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Mapping of ecosystem services provided by the Paraíba do Sul river alluvial plains APA

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Abstract: Ecosystem services (ES) are all the benefits provided by ecosystems essential to subsistence, human well-being, and economic development, and, consequently, their recognition is fundamental for sustainable territorial planning. To identify the priority ES provided by the APA of the Alluvial Plains of the Paraíba do Sul and Jaguari Rivers, a region fully integrated into the urban fabric of São José dos Campos (SP), a collaborative study was developed to obtain the environmental perception of location key-actors - public agents, researchers, and APA residents. The analysis was developed from interpreting maps of use and occupation of the territory and adaptation of the Rapid Participatory Diagnosis (RPD) methodology recommended in the TEEB Regional/Local context. The results reiterated the importance of the region, already legally protected, to ensure the local environmental quality and identified the priority ES: freshwater, photosynthesis, nutrient cycle, local microclimate, and regulation of water flows.

Keywords: Ecosystem Services, Collaborative Study, Environmental Protection Area, Public Policies and Environment, Territorial Planning.

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Introduction

Currently, 55% of the world's population resides in urban areas, mainly in megacities. As urbanization intensifies, the interrelationship between sustainable development and the need to consider the benefits of natural environments, or Ecosystem Services (ES), becomes more evident in territory planning (UN, 2018).

Sustain the flow of services provided by nature in a balanced way to urban areas, ensure climate regulation, protection against natural disasters, attend food and energy demand, prevent soil erosion, and offer experiences of recreation, cultural inspiration, and spirituality. To maintain this always viable, the ES should be considered for the formulation of policies, as it can reduce future costs for cities, leverage local economies, improve the quality of life, and guarantee subsistence. In this sense, environmental governance presents itself as a critical element to achieving the United Nations (UN) 2030 Agenda (GIZ; MMA, 2018; SEIXAS et al., 2020).

In the development of cities, there is a constant appropriation of landscapes, which entails interventions that try to control natural processes and flows. However, it is necessary to adopt an integrated long-term systemic vision where urban planning is based on the landscapes that will be its biophysical support and the historical and social context (HERZOG, 2013). That's why recognizing environments and the natural flows they provide, their ecosystem services, are fundamental to this reconnection between the city and nature.

The recognition and valuation of ecosystem services, on the rise worldwide since 2005 (AGUDELO et al., 2020), are still incipient in Brazil. However, considering the urban policy guidelines in the country, which address the integration and complementarity between urban and rural activities, in addition to the adoption of limits to urban expansion associated with environmental sustainability, it's possible to infer that the incorporation of the theme is necessary so that the planning guarantees the full development of the social functions of cities (BRASIL, 2001; CALZOLARI et al., 2020; GÓMEZ-BAGGETHUN; BARTON, 2013). Mainly when related to protected areas, which are effective instruments for protecting natural resources and their ES, they produce more significant benefits than the conservation investments demanded by them (BUSTAMANTE et al., 2019).

The Environmental Protection Area of the Alluvial Plains of the Paraíba do Sul and Jaguari Rivers (APA/PA-PSJ) was selected for this study due to its historical, environmental, social, and economic importance for the São José dos Campos (SP) city. Regionally, the area is known as the "São José dos Campos Sea" a name associated with the constant flooding of the Paraíba River before the Paraibuna/Santa Branca dams, which gave the marshland the feeling of the sea. Augusto Emílio-Zaluar, a European traveler on an expedition through the Province of São Paulo in the mid-1860s, reported on his passage through São José dos Campos over the marsh:

One of the most noteworthy things to see in this locality is the immense swamps, which are called 'banhado' here, and which extend for a great distance at the foot of the mountain on which the village is located (...) it seems that we are in the presence of a

sea in constant calmness (ZALUAR, 1953).

The EPA is recognized as highly important at all levels of governance, given its triple legal protection (federal, state, and municipal). It corresponds to a vast alluvial plain that makes up a scenario integrated into the urban landscape of the municipality of São José dos Campos, located in the Metropolitan Region of Vale do Paraíba and North Coast, where it occupies a prominent place - holding the largest GDP and population in the region (PMSJC, 2018). At the end of 2018, the Master Plan approved in the city indicated that the site demands specific rules of use and occupation be established through the implementation of a management plan, with the primary objective of protecting the environment and the natural landscape, promoting sustainable use, in particular for organic agricultural production, also including the climate lens, that is, recognizing their role in adapting to climate change.

