agents who oppose investment in programs of this nature.

3.3. Impact

The indicators of this dimension evaluated the changes in the external environment mediated by the implementation of the program under analysis. The fulfilment of payments to service providers (I_{Paym}) represents the creation of an administrative mechanism that can be used by new municipal projects. The engagement of stakeholders in meetings for decision-making (I_{Eng}) that bring together new partners (I_{Par}) to form a collective with the potential to continue the programs, as well as the legal framework (I_{Leg}) and the production of scientific knowledge (I_{Pub}), are legacies of the PWS projects of CEIVAP.

Our results indicate that the PWS3 project obtained the highest level of impact, achieving the highest score in all indicators of this evaluation dimension (Table 7). The PWS3 and PWS7 were the only projects to pay all the installments agreed upon with the ecosystem services providers hired, contemplated, and maintained in the project. For all projects, payment was made by the municipal governments—since the payment contracts involved only the municipal government and the providers—with funds transferred by CEIVAP, respecting the maximum amount of US \$30.00 ha⁻¹·year⁻¹.

Table 7. Impact indicator values of each project of the PWS pilot program of CEIVAP.

PWS	Scores					
	I _{Pag}	I _{Eng}	I _{Par}	I _{Leg}	I _{Pub}	S _{Impact}
PWS3	1.00	1.00	1.00	1.00	1.00	5.00
PWS7	1.00	0.33	0.33	0.50	0.33	2.50
PWS4	0.67	0.33	0.17	0.50	0.67	2.17
PWS1	0.67	0.17	0.17	0.50	0.33	1.83
PWS6	0.22	0.17	0.00	1.00	0.33	1.72
PWS5	0.67	0.17	0.00	0.50	0.33	1.67
PWS8	0.17	0.00	0.17	1.00	0.00	1.33
PWS2	0.00	0.33	0.00	0.50	0.33	1.17

The values of the indicators correspond to scores from 0 to 1 based on the standardization used.

Fiscal irregularities of the municipalities and slowness of the public administrative process prevented the payment of one or more installments in almost all other projects. For the PWS2 project, none of the entitled installments were paid to hire providers due to the lack of fiscal regularity of the municipality of Carapebus/RJ to receive resource transfers from CEIVAP. However, the failure to make full payments did not result in providers giving up on any of the projects. It is possible that the other benefits received by the providers, such as the maps of the properties, the support for the Rural Environmental Cadastre (CAR) [46], the isolation of the areas, and the planting for the restoration of Permanent Preservation Areas [46], have been perceived by the providers as direct benefits obtained from participation in the projects. We have identified that the scientific investigation of this perception by the stakeholders is complementary to our study.

The PWS3 project obtained the highest score for the I_{Eng} and I_{Parc} indicators given the institution and operation of an active Management Board (UGP, in the Portuguese acronym) which, in addition to making decisions, acted as a center of gravity in the aggregation of newly formalized and active partners such as the Technological Institute of Aeronautics (ITA), São Paulo State University (UNESP), Sanitation Company of the State of São Paulo (SABESP), Boticario Group Foundation, The Nature Conservancy (TNC), and the municipal ecosystem services fund itself. Other PWS projects have registered one-off partnerships. We can highlight the partnership of PWS1, PWS5, and PWS7 with the project “Replantando Vidas” of the Rio de Janeiro State Company of Water and Sewage (CEDAE), which donated native Atlantic Forest seedlings for complementary restoration actions in the contemplated areas.

Another important legacy of PWS projects is the constitution of a legal framework (I_{Leg}) for municipalities to operate their PWS projects and programs. We observed that, in most of the municipalities contemplated, the legal procedures were modified and in others were created, as in PWS3, to meet the criteria of Notice 004/2014/AGEVAP (Table 8). With this, we observed the impact on public policies of municipalities.

