The Importance of Integrating Financial Incentives and Command and Control Instruments to Protect Water Quality

Importância da Integração de Instrumentos de Incentivo Financeiro e de Comando e Controle na Proteção da Qualidade da Água

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ABSTRACT
Managing water resources is the most crucial challenge of the 21st century (UNESCO, 2018). Command and Control instruments, such as the 2012 Native Vegetation Protection Law, impose forest conservation and restoration mechanisms in order to protect water bodies, however, it is not enough to prevent deforestation (MELLO et al., 2018). Thus, Payments for Environmental Services (PES), a voluntary financial incentive, have been identified as a potential tool for adopting conservation practices to promote the protection of water resources and ensure public supply (SONE et al., 2019; LOPES et al., 2020). Thus, the main objective of this work is to assess how environmental command and control policies and financial incentive policies can be integrated as watershed management strategies to enhance the supply of water environmental services.

Keywords: Water Quality, Environmental.

RESUMO
O gerenciamento dos recursos hídricos é o desafio mais crucial do século 21 (UNESCO, 2018). Os instrumentos de Comando e Controle, como a Lei de Proteção da Vegetação Nativa de 2012, impõe mecanismos de conservação e restauração florestal a fim de proteger os corpos hídricos, no entanto, ela não é suficiente para evitar o desmatamento (MELLO et al., 2018). Assim, os Pagamentos por Serviços Ambientais (PSA), um incentivo financeiro voluntário, têm sido apontados como uma potencial ferramenta para adoção de práticas de conservação para promover a proteção dos recursos hídricos e garantir o abastecimento público (SONE et al., 2019; LOPES et al., 2020). Dessa forma, o objetivo principal deste trabalho é avaliar como as políticas de comando e controle ambientais e políticas de incentivo financeiro podem se integrar como estratégias de gestão das bacias hidrográficas para potencializar a oferta dos serviços ambientais hídricos.

Palavras-chave: Qualidade da Água, Ambiental.

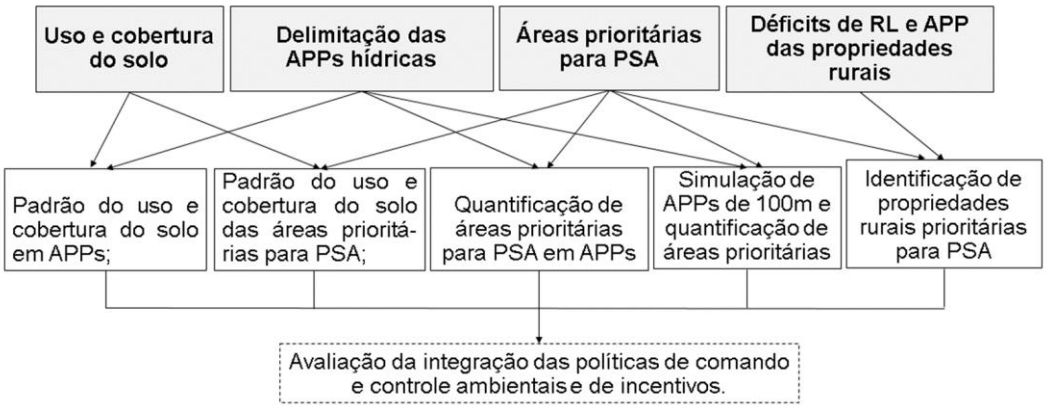
1 INTRODUCTION

Managing water resources is the most crucial challenge of the 21st century (UNESCO, 2018). Command and Control instruments, such as the 2012 Native Vegetation Protection Law, impose forest conservation and restoration mechanisms in order to protect water bodies, however, it is not enough to prevent deforestation (MELLO et al., 2018). Thus, Payments for Environmental Services (PES), a voluntary financial incentive, have been identified as a potential tool for adopting conservation practices to promote the protection of water resources and ensure public supply (SONE et al., 2019; LOPES et al., 2020). Thus, the main objective of this work is to assess how environmental command and control policies and financial incentive policies can be integrated as watershed management strategies to enhance the supply of water environmental services.

2 METHODOLOGY

The study area comprises the Sarapuí river basin, located in the state of São Paulo. We carried out a diagnosis of land use and land cover in the Sarapuí River basin and identified priority areas for conservation using multi-criteria analysis and participatory techniques, both stages within the scope of FAPESP project 2018/21612-8. Public data was also extracted from the "Biota-Fapesp Forest Code" project regarding the characterization of rural properties in the basin (MELLO et al., 2022a).

Figure 1 - Conceptual model for evaluating areas to receive PES in the Sarapuí river basin, SP-Brazil.



3 RESULTS AND DISCUSSION

The Sarapuí river basin is predominantly occupied by agricultural production (53.61%), 31% of the land is occupied by pasture while native forest occupies 27%. The APPs total 31,073 ha, around 20% of the total area of the Sarapuí river basin (Fig.2). More than half of the water APPs are occupied by native vegetation (around 52%). Pastures occupy an area of 9,054.69 ha (29.12% of the total APP in the basin) while agriculture occupies 3,007.65ha (8.39%).

Figure 2 - Land use and cover in the water Permanent Preservation Areas in the Sarapuí river basin, SP-Brazil.

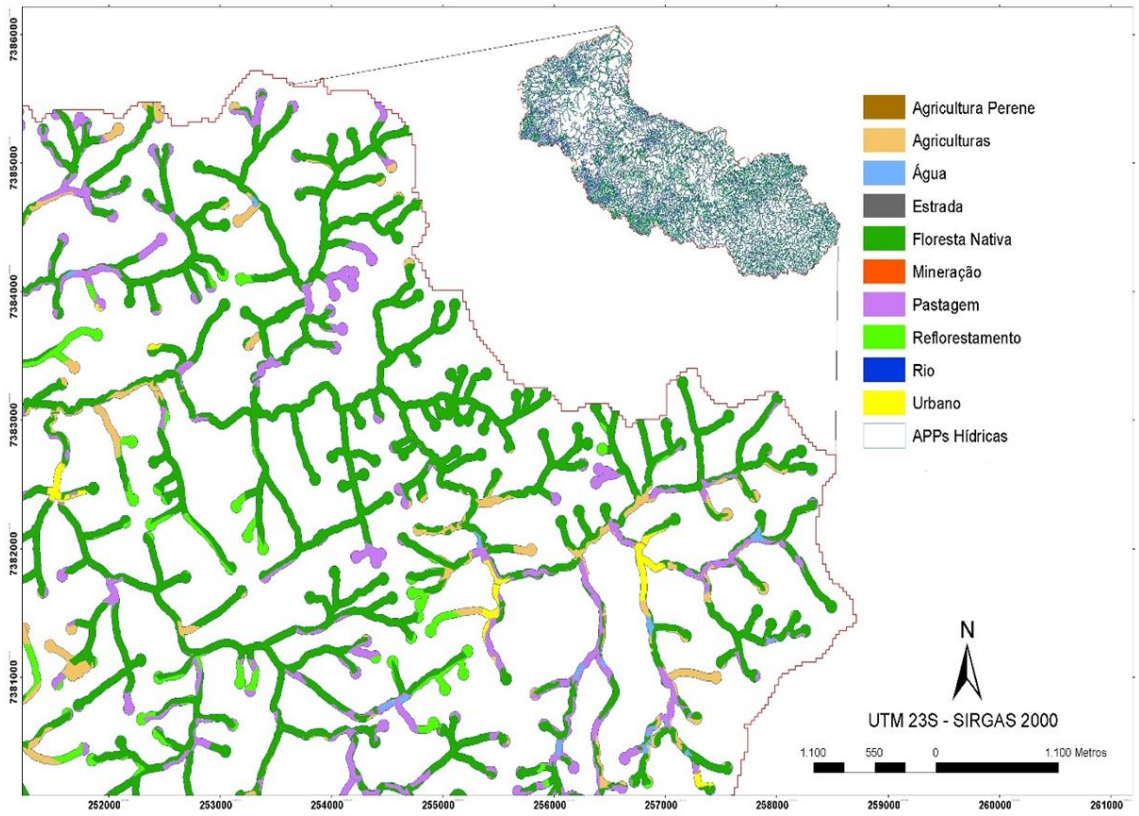
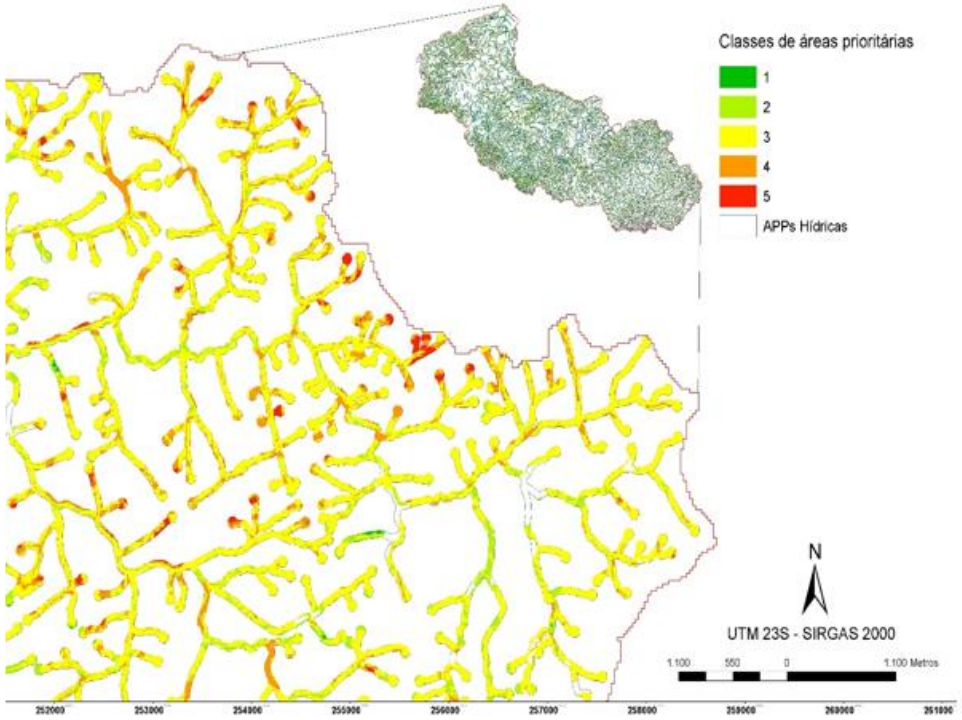


Figure 3 - Classes of priority areas for PES within APPs in the Sarapuí river basin, SP-Brazil.



