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Special Edition

Methodological proposal for Payments for Environmental Services (PES) aiming to produce clean water in springs

Proposta metodológica de Pagamentos por Serviços Ambientais (PSA) visando a produção de água limpa em mananciais

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ABSTRACT

The Payment for Environmental Services (PES) instrument aims to quantify an Ecosystem Service (ES), so that its production is valued and based on a socioeconomic financial system for conservation. The land use on the terrain and the environmental attributes of a watershed directly interfere in the capacity to store water in the system of a functional unit and can be transformed into an Environmental Service. The proposed methodology aims to determine environmental indicators that can support the valuation of the production of water of better quality. The environmental attributes of geology, soil, slope and land use land cover are measured and analyzed. The zoning of the most vulnerable rural areas was determined for possible implementation of PES programs and valuation of spring water in proportion to the contribution of their water production area in the sub-basin. The methodology has proven to be efficient in determining the most environmentally vulnerable areas, in order to classify water production by sub-basins, and it suggests a market form for financing ecosystem conservation that considers the principles of the provider-receiver (which contribute to the generation of environmental service –water and soil quality) and user-payer (who benefit from and pay for it). The financial incentive to rural producers in watershed areas is only provided when management and conservation practices are carried out through activities of plant and animal production on a sustainable land use.

Keywords: Land use policy; Soil and water conservation and management; Agroecosystem

RESUMO

O instrumento de Pagamento por Serviço Ambiental (PSA) visa quantificar um Serviço Ecossistêmico (SE) de forma que sua produção seja valorada e baseada em um sistema financeiro socioeconômico da conservação. O uso do solo nas vertentes e os atributos ambientais de uma bacia hidrográfica interferem diretamente na capacidade de armazenar água no sistema de uma unidade funcional e podem ser transformados em Serviço Ambiental (SA). A metodologia proposta tem como objetivo determinar indicadores ambientais que possam dar suporte a valoração da produção de água de melhor qualidade. Os atributos ambientais geologia, solo, declividade e cobertura do solo são mensurados e analisados. O zoneamento das áreas rurais mais vulneráveis foi determinado para possível valoração da água de manancial de forma proporcional a contribuição da sua área de produção de água na sub-bacia e para a implementação dos programas de PSA. A metodologia se demonstrou eficiente para determinar as áreas mais vulneráveis ambientalmente, de forma a classificar as áreas ambientalmente mais vulneráveis e na produção de água por subbacias. O processo é passível de se tornar uma forma de mercado da água para financiamento da conservação do ecossistema que considera os princípios do provedor-recebedor (que contribuem para a geração do SA – água e solo de qualidade) e usuário-pagador (que se beneficiam e pagam o SA). O incentivo financeiro ao produtor rural de áreas de manancial deve ser realizado somente quando ocorrem práticas de manejo e conservação por meio de atividades de produção vegetal e animal de uso do solo sustentável.

Palavras-chave: Política de uso do solo; Manejo e conservação do solo e da água; Agroecossistema

1 INTRODUCTION

The Millennium Ecosystem Assessment introduced a conceptual and methodological approach that ensures human welfare by means of assets and services in the provisioning, regulating, cultural, and supporting categories (MEA, 2005). The United Nations (UN) designed objectives to help society achieve the Sustainable Development Goals (SDG), which address key challenges to ensure anthropic action in a sustainable way. The process presents a "global call to action to eradicate poverty, protect the environment and the climate, and ensure all people enjoy peace and prosperity." It should also provide "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (ONU, 2021).

According to the reflections of Ruffo and Kareiva (2009), nature is not a luxury item, but rather a necessary ingredient for human survival. In order to implement vegetable and animal production systems to provide food, water, soil-quality enhancement, and other services that sustainably take into consideration ecological, social, and economic dimensions, it is necessary to understand anthropic actions and the issue of environmental management, which in many activities oppose each other. Accordingly, government managers should promote initiatives designed to strengthen actions toward development that promotes economic growth without exhausting future natural resources.

Since the 1990s, Sunkel *et al*. (1990) has called attention to actions that deteriorate natural resources as a result of the growing use of energy, supplies, and technology, and to the need for encouraging sustainability. Considering the soil-landscape relation, Pissarra *et al*. (2004), Valle Júnior *et al*. (2014), and Pacheco *et al*. (2018) point out that the study of environmental attributes is relevant to provide subsidies for a more efficient environmental and socioeconomic management and for the development of nations (Valera *et al*., 2019; Pissarra *et al*., 2019).