The amount of technical/scientific studies published (E_{Pub}) for PWS is also an important legacy of the PWS pilot program of CEIVAP. The PWS3 project was also the one that most inspired the scientific production, resulting directly from the partnerships established by the project. The exchange of technical information between the project’s partner institutions and the aggregation of research institutions to the project have made the pilot project a field of exploration of science in different areas of knowledge. It is also important to highlight the promotion and encouragement of science

production by the State Environment Agency (INEA), a partner institution of the PWS pilot program of CEIVAP, which organized a special issue of the technical-scientific journal linked to the institution, with the publication of works developed in projects PWS1, PWS2, PWS5, PWS6, and PWS7.

Table 8. Legal procedures created or modified due to the criteria of the notice of selection for the PWS projects of CEIVAP.

Project	Legal Procedures
PWS1	Municipal Law of Petrópolis n° 7342/2015
PWS2	Municipal Law of Carapebus n° 626/2015
PWS3	Municipal Law of São José dos Campos n° 8703/2012;
	Municipal Law of São José dos Campos n° 8905/2013;
PWS4	Municipal Decree of São José dos Campos n° 15,922 of 05 June 2014; and
	Municipal Decree of São José dos Campos n° 16,086 of 05 September 2014
PWS5	Municipal Law of Guaratinguetá n° 4252/11 and
PWS6	Municipal Law of Barra Mansa n° 4457/2015
PWS7	Municipal Law of Areal n° 835 of 17 December, 2014;
	Municipal Law of Paraíba do Sul n° 3141 of 16 December, 2014 and
PWS8	Municipal Law of Paty do Alferes n° 2158 of 04 March, 2014
	Municipal Law of Resende Lei n° 3117 of 15 August, 2014
	Municipal Law of Muriaé n° 4505/2013,
	Municipal Law of Rio Pomba n° 1521/2015, and
	Municipal Law of São Sebastião da Vargem Alegre n° 484/2015

3.4. Overview and Comparative Outcomes

The principal component analysis (PCA) provided interesting information on the distribution of scores achieved by the indicators. The principal component 1 (PC1) explained 44.66% of the total variance and the principal component 2 (PC2) explained 22.36%. Together, they explained 67.02% of the variation in the original data (Figure 4). The PCA shows that the restoration and survival rate indicators were strongly associated with PWS7, PWS1, PWS2, and PWS5, i.e., these indicators were determinant for the results of these projects in the overall comparative evaluation. Inversely related were the permanence and isolation indicators for PWS6 and PWS8. Conversely, all other indicators were more associated with the results of PWS4 and PWS3.

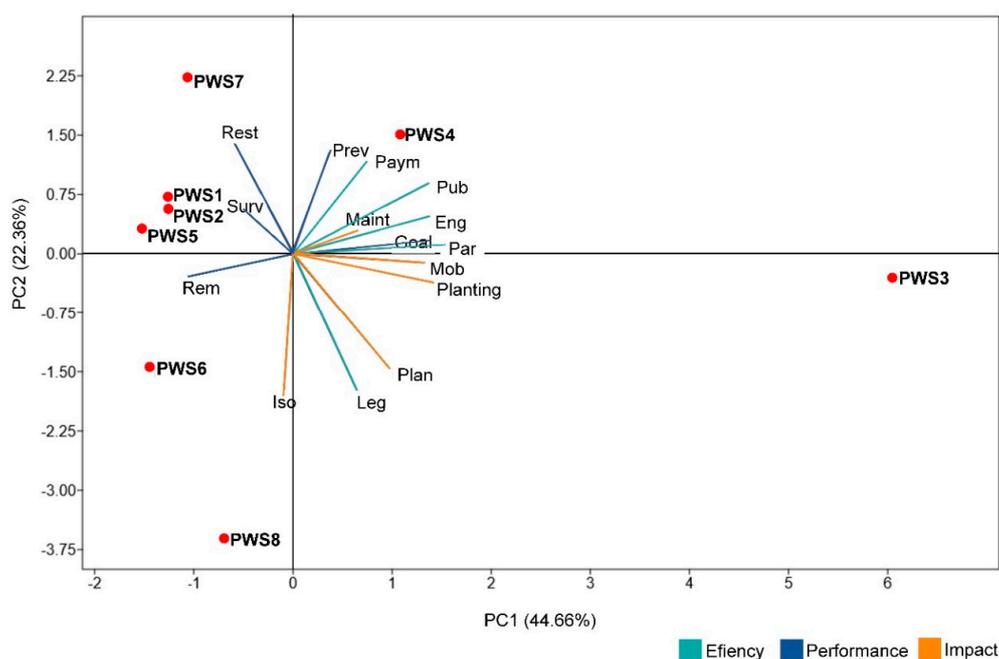


Figure 4. Principal component analysis (PCA) for all scores in three dimensions.

Our proposed indicators for the comparative evaluation of projects have made it possible to characterize successful experiences, such as the PWS3 project, the only project in which the municipality is also the executor (Table 9). It is worth noting that in PWS3 strategic partnerships were consolidated, forming an active collective for decision making and overcoming conflicts. The project worked as a mobilizer of the “Programa Municipal São José Mais Água”, stimulating a municipal public policy planned to continue acting from its network of partners and funders.

Table 9. Final score for the comparative evaluation of the efficiency, performance, and impact dimensions of the projects that integrate the PWS pilot program of CEIVAP.

PWS	Scores			
	S _{Efficiency}	S _{Performance}	S _{Impact}	S _{Final}
PWS3	4.49	3.78	5.00	27.06
PWS7	1.75	4.37	2.50	18.00
PWS4	3.76	3.80	2.17	17.86
PWS1	2.04	3.93	1.83	15.39
PWS8	3.70	3.31	1.33	14.31
PWS5	1.93	3.66	1.67	14.25
PWS6	2.02	3.37	1.72	13.92
PWS2	2.40	3.48	1.17	12.87

The experiences of the PWS7 and PWS4 projects are also noteworthy. The implementation of the PWS7 project represented an unprecedented experience in the municipality of Resende/RJ, which from a group of stakeholders engaged by nature-based solutions, obtained the best performance in field interventions. The PWS4 project overcame the difficulties by consolidating partnerships with the municipality of Guaratinguetá/SP, which already had skills in the management of payments for watershed services projects.

The PWS1 fully met the proposed goals of serving the hired providers, isolation, and planting of the areas. However, the selection of areas with a high degradation degree was not accompanied by effective recovery solutions. The PWS8, PWS5, PWS6, and PWS2 projects reduced targets to achieve results in service to hired providers, isolation, planting, and maintenance of areas.

4. Discussion

4.1. Lessons from PWS of CEIVAP

In general, the complex scope, the lack of planning for mobilization in the sub-watershed, the complexity of forest restoration actions, the reduction of executive targets, the program’s target plan, and the absence of a monitoring methodology can be pointed out as key elements that weakened the projects and the PWS program of CEIVAP itself. All of the PWS projects followed the same scope defined in the AGEVAP [36]. The projects had in common the installation of PWS demonstration units in the municipality within 48 months after the signature of contracts was obtained from the institutions serving as executors. The mobilization and engagement of stakeholders and the promotion of municipal territorial management policies, as well as forest restoration interventions, proved to be incompatible with the pre-established schedule for project implementation.

We identified that both the PWS object and the scope of the projects that brought together structuring activities (mobilization, institutional arrangement, selection, and design) and structural activities (isolation of areas, planting and maintenance for forest restoration), required unprecedented multidisciplinary expertise from most of the institutions involved in implementing the program, as a process of “learning by doing” [47]. This knowledge is one of the great legacies of the program that we seek to measure with the I_{Pub} indicator. We have shown that systematic experiences in the form of technical/scientific publications are still incipient when compared with the quantity and diversity of results of regular evaluations of the program that are fragmented in the form of technical reports, financial follow-up spreadsheets, technical notes, surveys, and meeting reports [38].