Due to the regional and strategic importance of the region for the Macrometropolis of São Paulo, the area requires governance that brings together, in a participatory and inclusive way, civil society in the resolutions relevant to the socio-environmental debate and that encompasses a level of multi-scale articulation (MARQUES et al ., 2020). Mainly in decisions involving the management of the Paraíba do Sul River watershed, whose waters serve for public supply to millions of people, electricity generation, and supply the industrial and agricultural sectors (PMSJC, 2016).

According to Gomes and Andrade, 2020, among the general problems of the Paraíba do Sul River basin, particularly the socio-environmental conflicts resulting from the exploratory and speculative use and occupation of the floodplain as those arising from the extraction of sand and urban expansion, and the limitations of managing protected areas as a stimulus for socioeconomic development and the preservation of communities and cultures.

In this context, this study was conducted to evaluate whether the environmental perception of different social actors is a good technique to map the ecosystem services provided by a conservation unit with multiple challenges for governance and, as a consequence, subsidize local public policies of integration and complementarity with the urban area of the municipality of São José dos Campos.

Literature review

Ecosystem services benefit from the planet's natural processes and systems. The collective awareness that a natural environment generates essential benefits for human well-being goes back to the beginnings of humanity, whereas the concept of ecosystem services is relatively new, being mainly used from the 90s onwards (AGUILAR-GÓMEZ et al., 2020; COSTANZA et al., 1997). Around the world, communities and individuals depend on ecosystem services for their livelihoods, well-being, and development, while companies use raw materials and resources provided by ecosystems for production and economic growth (FILHO et al., 2020; MA et al., 2005; RUSCHEL et al., 2020).

Urban regions are demanders of ES (XIE, ZHANG, et al., 2020) and, simultaneously,

one of the primary sources of global environmental impacts. Cities depend on natural environments to provide ES supply, such as water, energy, and food, which leads to the export of ecological degradation to regions outside the urban perimeter (WACKERNAGEL et al., 2006). The demand for ES in urban areas is, in many cases, supplied by the availability of these in rural or peripheral regions of their surroundings and determines territorial interrelationships that lack more comprehensive public policies to ensure the sustainability of these land uses (KROLL et al., 2012).

Table 1: Subsidies for the public management of ES mapping cases

Study	Local	Methodology	Subsidiaries for Public Management	Reference
Mapping Ecosystem Services Potential in Lithuania	Lithuania	Expert-based-ranking approach combined with the matrix method and spatial analysis, to determine potential ES through spatial patterns and relationships between multiple ES.	The study concluded that forest areas had the highest potential for ES delivery, while the lowest potential was in urban areas. It also reinforced that the approach has a great capacity to cover large geographic areas and is effective for cases where environmental and social data are scarce.	1
A Performance--Based Planning Approach Integrating Supply and Demand of Urban Ecosystem Services	Trento, Italia	Selection of ES based on public documents with municipal officials, scoring system for developing indicators on the supply and demand maps, and evaluation of the balance between positive and negative impacts on ES.	Ecosystem service assessments can support the design of public policy instruments, helping to shed light on the lack of knowledge about the role of ES in decision-making processes. The approach is applicable and transferable to other contexts, due to its flexibility.	2

Quantifying and Mapping Ecosystem Service Use Across Stakeholder Groups: Implications for Conservation with Priorities for Cultural Values	British Columbia, Canada	Publicizing the survey in advance to encourage community participation. Conducting interviews with drawing of polygons representing participants' use of ES. An overlay analysis of the maps to determine the ES provision: cultural, provision and groups combined.	Collaborative mapping has been shown to be a suitable tool for the spatial location of cultural and provisioning ES in varied stakeholder groups. The frequency of recognition of ES can determine regional conservation priorities.	3
Towards A National Set of Ecosystem Service Indicators: Insights from Germany	Germany	Presented and discussed the preliminary results of the approach adopted to define indicators for the implementation of the Mapping and Assessment of Ecosystems and their Services (MAES) - Objective 2 of the EU Biodiversity Strategy.	Proper land use planning can enhance ES provision. Specific data on ES is still needed to inform public policy.	4
Focusing Conservation Efforts on Ecosystem Service Supply May Increase Vulnerability of Socio- Ecological Systems	Argentina and Chile	Case studies conducted in Argentina and Chile, to compare conservation priorities according to ES supply maps versus socio-ecological vulnerability maps, using an improved version of the ECOSER protocol - GIS mapping tool.	Conservation prioritization should consider not only current ES, but their interactions and temporal changes. Strong spatial decoupling between the supply of ES, socio-ecological vulnerability and the loss of ecosystem services was noted.	5
Integrating Deliberative Monetary Valuation, Systems Modelling and Participatory Mapping to Assess Shared Values of Ecosystem Services	River Forth Estuary, Scotland	Integration between conceptual systems modeling, participatory mapping, and deliberative monetary evaluation to assess shared values of ES.	Only the monetary valuation would lead to insufficient recognition of ES, different from the values expressed through the participatory mapping, so the participatory mapping brings improvement to the monetary valuation of ES.	6