Ola *et al*. (2019) suggest preparing methodological proposals targeting equity and the signing of contracts in the communities as key elements for successful programs. This also demonstrates that the incentive mechanism for Payments for Environmental Services (PES) schemes suitable for a given region meets conservation and natural-resource preservation objectives. Parkhurst (2011), Canova *et al*. (2019), and Tsur (2020) highlight that such schemes depend on economic demand and on soil conservation and protection.

To be efficient, PES identifies possible financial incentives of the environmental service to valorize conservation and preservation and considers the principles of user-payer and provider-receiver (Valera *et al*., 2017). Farmers can contribute towards the creation of services and can be compensated for providing such services (as the users of clean water). Accordingly, PES becomes a market-based instrument and seeks to conserve and promote the proper management through protection activities and the sustainable use of natural resources, such as soil and water.

The vegetable and animal production system using soil and water conservation and management and economic anthropic actions that consider the relations between human beings and the environment can be valued (Bellver-Domingo, 2016, Tsur, 2020) and related to an investment, rather than to a cost for society. Sagoff (2011) shows criteria for identifying, measuring, and assessing services and investigates the differences between economic and ecological issues.

Ecosystem services should not be regarded as just another item for an economic assessment in order to secure funding for the provider of preservation in ecological restoration, but rather as an action of conservationist management in a production system to secure financial resources that improve earnings of the landowner farming with sustainable practices (Canova *et al*., 2019; Pissarra *et al*., 2021).

One of the most important ecosystem services is water resources, which represent a potential in integrated management to become an ES mechanism based on values (Andrade *et al*., 2020), with an ecological function and economic value (Settre *et al*., 2019; Cheng *et al*., 2019; Tsur, 2020; and Pissarra *et al*., 2021). According to water eco-services assessment indicators (Araújo and Chrispim, 2017; FAO, 2017; and Fan and Chen, 2019), the benefits are essential to health. When the production system is not valorized, the result is often a polluted and degraded water environment (Saran *et al*., 2018).

The National Water Agency's (ANA) Water Producer Program has been implemented as an instrument to valorize the production of water in springs. However, according to Lima *et al*. (2015), there is nearly no socioeconomic monitoring of the communities involved in these projects, which makes it impossible to identify social gains and losses under these initiatives. The methodological proposal for a scheme to implement a PES in River Basins (PES-RB) program defines indicators to present in simple terms the metrics of environmental attributes (Pissarra *et al*., 2021) in the basin, using as bases of comparison the dimensional characteristics of the basin and the volume of water produced there.

Using remote sensing data and geographic information system, we can analyze the agro-ecosystem and implement less impactful anthropic actions involving proper and sustainable management in the regions of hydrological importance. The methodology aims to define metrics and indicators that could appraise production systems in water-producing slopes. These should aim the development of farming and ranching practices that are economically viable and socially acceptable, with management that considers the conservation of soil, water, and vegetation diversity.

Another relevant aspect is considering the collective awareness for such sustainable actions in the water basin upstream the spring and being part of the Environmental, Social, and Corporate Governance (ESG) system regarding social and environmental factors. The results obtained from the values defined for the environmental attributes should be classified. The defined classes can be considered environmental assets, being property and rights that are monetarily measurable, to represent present and/or future benefits to preserve, minimize, and recover environmental quality and characteristics. Alcon *et al*. (2020) recognize the conflict between farming expansion and forest restoration. Yet they also emphasize the range of benefits provided by the sustainable management of an agricultural productivity system combined with livestock breeding (Geussens *et al*., 2019).

Farming, forestry, (Moraes *et al*., 2017) and pastureland (Oliveira *et al*., 2019) systems are relevant services, in high demand by society. They are related to social and economic development of a community. Accordingly, implementing a model that considers the uses of soil in production systems that balance sustainable ecological, social, and economic functions, in order to produce clean water in water basins, still represents a challenge (Settre *et al*., 2019; Cheng *et al*., 2019; and Tsur, 2020).

Oliveira *et al*. (2013) list some Brazilian programs of PES systems and the many actions have been carried out to implement these systems (ANA, 2019; 2021).

However, we are still missing farming policies that could create cooperation between farmers and a better management of soil use, in order to propose schemes for sustainable Payments for Environmental Services (PES). Núñez-Regueiro *et al*. (2019) highlight the technical and scientific gap to appraise such ecosystem.

Recognizing this fact, our study was designed to present a methodological proposal for PES based on environmental attributes, the vulnerability of ecosystems, and the production of water in sources of water basins. The key idea is to encourage landowners to implement farming and livestock production management aimed at protecting and conserving natural resources, valuing water in more sustainable environments as environmental services (ES). The goal is to achieve an ESG system and highlight the importance of building a new relation of sustainability with the means of production.