Only 32.5% of the high priority areas are within the limits of the water APPs imposed by the legislation, while the very high priority class has a proportion of 24.2% (Fig. 3). Thus, 69.4% of classes 4 and 5 are outside the APP limits established by the LPVN (Tab. 1).

Table 1 - Total area (in hectares) according to PES prioritization class and the total area of each class in Permanent Preservation Areas.

Class	Prioritization	Total in ha		% Total	Priority areas in APP	% of each class in APP
1	Very low	26327,2		17	1531,45	5,8
2	Low	49446,1		31,9	7662,67	15,5
3	Average	61064,4		39,4	17801,4	29
4	High	7472,4		4,8	2431,7	32,5
5	Very high	2172,7		1,4	525,44	24,2
TOTAL		**146482,8**		**94,5**	**29952,66**	**20,4**

There is intense agricultural activity in the APPs, which shows that the LPVN does not guarantee total protection of these areas and, consequently, the provision of water services in the watersheds. In our simulations, an area of 100m of APPs would increase the coverage of these highest priority classes by more than 150% in relation to the areas defined by the LPVN, which would represent a positive impact on water quality. Ou et al. (2016) point out that land use in a 100m riparian zone is responsible for 60% of the variation in water quality and that a 50m zone represents a low proportion of the entire watershed area, which weakens its influence on river conditions. However, a change in environmental legislation along these lines is unlikely.