In the execution of the structuring component, we identified failures in the process of mobilizing ecosystem services providers. We observed that, in most projects, the mobilization of providers did not follow a strategic planning that considered, for example, the hydrographic area in the municipal territory, the formation of a bank of areas with non-hired providers, and further mobilization actions. This planning would increase the efficiency of mobilization (E_{Mob}) and action planning (E_{Plan}), selecting areas with greater potential for forest restoration in the short term that would reflect in increased efficiency (E_{planting} and E_{maint}) and performance of restoration actions (P_{Surv} and P_{Rest}).

Our results showed that failures in the mobilization process may have compromised the greater participation of ecosystem services providers in preventative actions for degrading agents (P_{Prev}), permanence (P_{Rem}), and engagement (I_{Eng}) in the projects. In addition, by not considering hydrographic area in the mobilization planning, the actions were fragmented in the territory making it impossible to apply hydrological monitoring methodologies that could contribute to more tangible results, attracting new partners to the project (I_{Par}).

4.2. Local Transformations, Actions, and Challenges

Only the PWS3 project had a planning for mobilization based on the hydrographic area of the municipality's territory in order to concentrate the interventions in a strategic stretch of a micro watershed. Therefore, it was also the only project to carry out hydrological monitoring throughout the period of its implementation. We observed that hydrological monitoring is a key element in the PWS3 project for partnerships (I_{Par}) and stakeholder engagement (I_{Eng}). In an assessment of water quality of the Ribeirão das Couves river (PWS3), the authors concluded that the water quality does not meet the limits for classification as the best-quality water by the Sanitation Company of the State of São Paulo, since there is a concentration of thermotolerant coliforms, such as *Escherichia coli*, in the water [48]. The results presented by Fiore et al. [48] indicate that these interventions carried out on rural properties included in the PWS3 project should be complemented with rural sanitation works to enhance the provision of environmental services effectively.

In another case study also conducted in the Brazilian Atlantic Forest, Hamel et al. [18] suggests that the hydrological information should be coded by those who will use this information, such as investors or project managers who may use the information and landowner who ideally are part of the planning process. Both qualitative and quantitative water (hydrological) monitoring should be performed in an integrated manner [19]. According to Taffarello et al. [19] the hydrological monitoring is essential to validate implemented land management actions as generators of water services, proving the effectiveness of PWS projects in providing these services. It is an important tool to convince water users (companies of water supply and hydroelectricity) to support the project, ensure its financial sustainability, and to provide funding for impact evaluations [49,50].

In PWS of CEIVAP, only quantitative targets of areas to be restored and conserved were described, with only field interventions for isolation of areas, planting, and maintenance for forest restoration being contemplated. From the forecast of restoring 395.15 ha of degraded areas and conserving 452.23 ha of forests, the PWS projects reached 188,58 ha of areas in the process of forest restoration (47.72%) and 718.63 ha of forest conservation areas (150% more than the initial target). If we consider the total area of the sub-watershed where the projects were implemented, the intervention achieved by the program (total restoration and conservation areas) accounts for less than 0.05% of the territory.

Two PES projects in the Brazilian Atlantic Forest (“Conservador de Águas” e “Produtor de Água e Floresta”) showed gains in forest cover, of 5.6% and 2.8% respectively, over 5 years [51]. The potential increase in forest cover achieved with the PWS program of CEIVAP has a smaller gain when compared to these projects. We can still highlight the fragmentation of these shares, making the results of the projects even less tangible. Successful forest restoration actions become a tool for institutional communication and efficient social mobilization. There is evidence in most projects of new landowners showing interest in joining the projects after field actions have been taken. This passive mobilization is

another important legacy of the projects and demonstrates the importance of creating area banks with partners to ensure the continuity of the projects.

We observed that the execution of forest restoration actions and the structural component of the projects as a whole, proved to be a challenge due to the technical complexity of the field activities and the higher cost of the activities when compared to the structuring component. As the transfer of financial resources from CEIVAP is only executed by providing the service, the execution of the structural component by implementing institutions, almost all non-profit entities with limited working capital, functioned as a significant bottleneck for the projects [38].