2 MATERIAL AND METHODS

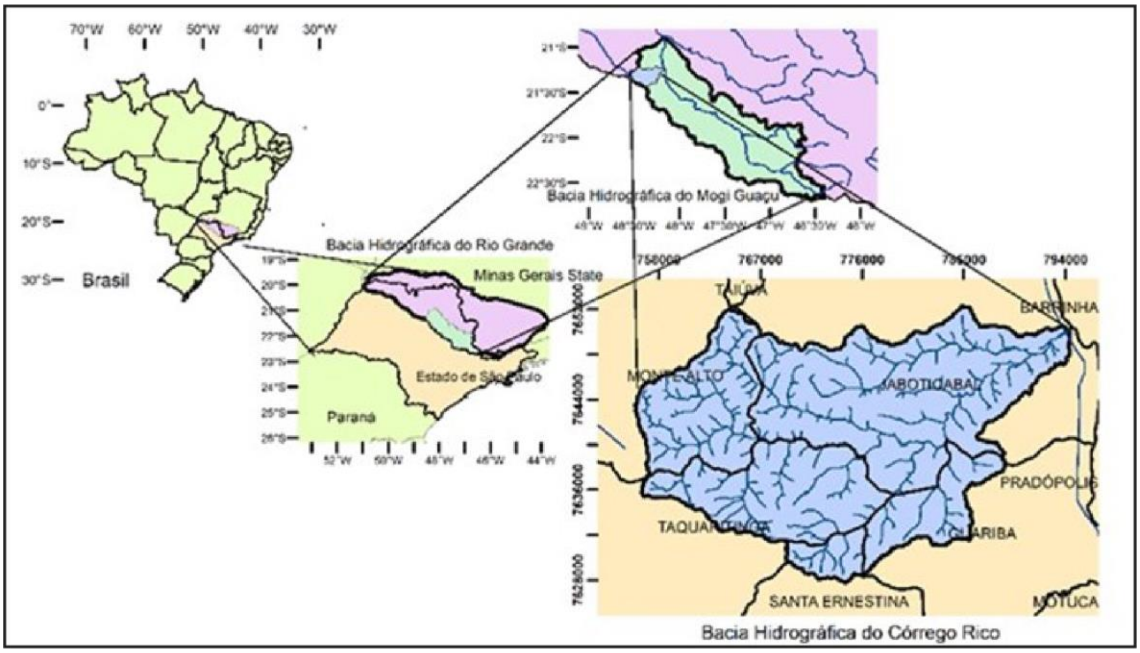
Our area of study is the water basin of the Rico Stream, which covers 530 square kilometers in the northwest section of the state of São Paulo and includes the municipalities of Jaboticabal, Monte Alto, Taquaritinga, Santa Ernestina, and Guariba, as shown in Figure 1.

This area is located in the 9th Water Resources Management Unit (UGRI in Portuguese) of the State System for Water Management and State Water Policy (SIGRH in Portuguese), called Rios Pardo/Mogi-Guaçu. Its coordinates are latitude 7652337m and 7628137m North, longitude 756463m and 794623m East; Córrego Alegre, UTM, Zone 22S, in a Mercator cross-projection.

According to the Köppen system, the climate is Cwa, monsoon-influenced humid subtropical climate; average annual rainfall ranges between 1,100 mm and 1,700 mm; average temperature during the hottest month is 22°C and during the coldest month is 17°C (Alvares *et al*., 2013). The area is located in the V-Western

Plateau geomorphic province. Its geology consists of consolidated sandstone with limestone cement, part of the Bauru formation (upper cretaceous Kb), conglomerate facies and effusive rocks of the Serra Geral Formation, according to Almeida *et al*. (1981). The area's topography is strongly undulating, within a limit with the Jaboticabal range (irregular to mountainous); altitude ranges between 488 meters and 700 meters, according to Penteado e Ranzani (1971). According to Camargo *et al*. (1987), the main soil units were identified in the Brazilian Soil System as Latosol and Acrisol. The original natural vegetation is semideciduous broadleaved forests (Veloso *et al*., 1991); the main soil uses are annual crops, permanent crops (sugarcane, planted forests, etc.), and pastureland.