Perception of Ecosystem Services of Urban Green Areas in Curitiba/ PR	Curitiba, Paraná, Brazil	Qualitative research with environmental experts, using the Ecosystem Services Review - ESR tool, to identify the most important ES in the context of socioeconomic well-being generation.	The regulation of the local climate and the maintenance of air quality was highlighted as the most important ES provided by the green areas in Curitiba. It was concluded that the ES analyzed, especially the most relevant ones, should be carefully observed and incorporated in the management of the urban green areas, besides pointing out which areas are considered as not being able to be replaced, in case of the suppression of the green areas.	7
Mapping and Valuation of Ecosystem Goods and Services in in the Brazilian Semi-arid	Taperoá River Basin, Paraíba	Participatory mapping with the community, managers, and experts to identify ecosystem goods and services by assigning a level of importance (social valuation) for each good or service. The mapping was interpolated in ArcGis software for the preparation of digital maps.	Despite the degradation process that the stretch of the Taperoá River basin faces, it was possible to identify a high number of ecosystem goods and services, except in the urban area and to the north of the dam, where agriculture and cattle breeding predominate and are among the most cited and valued by the stakeholders, despite the relationship with the environmental degradation of the region due to the practice of traditional agriculture and cattle breeding.	8

Source: 1. DEPELLEGRIN et al., 2016; 2. CORTINOVIS; GENELETTI, 2020; 3. DARVILL; LINDO, 2015; 4. ALBERT et al., 2016; 5. LATERRA et al., 2016; 6. KENTER, 2016; 7. PANASOLO et al., 2019; 8. GOMES, 2019.

Specifically, national studies and projects that deal with the theme of ecosystem services applied to urban development have been increasing and explaining the importance of the ecosystem approach in developing public policies (SCHERER, 2019).

Among them, stands out the application of the methodology for mapping ecosystem

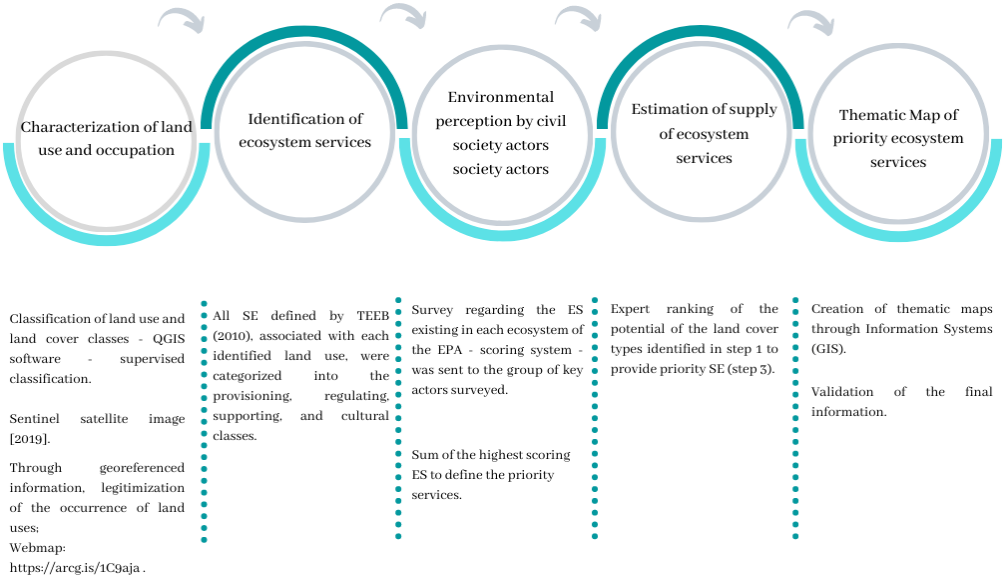
services in the territory in Duque de Caxias - RJ, in 2018, developed through the project of the Brazil-Germany cooperation "TEEB Regional-Local", which resulted in a methodological booklet replicable in different spheres, aimed at local actors and decision-makers (GIZ; MMA, 2018). This work adopted the Rapid Participatory Diagnosis (RPD) and highlighted the importance of civil society participation in recognizing ecosystem services.