Da Silva et al. (2023) found that 99% of deforestation between 2012 and 2020 in both the Atlantic Forest and the Cerrado occurred on private land, indicating that native vegetation is under strong anthropogenic pressure in both biomes. Considering that there are no conservation units in the basin and that 70% of the basin's total area is occupied by private properties that cover more than 63% of the highest

priority class areas (4 and 5), preserving native vegetation within private properties is a fundamental strategy.

In the basin there are still few deficits in APPs, even though almost half of these areas are not covered by native vegetation, probably due to the LPVN which allows the consolidated use of these areas that were deforested until 2008. In relation to RL, there are also few deficits in relation to the areas with surplus vegetation that can be offered as CRA. According to Da Silva et al. (2023) these surpluses can be artificial, because as landowners have the legal right to decide where to conserve natural vegetation as RL within their properties, they can declare RL in areas suitable for human use and create "artificial surpluses" of native vegetation that can be cleared or traded as CRA. In addition, 69.4% of the highest priority class areas are outside the limits of APPs, which makes them unprotected under environmental legislation and susceptible to deforestation. It is therefore clear that the LPVN is not enough to stimulate reforestation and the conservation of additional areas, so it is necessary to adopt and integrate other conservation strategies.

Strict protection of native vegetation areas should be a priority to minimize the impacts of land use on freshwater ecosystems. Sparovek et al., (2015) point out that command and control policies are positively related to the protection of primary vegetation and the decrease in deforestation, the increase in secondary vegetation (SARAIVA et al., 2020), the protection of riparian areas and help mitigate point source pollution (KIMANI, THIONG'O; MWANGI, 2020). However, they are not enough to deal with diffuse pollution (KIMANI, THIONG'O; MWANGI, 2020) or to conserve other areas that directly influence the quality of water resources, in addition to riparian areas, as identified in our analysis. In this sense, integrating legislation with other conservation strategies can help landowners protect areas not covered by the LPVN, but which directly impact water quality. This integration can contribute to more effective management of water resources.

PES as a tool to help conserve native vegetation, especially in areas not protected by other policies, is a strategy advocated by several authors who further argue that PES can raise awareness about the value of ecosystem services, positively influencing community attitudes (BANKS-LEITE et al., 2014). These initiatives have the potential to fill regulatory gaps, improve land use practices and contribute to broader changes in environmental management. PES can generate income for farmers, as well as enabling them to comply with environmental legislation and generate deforestation-free products (STABILE et al., 2020). It should be noted that analyzing the regional context and land use practices throughout the basin can help define specific widths of riparian reserves and develop complementary land use strategies at the watershed level.

4 CONCLUSION/FINAL CONSIDERATIONS

Large portions of areas defined as priorities for conservation are not covered by the LPVN and are located outside the limits of the APPs. A protective margin of 100m would increase the protection of these areas by more than 150%. The basin is largely occupied by private rural properties, mostly family farms. The deficits in Legal Reserves and APPs are not significant compared to the surpluses that can be offered as CRAs. Thus, there is no incentive on the part of the LPVN to conserve or restore areas in the Sarapuí river basin. In this way, PES can be a strategy to promote conservation and forest restoration of priority areas both within the APPs and for the additional conservation of regions that are important for maintaining water quality but which are not regulated by environmental legislation. We believe that the methodology applied in this work was able to take advantage of the correlations between environmental policies and could optimize the results of integrated approaches to solving complex environmental problems.

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