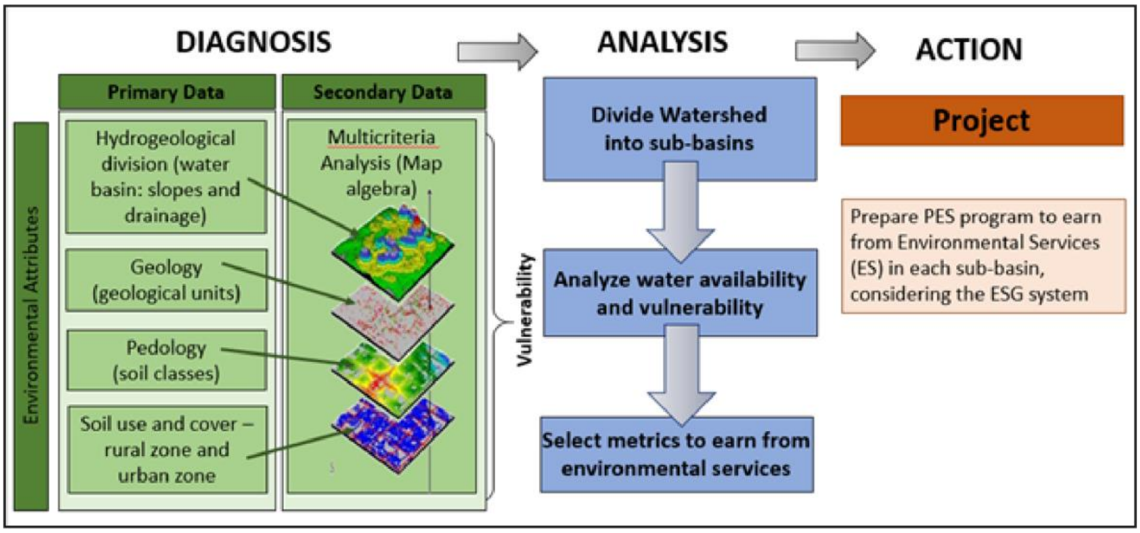
Figure 1 – Location of the Rico Stream basin, State of São Paulo, Brazil



Source: Authors, 2021

Our proposal aims to assess environmental attributes and determine the vulnerability of the water spring areas in the territorial unit of the water basin, using diagnostic data, analysis, and action based on the flowchart (Figure 2).

Figure 2 – PES Model Flowchart based on vulnerability and land use



Source: Authors, 2021

The diagnostic for primary and secondary data were realized and analyzed by map algebra in multicriteria analysis in the sub-basin division areas, and ecosystem vulnerability and water production.

Primary data for each cell (considered as a pixel per remote sensor/raster image unit) consisted of information plans of primary data: (1) Hydrogeological division of the water basin contour processed in a digital elevation model (MDE) using a basin outlining tool of the Soil and Water Assessment Tool (ArcSWAT) hydrological model. The hydrological compartments of the areas studied (sub-basin functional units) were defined according to the slope of the terrain in the set of altimetric data that formed the drainage lines and the topographic dividers. (2) Geology, obtained from CPRM (2005); (3) Soil pedology obtained from the Soil Map of the State of São Paulo (Rossi, 2017); and (4) obtained with the land use and land cover (LULC) of the soil (natural vegetation soil and land uses based on anthropic actions) in the Biome Map, a multi-institutional initiative to generate annual maps of LULC based on automatic classification processes applied to satellite imaging. The full description is available at http://mapbiomas.org.

Secondary data consisted of a set of cartographic algebra that manipulates operations of geographic data in a geographic information system (GIS). The raster

(PIs) layers were in the same dimension to produce the results of the addition algebraic additions and subtractions that were made and followed a methodology executed in the Spatial Analyst tools, operators, and functions. The PI algebra was integrated using Python and the Python and ArcPy functionalities and their extensions (modules, classes, functions, and properties) were made using the ArcGis. Each pixel of the landscape elements performed an environmental function in the geomorphological development of the sub-basin. The spatial vicinity and the transformations were categorized in cell areas that shared the same value.

Environmental vulnerability (Vu) refers to the incapacity of the sub-basins (the functional work unit) within the water basin of supporting the severe effects of the climate on the natural environment over decades, considering the natural erosion process and the anthropic use pressure. The understanding of vulnerability, as a methodological approach, involves the analysis of risks and assets of the vulnerability index, which is a measure of the exposure of the environment to some danger (natural soil loss).

To evaluate vulnerability data, we applied a modification of the methodology presented by Crepani *et al*. (2001), Santos *et al*. (2016), and Machado *et al*. (2018). The vulnerability index (Vu; Eq.1) comprises quantitative indicators of environmental attributes of geology (G), soil (S), declivity (Dd), and land use (LU). Each cell (pixel) contained a set of information to perform the functions in the development of the geographical entity containing the environmental attribute, defined by weights according to the work of Saaty (1977) and Pissarra *et al*. (2021), as shown in equation (1):

$$\mathrm{Vu} = (0{,}056\mathrm{xG}) + (0.122\mathrm{xS}) + (0{,}263\mathrm{xDd}) + (0.558\mathrm{xLU}) \quad (1)$$

Data were processed and analyzed statistically in a spatial-decision-support system based on Multi-Criteria Decision Analysis (Saaty, 1977), which defined areas of higher or lesser vulnerability of the water basin according to environmental attributes and human actions.

For the hydrological calculation of the sub-basins, we used the "*Estudo de Regionalização de Variáveis Hidrológicas*" (Regionalization of Hydrological Variables Study) developed by DAEE (1994) and the work of Vilella; Mattos, (1975). We determined the annual minimum flow values of seven consecutive days ($Q_{7,10}$) over a 10-year period (T).

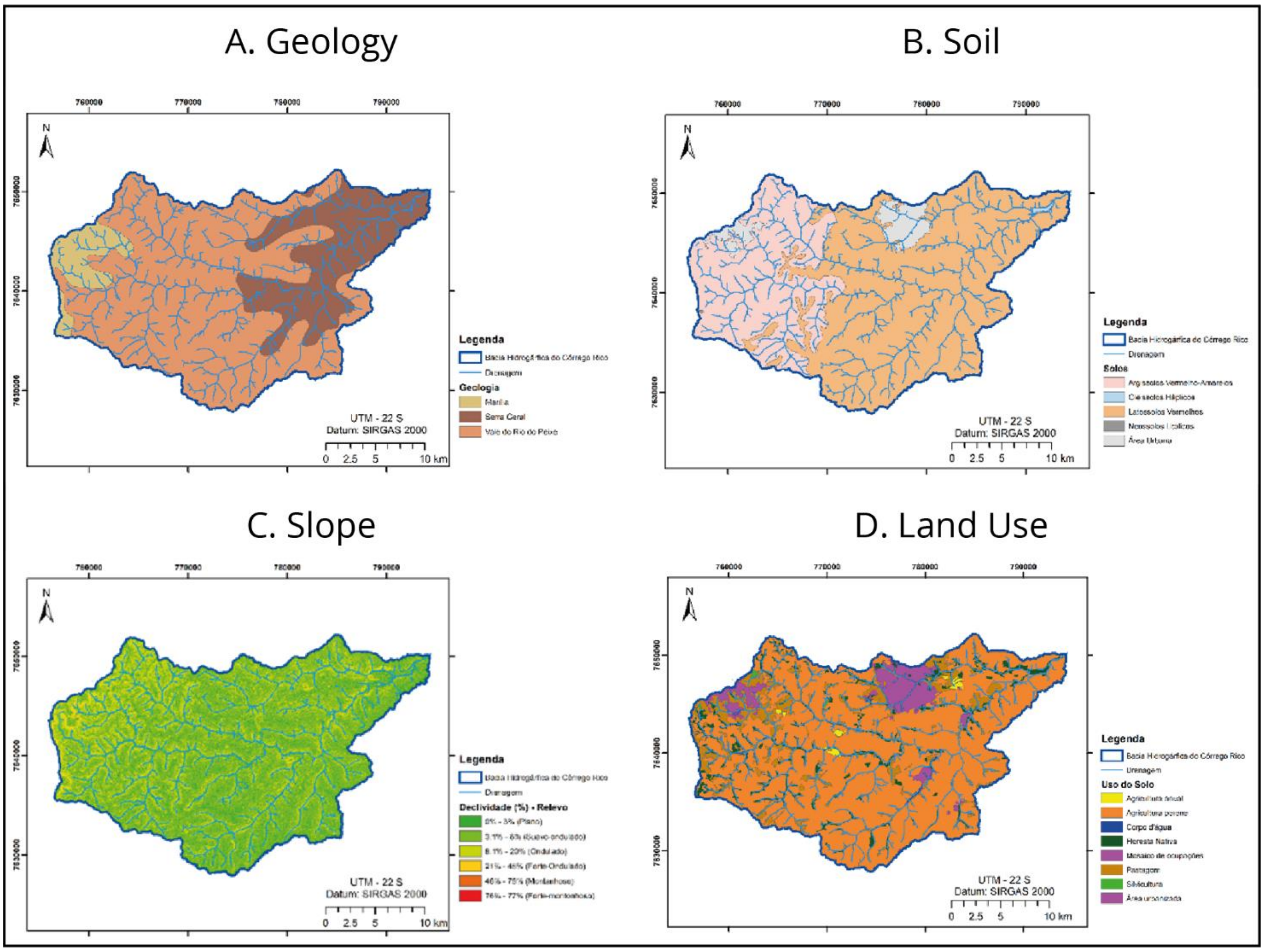
These values were determined based on Conama Resolution 357/2005 (BRASIL, 2005), which defines criteria for classifying rivers for categorization regarding a reference flow in the most critical flow condition, which is that of drought, when the dilution capacity of the river is reduced (the river has less flow to dilute the discharge entering it) with a 10-percent risk of having values equivalent to or less than that in any year.