The RPD, a technique that contains collaborative mapping, is a methodology that allows the collection of local information from the community's viewpoint. It is usually used in the diagnosis and rural planning, but it has been democratized in several other areas. It is a methodology based on the collection of information that captures individuals and groups' perception and knowledge of the territory they live in, generating a result rich in details and local experiences (ANTUNES et al., 2018 and MENDONÇA; SOUZA, 2009). In this way, diagnoses carried out with local actors can provide relevant information for urban planning and decision-making for public policies (JOHNSON; SIEBER, 2013).

Material and methods

The study comprised five sequential and complementary steps. The logical sequence of the search is shown in Figure 1.

Figure 1: Stages of conducting the research



Source: Prepared by the author.

Characterization of land use and occupation of the APA/PA-PSJ

For the characterization of the APA/PA-PSJ, bibliographic research was initially carried out through the collection of geospatial and documentary information from the files of the São José dos Campos City Hall, the environmental spatial data infrastructure portal of SP, and the database at São Paulo State University - UNESP, in 2019. Parts of the information were systematized through a Web map and made available online on the ArcGIS platform, where an interactive visualization of the data is possible through the link < https://arcg.is/ 1C9aja >.

Land use was identified by analyzing the region of interest using the QGIS 3.6.0 software, applying the supervised classification - maximum likelihood method, and using the 'Copernicus Sentinel [2019]' satellite image as a basis. In the classification stage, the following classes were identified: water, agriculture, vegetation, urban pressure, exposed soil, and pasture.

Identification of ecosystem services

In the resulting map, the potentially existing ecosystem services in the EPA were evaluated, based on The Economics of Ecosystems and Biodiversity, 2010, that is, for each type of use and land cover identified, all possible ES existing in that ecosystem were surveyed.

The characterization sought to highlight each type of land use and land cover, in addition to identifying the most significant pressures on them (and, therefore, on the associated ecosystem services). To guide the work, the Integration of Ecosystem Services - ISE approach was used, aimed at projects and planners, to recognize the relationships between nature and urban development, considering the associated environmental and economic trade-offs and thus assist in the integration of opportunities and risks linked to ecosystem services in the planning and development of strategies (KOSMUS et al., 2012).

Environmental perception and prioritization of ES by local key actors

The social actors' environmental perception of the existing ES in the EPA/AP-PSJ was identified and weighted through a Survey carried out using a structured questionnaire, applied on an online platform - Forms (Microsoft), in the first half of 2019. The questionnaire aimed to capture the environmental perception of stakeholders about the EPA through questions designed for this purpose. It listed all ecosystem services, defined by TEEB (2010), associated with each identified land use (first and second steps), separated into provision, regulation, support, and cultural classes. The main objective was to prioritize the ES as specified by step 2 of the ISE approach explained by Kosmus et al. (2012).

Based on the principles of the Rapid Participatory Diagnosis - RPD, and, because of the qualitative approach, the questionnaire was sent to the key actors selected for having some degree of interaction and knowledge about the place, such as public agents of the city hall, researchers and technical experts, members of the Management Council

and residents of the Banhado State EPA, considering the requirements for the proper collection of qualitative information as suggested by Yin (2016).

For the weighting of the indicators, such as the mapping of Duque de Caxias, the criterion for determining weights was adopted on a scale from 0 to 5, where 0 corresponds to the non-existence of the ecosystem service and 5 to its full significance. After collection, values assigned by the respondents were added up for each of the ES, and the top ten with the highest scores were considered a priority.

Although it represents an assessment of a qualitative characteristic, this type of analysis is a scientific method and, therefore, used in studies of renowned entities such as, for example, the IPCC ("expert elicitation"). Expert elicitation is based on the assumption that, through experience, individuals have sufficient knowledge about the research subject for their opinion to be officially trusted (JACOBS et al., 2015).

Assessment of the ES offered by experts for creating thematic maps

The supply estimate occurred considering the potential of different land cover types to provide specific ecosystem services, followed by spatial analysis. The approach used was adapted to the one applied in the Duque de Caxias mapping, the Matrix Method (GIZ; MMA, 2018), and also based on the study "Capabilities of landscapes to provide ecosystem services - A concept for land cover-based assessments" (BURKHARD et al., 2009), which relies on the specific knowledge of experts to assess the ES provided by certain areas. The approach is recommended for assessments at local and regional levels and is used in situations where there are uncertainties or little data available.

The main objective of this step was to represent the ecosystem services in the geographic space of the EPA through collaborative mapping with an expert with exceptional knowledge about the floodplain of the Paraíba do Sul River. From the land use map and the identification of ecosystem services priorities, it's possible to evaluate the supply of ES, considering the offer (current and potential). The assessment is based on landscape units, so the value (relative importance) for each landscape unit can be carried over to Geographic Information Systems (GIS) (GIZ; MMA, 2018).

Land use classification provided a spatial reference to start assessing ecosystem services. As they originate from satellite images, the representation of the actual situation of the surface makes it possible to analyze with greater fidelity the condition of the supply of the ecosystem service, which leads to an adequate basis for consistent assessments. This approach allows the mapping of ecosystem services to coherently portray reality (GIZ; MMA, 2018; JACOBS et al., 2015).

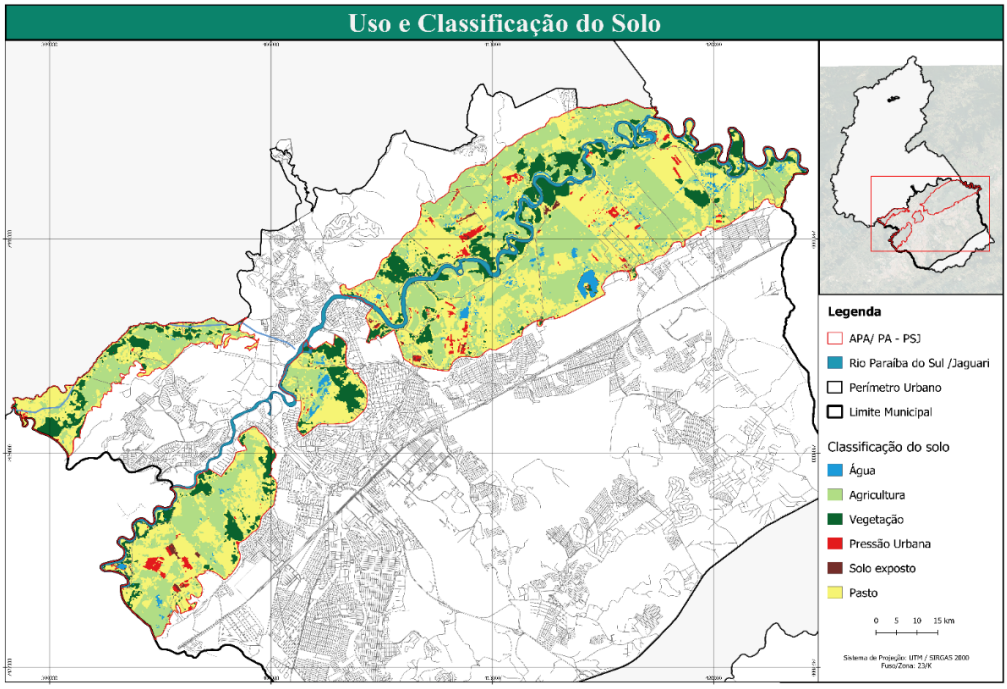
An external expert and the researchers responsible for the project estimated the ES supply in this work. Scores ranging from 0 (irrelevant state), 1 (low state), 2 (medium relevance state), 3 (high state), and 4 (very high state) were assigned for each priority ecosystem service about the land use classes identified in the EPA/AP-PSJ. The method consists of a matrix where the lines are land uses, the columns are ecosystem services, and the score is inserted at the intersection. Subsequently, this score was spatialized through geoprocessing, using the software QGIS 3.6.0. to create thematic maps of all priority services.

Results

Uses and land occupation of the EPA/AP-PSJ

The area under study, called EPA Municipal Alluvial Plains of the Paraíba do Sul and Jaguari Rivers, overlaps the EPA Banhado State, the Federal EPA of the Rio Paraíba do Sul springs and the Municipal Natural Park of Banhado. Figure 2 presents the characterization of land use for the EPA Municipal Alluvial Plains of the Paraíba do Sul and Jaguari Rivers, and the result reflect the portrait of the area in March 2019, date of the satellite image used.

Figure 2: Land use in the EPA Municipal Alluvial Plains of the Paraíba do Sul and Jaguari Rivers. In percentage terms, the area comprises 46% of pasture/anthropic fields, 36% of arable fields, 12% of vegetation, 3% of water bodies, 2% of urban pressure, and 0.4% of exposed soil. The red outline indicates the limit of the EPA Municipal Alluvial Plains of the Paraíba do Sul and Jaguari Rivers, defined by LC No. 612/2018



Source: Prepared by the author.

The mainland use in the area is characterized by pastures intended for extensive livestock, followed by temporary crops and fragments of native vegetation. As it is a scenario integrated into the urban landscape of São José dos Campos, it's noted that significant anthropic pressure, mainly resulting from the implementation of high-end gated communities, clandestine constructions, real estate speculation, and urban infrastructure projects. