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PAYMENT FOR ENVIRONMENTAL SERVICES IN A MUNICIPALITY IN THE STATE OF SÃO PAULO: EQUIVALENT UNIFORM ANNUAL COST

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Resumo

Pagamento por serviços ambientais em um município do estado de São Paulo: Custo Anual Uniforme Equivalente. A implantação e as discussões acerca dos programas de Pagamento por Serviços Ambientais (PSA) tem ganhado destaque nas pautas ambientais. Entretanto, ainda existem lacunas de conhecimento relacionadas aos indicadores econômicos fundamentais para a análise de viabilidade e financiamento de projetos de Pagamento por Serviços Ambientais (PSA). Desse modo, a obtenção de informações relacionadas à análise de projetos de investimento em programas de PSA pode contribuir em futuras tomadas de decisões. Neste contexto, o objetivo foi estimar o Custo Anual Uniforme Equivalente dos projetos de investimento envolvendo o Pagamento por Serviços Ambientais em sub-bacias hidrográficas no estado de São Paulo sob condições de incertezas, bem como analisar se o CAUE permite atestar a viabilidade econômica desses projetos de investimento. A partir dos custos das ações do PSA, foi calculado o CAUE e, posteriormente, aplicado o método Monte Carlo para incorporar soluções estocásticas. O CAUE médio dos projetos de investimento envolvendo o PSA para as áreas das sub-bacias hidrográficas prioritárias e não prioritárias é, respectivamente, de US$ 1.814,11 e US$ 1.675,54. Os custos referentes à aquisição de adubo orgânico e mourões são os que mais impactam o CAUE, tanto nas áreas prioritárias quanto nas não prioritárias. O CAUE combinado à correlação de *Spearman* permite analisar a viabilidade econômica dos projetos de investimento envolvendo o PSA e, consequentemente, auxilia na tomada de decisão quanto à priorização de alocação dos recursos nas sub-bacias hidrográficas.
Palavras-chave: *Análise econômica; Serviços ecossistêmicos; Provisão de água.*

Abstract

The implementation and discussion of Payment for Environmental Services (PES) programs has gained prominence in environmental policy. However, there are still knowledge gaps regarding economic indicators that are fundamental for the analysis of the viability and financing of PES projects. Thus, obtaining information related to the analysis of investment projects in PES programs can contribute to future decision-making. In this context, the objective was to estimate the Equivalent Uniform Annual Cost (EUAC) of investment projects for PES in subwatersheds in the State of São Paulo under conditions of uncertainty, as well as to analyze whether the EUAC allows attesting to the economic viability of these investment projects. From the costs of the PES actions, the EUAC was used and then the Monte Carlo method was applied to incorporate stochastic solutions. The average EUAC of the PES investment projects for the priority and non-priority subwatersheds is USD 1,814.11 and USD 1,675.54, respectively. The costs associated with the purchase of organic fertilizer and fence posts have the greatest impact on the EUAC in both the priority and non-priority areas. The EUAC, combined with Spearman's correlation, allows for the analysis of the economic viability of investment projects and thus assists in the decision-making process regarding the prioritization of resource allocation in sub-watersheds.
Keywords: *Economic analysis; Ecosystem services; Water supply.*

INTRODUCTION

The Payment for Environmental Services (PES) is an environmental policy instrument created to promote the conservation and restoration of ecosystems and, consequently, the maintenance of ecosystem services. Even with the advances and information disseminated over the more than 20 years of existence of PES programs, there are still gaps in knowledge related to metrics for decision-making, fundamental for economic analysis and a premise for financing these projects.

Ecosystem services are understood to be the relevant benefits to society generated by ecosystems. Environmental services, in turn, consist of individual or collective initiatives to favor the maintenance, recovery or improvement of ecosystem services (BRASIL, 2021). The PSA is a voluntary transaction between users and providers of environmental services, subject to agreed rules for managing natural resources to generate environmental services, considered positive externalities (WUNDER, 2015). The dominant theory for PES is based on the assumption that the lack of supply of ecosystem services is the result of market failures, therefore valuing and paying for these services will help address these environmental externalities (ENGEL *et al*., 2008).