The values are related to the balance between the water production potential and the volume demanded by the different consumptive uses. To represent this drought period and guide the granting of water use permits, we adopted this minimum flow of reference, as defined by the Water Basin Plan and by State Law no. 9034 of 1994, "$Q_{7.10}$," which is the same suggested for the State of São Paulo under State Law no. 9034 of 1994.

3 RESULTS AND DISCUSSION

In the ecosystem of the Rico stream basin, the geology, soil, declivity, and land use environmental attributes (Figure 3) were considered in the calculation of the environmental vulnerability.

Figure 3 – Environmental attributes



A. Geology – G; B. Soil – S; C. Slope – Dd; D. Land Use – LU of the Rico Stream Basin
Source: Authors, 2021

Classification and quantification of the occurrences of these attributes are reproduced in Tables 1, 2, 3, and 4.

Table 1 – Classes and percentages of geologies located at Rico Stream basin, State of São Paulo

Geology	**Area (km²)**	**Area (%)**
Marília	37.51	7%
Vale do Rio do Peixe	394.81	69%
Serra Geral	140.01	24%
Total	572.32	100%

Source: CPRM – Mapa Geologico do Estado de Sao Paulo 1.750.000

Table 2 – Classes and percentages of soils and urban areas located at Rico Stream basin, State of São Paulo

Soils / Urban Area	**Area (km²)**	**Area (%)**
Urban Area	26.14	4.6
Red-Yellow Acrisol	176.32	30.8
Haplic Gleysol	0.90	0.2
Red Latosol	368.80	64.4
Litolic Neosol	0.18	0.0
Total	572.33	100%

Source: State of São Paulo: Secretaria do Meio Ambiente, Instituto Florestal (Environmental Secretary, Forestry Institute). Mapa pedológico do Estado de São Paulo: revisado e ampliado (Pedologic map of the state of São Paulo: revised and expanded). Marcio Rossi. – São Paulo: (2017).

Table 3 – Classes and percentages of relief located at Rico Stream basin, State of São Paulo

Relief	**Area (km²)**	**Area (%)**
Flat: 0% – 3%	62.77	11%
Slightly undulating: 3.1% – 8%	332.54	58%
Undulating: 8.1% - 21%	170.71	30%
Highly undulating: 21.1% – 45%	6.24	1%
Mountainous: 45.1% – 75%	0.06	0%
Highly mountainous: < 75.1%	0.01	0%
Total	572.33	100%

Source: ALOS image (12.5 X 12.5)
EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA (EMBRAPA). Serviço Nacional de Levantamento e Conservação de Solos (National Soil Survey and Conservation Service) (Rio de Janeiro, RJ). Súmula da 10. Reunião Técnica de Levantamento de Solos. Rio de Janeiro, 1979. 83p. (EMBRAPA-SNLCS. Miscellaneous, 1).

The delimitation of the 96 territorial sub-basin units (Figure 4) in the Rico Stream basin was defined in the line of higher altitudes starting at the outlet point of each unit, which corresponds to the point of smallest altitude in the polygon. At the outlet point, we collected flow data $Q_{7,10}$. The drainage system in each region corresponded to the drainage line of points of smaller altitudes of the functional ecosystemic unit. The drainage density was formed according to the geology and relief characteristics. The areas with the most rugged relief are located upstream, while in the downstream area of the relief it is slightly undulating, causing dissection of the landscape (Figure 4, A).