One of the alternatives found by the implementing institutions was the outsourcing of the services of the structural stage. One of the problems with outsourcing activities is that companies offer the service at low cost and, potentially, with low quality [52]. Another characteristic of this type of contracting is the constant rotation of the outsourcers preventing them from engaging with the project objectives [53]. The outsourcing of forest restoration services has generated instability in the provision of forest restoration services, which has consequently had an impact on the increase in costs of maintaining the areas. Poor quality planting severely compromises the flow of the restoration process in the areas, given the delay effect on the speed of growth and development of the seedlings planted [54], demonstrated by the P_{Rest} indicator. Our results suggest that the lack of operational training of the hired labor is related to the increase in post-plant mortality rates and loss of maintenance efficiency, characterized by the P_{Surv} and E_{Maint} indicators.

In addition, the scope pre-defined that forest restoration actions would use no-till planting techniques, forest enrichment, or implementation of Agroforestry Systems (SAFs). No-till increases the cost range per hectare from \$3.72 to \$10.16/ha [55]. Although it has the predication of generating revenue in a forest ecosystem, SAFs were not adopted in any of the projects [56,57]. The E_{Iso} , $E_{Planting}$, and E_{Maint} indicators could indicate the cost of the different techniques adopted, but as in almost all projects where full planting was adopted, the variation in efficiency reflects the variation in local input costs and project management strategy. In our study, we observed that the projects with the highest cost were also those with the highest percentage of areas in the forest restoration modality (PWS1, PWS4, and PWS8) with no-till planting at 3.0×2.0 m spacing.

During field visits, we observed technical solutions in some projects capable of optimizing forest restoration processes (P_{Rest}), as well as minimizing costs (E_{Maint}), such as the combined use of soil preparation techniques with animal traction following the contour lines of the terrain, the compatibility of species to the forest site, the control of exotic grass population through chemical weeding, and periodic maintenance activities [55,58], which resulted in the distinctive performance of the forest restoration process in the PWS4 and PWS7 projects. We highlight that for PWS3 and PWS4, the UGP meetings were used as a space for alignment of stakeholders' efforts in avoiding degradation agents to excel in maintenance efforts in areas with low forest restoration performance. Especially for the PWS4 project, stakeholders' engagement through UGP meetings (I_{Eng}) avoided even worse project performance in occurrence of area degradation (P_{Prev}) and withdrawals (P_{Rem}).

4.3. The Role of Environmental Planning in Local Issues

Restoration actions are more expensive, complex, and dependent on the seasonality of the climate than the conservation actions [59–61]. The failure to achieve full restoration targets in some of the projects could have been accompanied by an increase in the conservation areas among the properties in the projects. The PWS2 project is an example of low performance in meeting targets (P_{Goal}) for the need to reduce forest restoration targets. However, for this project, no efforts were made to increase the conservation areas, as was done in PSW3. In the latter, the reduction of restoration targets was accompanied by an increase in conservation areas with the incorporation of large areas of Private Natural Heritage Reserves (RPPN, in the Portuguese acronym) [62].

We also observed the need for investment in complementary practices such as the readjustment of rural roads, soil erosion control, conservationist management in livestock production, and rural

sanitation, given the situation of areas located inside the properties contemplated by the program (Figure 5). We highlighted that soil conservation practices could increase baseflow and decrease direct runoff in a short period of time [63]. These interventions, besides potentializing the provision of water ecosystem services, may contribute to the perception of direct results of the projects [33,64], but all of this depends on field monitoring. However, in practical terms, the costs of monitoring are an obstacle for its implementation [49].



Figure 5. Examples of degraded areas located in rural properties covered by the PWS projects of the CEIVAP pilot program.

Since the territorial management is a central objective of the PWS of CEIVAP, our results showed that most of the projects failed to promote effective transformations such as the creation of a legal framework (I_{Leg}), knowledge production (I_{Pub}), and even payment for ecosystem services (I_{Paym}). The absence of a general evaluation methodology of this project compromised the establishment of partnerships and engagement of the stakeholders and, in fact, compromised the appropriation of this type of project as an instrument of territorial management by the municipalities.

4.4. Beyond the Economic Benefits

The specialized scientific literature reports a discrepancy between the conceptual model of PES arrangements and the practical establishment of these arrangements [65–67]. In fact, none of the projects obtained a PES arrangement that achieved functional autonomy. Even for the projects that achieved the best results in the indicator that measures the amount of PES installments paid (I_{Paym}), there is uncertainty about the maintenance of these arrangements after the suspension of CEIVAP investments. By December 2019, only the municipalities of Resende/RJ and São José dos Campos/SP had executed the payment of all the PES installments foreseen in the PWS7 and PWS3 project, respectively. In the

remaining projects, only half of the installments were paid and in 4 of the 11 municipalities (36.36%) the PES payments were not executed.

The failure to make payments exposed the PWS2, PWS6, and PWS8 projects to the failure to achieve their main objectives. However, we do not see withdrawals motivated by the failure to achieve the PES payment. This indicates that the providers may be satisfied with the interventions carried out on the rural property, especially the environmental adequacy of the rural property. However, the discontinuity is a common element to PES initiatives in Brazil [68].

Our results indicate that the PWS projects implemented in municipalities that already have a municipal PWS program, with its own investment fund, such as in the municipalities of Guaratinguetá/SP (PWS4) and São José dos Campos (PWS3), fostered the improvement of the municipality's legal framework and the production of knowledge. For municipalities that did not have this type of program, the projects provided the opportunity to implement this new conservation policy. Nevertheless, the PWS required changes in land use practices that are associated with social and cultural factors, based on the individual and collective values of the landowners [69,70].

Regarding the legal factor, we highlight the guidelines of the Native Vegetation Protection Law (LPVN or "Forest Cod", Law No. 12,651/2012), and the Atlantic Forest Law (Law No. 11,428/2006). After a property is reforested, Brazilian law requires special authorization for new land use conversion, especially in the Atlantic Forest [71]. Thus, PWS payments to those landowners who have designated areas for reforestation need to be large enough to offset the opportunity cost of future alternative land uses [55]. On the other hand, Richards et al. [69] suggest addressing the perceived risks of non-compliance with legislation to win more available providers for reforestation. In any case, this instrumental aspect of PWS projects shows that, in addition to the restoration goals for the Atlantic Forest being large, there are also major challenges that will require investments from various sources and under more diversified conditions [72]. The targeting of these actions based on the provision of ES can provide major gains in the impacts of PES and PWS [73].

The benefits to PWS project registrants may go beyond compliance with the law. Impacts on the forest may include ecological benefits, such as greater forest connectivity, but also socioeconomic benefits such as the generation of "green jobs", improved institutional capacity, and local governance, as presented by Fiorini et al. [55] in an evaluation of the PES project "Produtores de Água e Floresta", also in the Atlantic Forest in the state of Rio de Janeiro. In the review by Bremer et al. [70], they found that the influence of the PWS projects on local governance systems was sometimes due to collective rights and responsibilities to take care of the land. In our study, we found similar results regarding the prevention of degradation agents (cattle, fire, and soil erosion). Prevention actions are understood in the PWS projects of CEIVAP as a collective responsibility. Therefore, the more engaged, the more favorable the conduct of the provider in the care, follow-up, and monitoring of the areas contemplated.

The amount paid in the form of PES was also not reported as a reason for withdrawing the projects. For PWS projects in the Atlantic Forest, payment amounts range from \$5 annually to \$272 per hectare monthly [74]. For example, in "Oasis Project", in Apucarana, Santa Catarina, south of Brazil, the average value would be approximately \$6/ha/month [49]. In the PWS of CEIVAP, the maximum amount is \$30.00 ha⁻¹.year⁻¹, based on the average cost for leasing pasture for livestock production in BHRPS [29]. On average, it is a higher value than presented by Fiorini et al. [55], in which values varied between \$5 and \$29 ha⁻¹.year⁻¹. In the research of Ramos et al. [75], the providers of this program consider the value irrelevant, and are interested in joining the project due to the perception of the need for conservation and forest recovery.

5. Limitations of Research and Future Perspectives

The limitations of this research are in the field of data collection. Several researchers have noted the limitations involved with using observations as a tool for data collection [43]. Furthermore, according to Kawulich [43], the researcher must understand how their conceptions can affect observation, analysis, and interpretation. Regarding the methodology application, the major limiting factor was data access in

the documental analysis. The Pilot Program of PWS by CEIVAP did not present a cohesive organization of monitoring data. There were many types of secondary sources (reports and technical notes, minutes of meetings, measurement bulletins of works in PWS projects, schedules, and budgets) that we had to carefully analyze for a robust documental analysis process. However, we have shown that it is possible to use the proposed indicators in other programs is perfectly achievable once the required data are presented as “inputs”.

Continuing the policy of PWS by CEIVAP, the program “*Mananciais*” [76] was planned aiming to “protect, maintain, recover, expand, and/or ensure the provision of ecosystem services that contribute to the maintenance of quality and regulation of water availability of strategic springs for the affluent of the Paraíba do Sul river in an inclusive and participatory way, ensuring human well-being, water security, and health of ecosystems associated with water in the medium and long term”. Thus, the elements identified from this case study should be addressed in the scope of the “*Mananciais*” program, in order to enhance successful solutions and remove or mitigate inadequate measures. Hence, we understand that Brazilian PES programs should have a more robust plan to guarantee its assessment and reports for investors, partners, and users [63].

Future studies should be encouraged to analyze the social dimension of the impacts of the PWS projects of CEIVAP, since encouraging pro-environmental behavior requires consideration of all barriers to action faced by the target population [77]. These studies should support a water-energy-food nexus approach for enhancing environmental planning in watersheds, beyond the public water supply [78]. After all, PES or PWS projects should no longer be seen strictly as market transactions [5].

6. Concluding Remarks

The implementation of this Pilot Program represents a conceptual framework for water resources management in the Paraíba do Sul River Basin. By encouraging the use of PES as a tool for territorial management, CEIVAP contemplates from ecological economy to environmental democratization [79,80]. It evokes the “conservative-recipient” principle as a key instrument in the implementation of the National Water Resources Policy in one of the most important watersheds in Brazil.

Our methodological proposal allowed a comparative analysis of the PWS projects of CEIVAP based on easily measured indicators. We characterized the projects with the best effectiveness and projects that showed commitment to performance by the prevalence of key elements that weaken the implementation process. We presented the performance of the projects due to the prevalence of key elements that weaken the implementation process. The excessive reduction of targets and, consequently, the increase in project costs characterize the projects with the worst effectiveness. On the other hand, the consolidation of partners, the maintenance of the collective of engaged stakeholders, and the engineering solutions that allowed effectiveness of field actions can be pointed out as the elements that helped the projects to overcome innate weaknesses (of scope) and obtain a good performance compared to other projects.

In this process of continuous improvement of its investment tools, CEIVAP consolidates an investment policy in ES that presents synergy with the Sustainable Development Goals [81], Brazil’s national commitment to the Paris Climate Agreement [82], and to the environmental regularization of rural properties, as provided in the LPVN [46]. Combining water resources management with environmental and territorial management optimizes the application of public financial resources, increasing the effectiveness of public policies for solutions based on nature. We emphasize that the PWS program performance assessment is an important opportunity to improve our understanding of the linkages between land management practices and ecosystem services in watersheds, also making ecosystem services more resilient to climatic variables [50,63,83]. PWS programs can be mechanisms to encourage the provision of ecosystem services for human wellbeing and nature conservation. They are schemes that can change regional landscapes and achieve global sustainability goals.

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