In Brazil, although the first PES program was implemented in 2005 (KFOURI; FAVERO, 2011), the National Payment Policy for Environmental Services was instituted only in 2021 through Law No. 14,119 (BRASIL, 2021), whose regulation is still under discussion. In the State of São Paulo, Payment for Environmental Services was instituted by the State Policy on Climate Change (SPCC) in 2009 (SÃO PAULO, 2009).

The estimation of economic metrics can contribute to the improvement of new PSA projects that involve forest restoration, in addition to adapting or improving those in execution. Among the metrics that can be applied, the Equivalent Uniform Annual Cost (EUAC) stands out, defined as the transformation of cash flows into a uniform annual series, allowing comparison of investment alternatives based on incurred costs. The costs associated with these flows of investment projects in forest restoration can be raised, characterizing the deterministic analysis procedure. However, despite being practical, this type of analysis may result in simplified or overestimated information (BASSOLI *et al*., 2020; MOTTA; CALÔBA, 2011; CORDEIRO *et al*., 2010).

These costs have associated uncertainties, justifying the application of methods that consider them, such as, for example, simulation using the Monte Carlo method, which allows the investment project manager to make consistent decisions based on pseudo-random samples of the input variables and measure the risks intrinsic to these projects (SIMÕES *et al*., 2018; RIBEIRO *et al*., 2016; SIMÕES; GOUVEA, 2015). That said, there is the hypothesis that the Equivalent Uniform Annual Cost (EUAC) allows for analyzing the economic viability of investment projects involving Payment for Environmental Services.

Given the above, the objective was to estimate the Equivalent Uniform Annual Cost of investment projects involving Payment for Environmental Services in hydrographic sub-basins in the state of São Paulo under conditions of uncertainty, as well as to analyze whether the CAUE allows attesting the economic viability of these investment projects.

MATERIALS AND METHODS

Study object

The Payment for Environmental Services (PES) program was carried out in the municipality of Louveira, state of São Paulo, Brazil (Figure 1). The program aimed to obtain the benefits provided by forests to help improve water quality and regulate the flow of rivers in the 12 hydrographic sub-basins related to municipal public supply.

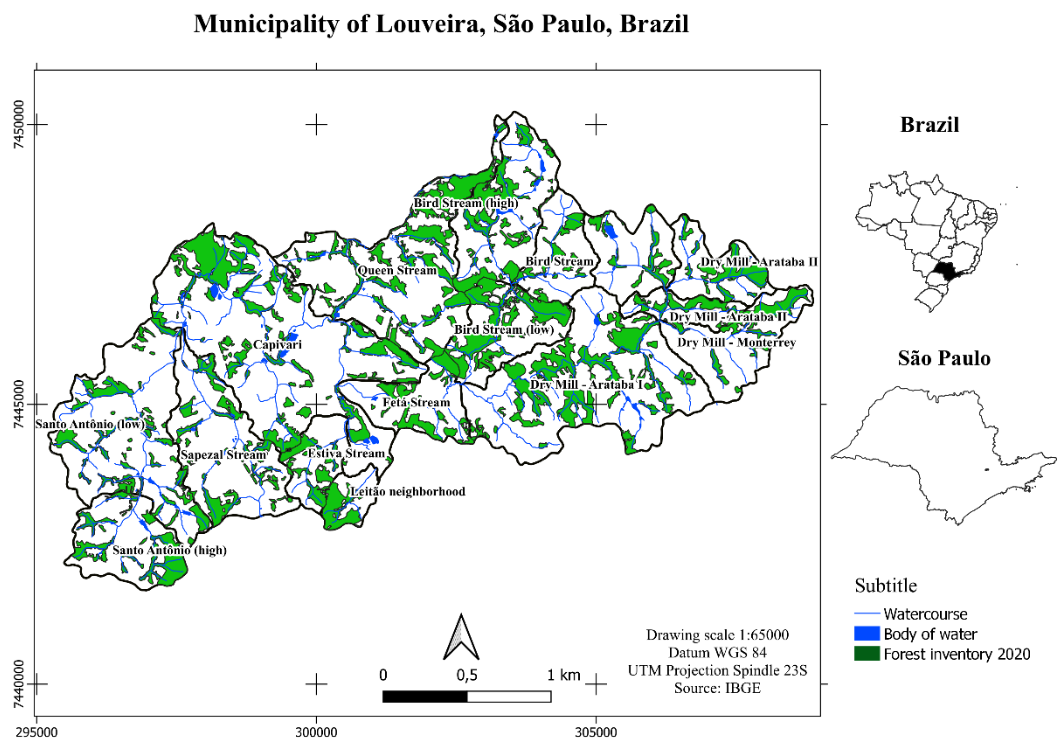

Figure 1. Location of the Municipality of Louveira, São Paulo, with division into sub-watersheds.
Figura 1. Localização do Município de Louveira, São Paulo, com as divisões em sub-bacias hidrográficas.

Source: Own elaboration, based on information from the Brazilian Institute of Geography and Statistics (IBGE), Brazilian Foundation for Sustainable Development (FBDS) and Forestry Inventory of the State of São Paulo, 2020.

Louveira's PSA was created in 2015 by Municipal Law No. 2,456 of August 5, 2015 (LOUVEIRA, 2015) and its implementation began in 2017. The formalization of adherence to the PSA took place through a Term of Adhesion and Commitment, valid for three years. Once the adhesion was formalized, the individual project of the property was prepared, updated annually, with the definition of the goals to be reached and recomposition methodologies to be adopted. PSA providers (landowners) were paid an amount per hectare of area preserved or to be recovered. This value was updated according to the Extended National Consumer Price Index (IPCA/IBGE).

The order of priority of the hydrographic sub-basins for the implementation of the PSA followed criteria established in Municipal Decree No. 4,443, of April 5, 2016 (LOUVEIRA, 2016), which regulated the law that created the PSA. According to the criteria established in that decree, the order of prioritization of the 12 hydrographic sub-basins was: (1) Engenho Seco – Arataba I; (2) Córrego do Passarinho (low and high); (3) Engenho Seco - Arataba II; (4) Córrego Rainha; (5) Córrego Fetá; (6) Engenho Seco – Monterrey; (7) Capivari; (8) Santo Antônio (bass); (9) Santo Antônio (high); (10) Sapezal Creek; (11) Córrego Estiva; and (12) Bairro Leitão. The sources of interest for public water supply in Louveira are: Capivari River, Córrego Fetá, Córrego Santo Antônio and Córrego Rainha.

Economic analysis

According to the Louveira PSA creation law, the amount paid for the service must differ depending on the location of the area, that is, whether or not it is located in an area considered a priority for public supply. As a result, for analysis in this work, two investment projects involving priority and non-priority areas were defined, called Project A and Project B, respectively.

The cash flows were characterized as unconventional, projected for a time horizon of nine years, which considers the stages (areas to restored, areas in early stage of restoration, and areas in medium stage of restoration) and the time (three years each) for changing this stage, if the process occurs as expected, both established by the Louveira PES creation law (Table 1). The costs incurred were extracted from the PSA creation law (LOUVEIRA, 2015), considering 1,667 tree seedlings ha^{-1}, with 3 m x 2 m spacing, and one employee to carry out the necessary procedures for environmental recovery in one hectare.

Monetary values were deflated, considering the month of January 2021, so that they could be compared and analyzed over time, as proposed by Mendes and Padilha (2007). Therefore, the General Price Index – Internal Availability (IGP-DI) was adopted. Monetary values were expressed in US dollars (US$), considering as the exchange rate the price of the official foreign currency of the Central Bank of Brazil at the sale price, which was 5.1184 BRL on June 11, 2021.

Table 1. Costs per hectare of the implementing stages and amounts paid to PES providers in the Municipality of Louveira, São Paulo.
Tabela 1. Custos por hectare das etapas de implantação e valores pagos aos provedores do PSA no município de Louveira, São Paulo.

Planting	**US$ ha^{-1}**
Tree seedlings	1,563.71
Limestone	139.62
Organic fertilizer	2,513.11
Mineral fertilizer	201.05
Miscellaneous costs	57.08
Labor	402.02
Fence building	
Concrete post	1,673.39
Wire	871.04
Miscellaneous costs	50.89
Labor	670.03
Amounts paid to providers in priority sub-basins (Project A)	
Areas to restored	333.82
Areas in early stage of restoration (3 years)	417.28
Areas in medium stage of restoration (6 years)	556.37
Amounts paid to providers in non-priority sub-basins (Project B)	
Areas to restored	222.55
Areas in early stage of restoration (3 years)	278.18
Areas in medium stage of restoration (6 years)	370.91

Source: Adapted from Louveira (2015).

Discount rate of investment projects

The discount rate of investment projects, denoted by $\overline{R}$, was estimated using the *Capital Asset Pricing Model* (CAPM) (Equation 1), according to Ross *et al.* (2015). Furthermore, the country risk premium advocated by Dachraoui *et al.*, (2020) was added.

$$\overline{R} = R_F + \beta\,(\overline{R}_M - R_F) + \lambda \quad (1)$$

In which:
$\overline{R}$ is the expected rate of return on the asset;
R_F is the expected rate of return on the risk-free asset;
β is the systematic risk coefficient of the asset;
$\overline{R}_M$ is the expected rate of return on the forestry market portfolio;
λ is the country risk premium.

Equivalent Uniform Annual Cost

The Equivalent Uniform Annual Cost (EUAC) was calculated according to Simões *et al.* (2021), transforming cash flows into a uniform annual series of payments (Equation 2).

$$CAUE = P_0 \left[\frac{(1+i)^n \times i}{(1+i)^n - 1}\right] \quad (2)$$

In which:
P_0 is the total of all payments and disbursement flows over the project period;
n is the duration of the project;
i is the discount rate.

Stochastic analysis

Due to the uncertainties associated with the costs of implementing the PSA, the Monte Carlo method was used to incorporate stochastic solutions. That said, as we do not know the distributions of each variable that has the greatest implication on the outcome of the project, the triangular probability distribution was adopted (LYRA et al., 2010), delimited by ±15% of the base values of the costs.

The 100,000 pseudorandom numbers were generated using the @RISK© software (PALISADE CORPORATION, 2021). The number generator used was the *Mersenne Twister* (HARASE, 2019). To measure the degree of association between incurred costs and CAUE, *Spearman*'s linear correlation coefficient was used (CROUX; DEHON, 2010), with a significance level of 1%.

RESULTS

The discount rate (i) of investment projects was 9.73%. The average value of the CAUE of project A, in areas of priority sub-basins for public supply, was 7.64% higher than the CAUE of project B in areas of non-priority sub-basins. The CAUE for both projects presented a frequency close to the normal distribution, with a slight asymmetry of the curve to the right (asymmetry > 0) and platykurtic kurtosis (kurtosis > 0) (Table 2).

Table 2. Descriptive statistics of the Equivalent Uniform Annual Cost (USD ha^{-1}) for the implementation of PES.
Tabela 2. Estatística descritiva do Custo Anual Uniforme Equivalente (US$ ha^{-1}) para a implantação do PSA.

Parameters	Project A	Project B
Minimum EUAC (US$ ha^{-1})	1,648.51	1,522.08
Maximum EUAC (US$ ha^{-1})	1,978.39	1,826.99
Standard deviation (US$ ha^{-1})	40.60	39.10
Coefficient of variation (%)	2.24	2.33
Mean (US$ ha^{-1})	1,814.11	1,675.54
Asymmetry	0.0055	0.0026
Kurtosis	2.8207	2.8006

Percentiles		
10%	1,761.66	1,624.97
20%	1,779.09	1,641.98
30%	1,792.27	1,654.43
40%	1,803.52	1,665.26
50%	1,814.11	1,675.54
60%	1,824.65	1,685.64
70%	1,835.86	1,696.45
80%	1,848.94	1,709.16
90%	1,866.78	1,726.47

For both investment projects (A and B), the cost components that most impacted the total costs were organic fertilizer and tree seedlings in the area restoration phase and fence posts and wires in the delimitation phase. In this analysis, the moderate negative correlations (−0.40 < ρs < −0.69) of the costs of organic fertilizer in projects A (ρs = −0.64) and B (ρs = −0.67) and of the fence posts in projects A (ρs = −0.42) and B (ρs = −0.44). The amounts paid to the provider for areas to be restored showed a negative correlation considered weak (−0.20 < ρs < −0.39) in project A and very weak (−0.01 < ρs < −0.19) in project B (Figure 2).

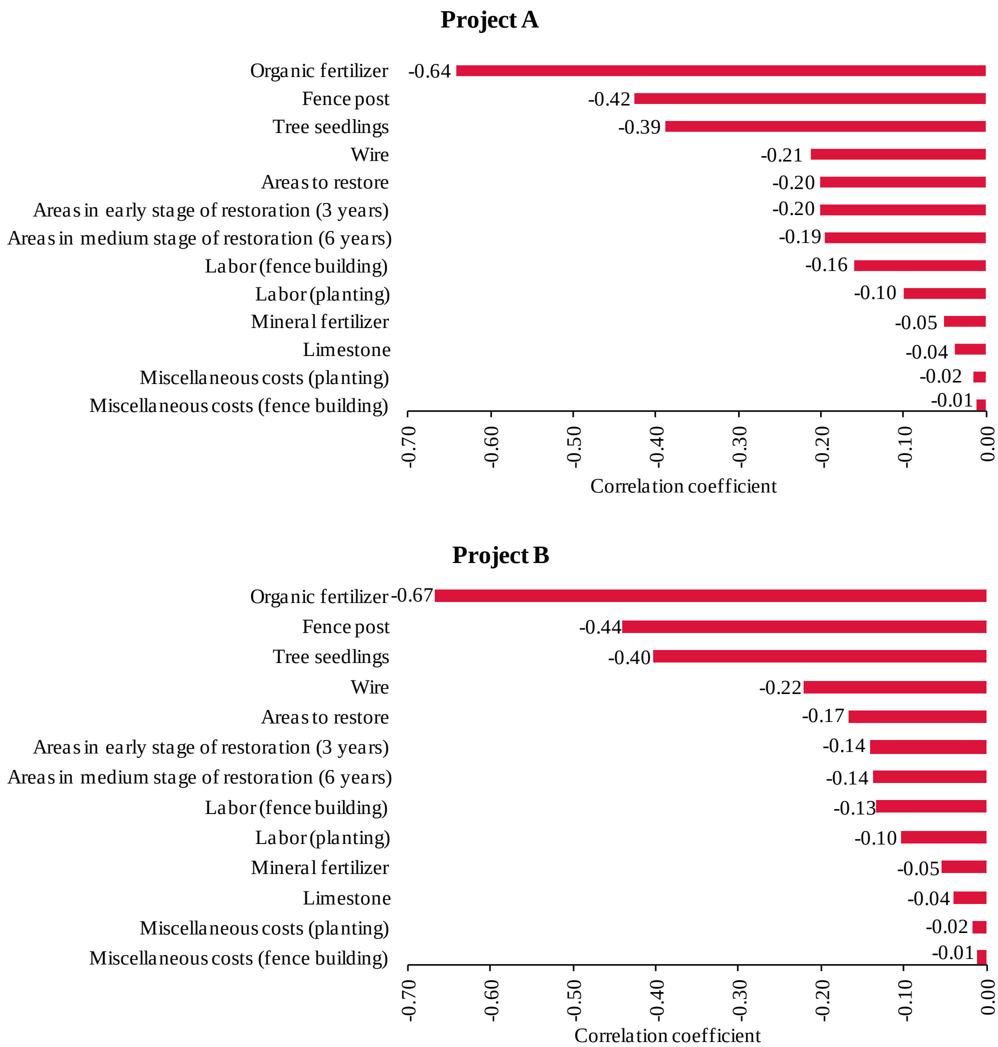

Figure 2. *Spearman's* correlation coefficient between costs incurred and amounts paid to PES providers and EUAC for investment projects A (priority areas) and B (non-priority areas).
Figura 2. Coeficiente de correlação de *Spearman* entre os custos incorridos e valores pagos aos provedores do PSA e o CAUE dos projetos de investimento A (áreas prioritárias) e B (áreas não prioritárias).

DISCUSSION

The estimate of the Equivalent Uniform Annual Cost of investment projects involving Payment for Environmental Services in hydrographic sub-basins of interest for public water supply is a fundamental metric, as it helps future decision-making in these projects. According to Stanturf (2021), these projects require incentives for restoration and disincentives for destructive land use practices. Agrawal *et al*. (2018) point out that incentives can occur in the form of direct benefits that are usually financial, however, ecological and social benefits are also important and must be considered.

The discount rate, considered one of the most important variables for estimating economic metrics that consider the value of money over time contributed by a single funding source, can be decisive for investment projects in PES. Verdone and Seidl (2017) point out that, in the context of a global effort to restore 350 million hectares of degraded forest landscapes by 2030, it was found that, when the benefits and costs of forest restoration are discounted at a 10% discount rate, only 230 million hectares could be restored to create benefits greater than costs. That said, the need to estimate it as accurately as possible is corroborated, which can support the increase in areas with PES projects.

The lowest EUAC occurred in project B (US$ 1,675.54), which refers to areas considered non-priority for public water supply in the municipality studied, which may be associated with the amount paid to the ecosystem service provider, being lower in these non-priority areas. However, it is important to emphasize that the main focus of the implemented PSA was the ecological and social benefit, evidenced by the provision of water for the public supply.

The cost components that most influenced the CAUE were those of the implementation and delimitation phases of the areas, mainly the organic fertilizer, which presented a moderate negative correlation in both projects. In projects involving active forest restoration with tree seedling planting, inputs accounted for more than 50% of total restoration costs (BRANCALION et al, 2019). The benefits of restoring degraded areas are received in the long term, while most of the costs related to this activity occur in the short term, together with the initial restoration actions.

The amounts paid for areas to be restored showed a negative correlation considered weak, in priority and non-priority areas. This result may be related to the horizon used for the nine-year evaluation, as Verdone and Seidl (2017) point out that decisions in forest restoration projects are particularly sensitive to the choice of time horizon and the discount rates adopted.

CONCLUSION

- The average Equivalent Uniform Annual Cost of investment projects involving the Payment for Environmental Services for priority and non-priority water sub-basin areas for public water supply is, respectively, US$ 1,814.11 and US$ 1,675.54.
- The costs related to the acquisition of organic fertilizer and fence posts are those that most impact the Equivalent Uniform Annual Cost, both in priority and non-priority areas.
- The Equivalent Uniform Annual Cost allows for analyzing the economic viability of investment projects involving Payment for Environmental Services.

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