Table 4 – Classes and percentages of land uses located at Rico Stream basin, State of São Paulo

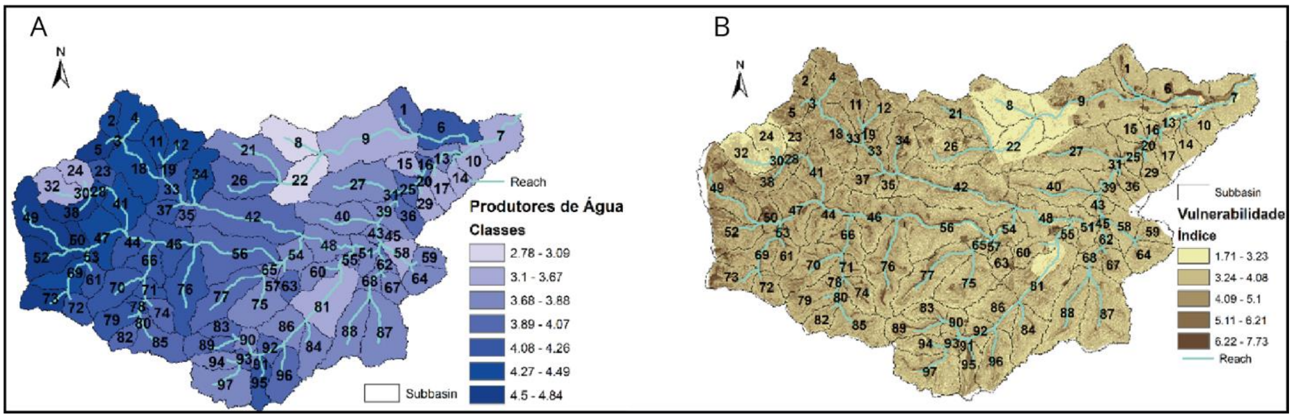
Land Uses	**Area (km²)**	**Area (%)**
Annual crops	3.03	1%
Perennial crops	431.20	75%
Water area	0.79	0%
Urbanized area	35.57	6%
Native forest	39.86	7%
Occupancy mosaic	0.17	0%
Pastureland	61.04	11%
Forestry	0.73	0%
Total	572.37	100%

Source: Projeto TerraClass Cerrado 2013 – Mapeamento do Uso e Cobertura Vegetal do Cerrado (INPE, 2015)

The most vulnerable areas were observed at the higher levels, the source of the Rico Stream basin, as shown in Figure 4 B. Sub-basins 32, 24, 22, and 8 are urban areas and were not included in the vulnerability analysis of the rural zone. The calculations in each pixel provided access to the cause-effect relations between the environmental attributes of geology, soil, declivity, and land use that comprise each sub-basin in determining the most vulnerable environments (Figure 4B). Resolutions (spatial, spectral, temporal, and radiometric) of the images should be considered equivalents in the coherent relations between each information plan of the environmental attributes in calculating the vulnerability.

In the sector of each sub-basin, the water natural resource had its flow calculated ($Q_{7,10}$). We observe that in the Rico Stream basin the areas producing water (Figure 4 A) are shown in the upstream source, which is the most vulnerable region of the basin (Figure 4 B).

Figure 4 – Functional water-producing units (A); Environmental vulnerability (B) of the Rico Stream basin, State of São Paulo



Source: Authors, 2002

Because water quality and water production efficiency are not numerical factors, it was necessary to use indicators to calculate the level of service. This way, the methodology is based on the efficiency of water production, evaluated in relation to the ratio between flow and the area of each functional unit, which provides the availability and the water rate to determine metric indictors and make the system measurable. Thus, the calculated water service is based on the land management to increase flow of water (seepage/runoff) and of the goods and services in the performance of the source area in supplying water. The result represents a percentage that shows the volume of the resource (water) is produced in each functional unit. After calculating each sub-basin, the percentage value is obtained in relation to the entire area, i.e., in the ecosystem of the Rico Stream basin.

Reading Law no. 14119, of January 13, 2021, which creates the National Policy for the Payment of Environmental Services (PNPSA) and defines concepts, objectives, guidelines, actions, and criteria for implementing this policy, and creates the National Register of Payment for Environmental Services (PFPSA), which govern contracts for the payment for environmental services, in this methodology, the water basin is considered an ecosystem, a complex and dynamic region of vegetable, animal, and microorganism communities, which together with their inorganic environment (environmental attributes) interact as a functional unit (BRASIL, 2021).

The eco-systemic services represent relevant services for society generated by ecosystems (sub-basins) in terms of maintenance, recovery, or improvement of environmental conditions, in the following ways: provision services, support services, regulation services, and cultural services (BRASIL, 2021). The production of water as a service depends on the eco-systemic function, which is the interaction between structural elements of the water basin comprising the environmental attributes (Figure 3 and Tables 1, 2, 3, and 4). Environmental services (i.e., storing more water in the system) should be rendered together with individual or collective activities that will help maintain, recover, or improve eco-systemic services (BRASIL, 2021). When rendered by economic agents, these services should conserve and/or recover natural resources, such as water and soil.

The payment for environmental services is a voluntary transaction, under which a payer of environmental services transfers to a provider of such services the financial funds or other form of remuneration, under the conditions agreed, always in accordance with applicable laws and regulations. The payer of environmental services can be the public authority, civil society organization, or private agent (individual or organization), local or international, which provides payments for environmental services in accordance with the above. The provider of environmental services will be an individual or organization (private or government controlled), or family group or community groups that meets eligibility criteria and maintains, recovers, or improves environmental conditions of ecosystems (BRASIL, 2021).

The methodological proposal for a PES program as a planning tool for public policies in the Sustainable Agricultural and Ranching Model (MAS), regarding ESG for the Production of Clean Water in River Basins (MASPAL-BH) is based on Law no. 14119, of January 13, 2021, and which proposes spring areas in ecosystems of water micro-basins, as shown in the diagram reproduced in Figure 5.

Figure 5 – PES planning scheme for spring areas in water basins

Source: Authors, 2002

The set of soil and water management and conservation practices in the headwater sub-basins (water sources) is considered an environmental service (ES). In this set of activities, farmers that actually carry out demonstrably sustainable farming practices, such as the implementation of agro-forest systems (SAF), will be the providers and receivers of the incentives. If this set of activities improves, conserves, and recovers eco-systemic services (ES) that generate benefits, such as clean water and soil of very high quality, this activities will be considered relevant benefits for society produced by natural resources. Since the PES assumes that is providers carry out clear, effective, and lasting activities in the ecosystems involved (source sub-basins – water production springs), we can implement the "provider-receiver" and the "user-payer" PES (Valera *et al*., 2017).

In each sub-basin, based on the percentage of water flow of each spring/unit of the area (percentage of water to be used by society and the homes served), we can calculate the level of ES directly associated with the flow and the water capture area in each sub-basin, as well as the water storage process in the hydrogeological system. This result gives us an indicator of the water-producing spring functional units. When detecting more vulnerable areas in the basin, the PES program will be programmed to provide subsidies to the farmer, in the form of supplementary financial funding, to build a sustainable vegetable and animal production system in these areas.

The PES manager will monitor and check if the region producing water is in the most vulnerable area. If the landowner is applying best management practices to preserve and conserve water and soil resources in the headwater hydrographic sub-basins, the results of the model will indicate that the monitoring of water in the source and the uses of land under an ES scheme are sufficient for the payments; and this will be the key point to ensure the success of the PES program.

This way, we can improve indicators and offer sustainable water services and farming and ranching practices, with higher volume and better quality of water to the Rico Stream. A qualitative analysis shows that adopting more sustainable farming and ranching activities, in line with ESG principles, and the introduction of fairness and contracts with the community are the key elements for successful programs.

The providers will be farmers that will offer to preserve and maintain water and soil environmental services with good quality based on the implementation of sustainable production practices. Users will be able to buy cleaner water and to benefit from such ES. In this article, the focus of the PES is the management of areas upstream the springs, to increase biodiversity and the storage of clean water in the system of each sub-basin using a series of management techniques and conservation of both the soil and water in agro-ecosystems.

The steps implemented should be monitored. The main objectives are to revert the environmental deterioration situation and to ensure the main area where groundwater recharging takes place has denser vegetation coverage. This PES methodological proposal does not consider a system as a tax, but rather as remuneration for implementing vegetable, forestry, and animal production systems that maintain and recover water basins that supply water of good quality (ES). This represents a first version for a methodological proposal for Payments for Environmental Services (PES) designed to produce clean water in springs – Clean Water (B) in the Rico Stream Basin (MASPAL - BH).

4 CONCLUSION

The methodology proposed for program for Payment of Environmental Services (PES) is based on determine the environmental attributes to evaluate the most vulnerability areas and the availability of water in the sub-basins of the water sources to indicate the areas that must implement a better and sustainable management practices. This involves the targeting and implementing payments for ecosystem services for bundling biodiversity conservation with water services market for the funding of ecosystem conservation, which considers the user-payer and provider-receiver principles, under which those benefiting from environmental services (e.g., users of clean water) should pay for them, while those who contribute to create such services (e.g., landowners of upstream areas of the sub-basins that implement highly-sustainable management practices) should be compensated for providing water and soil in better quality such services. Thus, this tool (in its initial version) seeks to conserve and promote the proper management through protection activities and the sustainable use of natural resources, such as soil and water in sources.

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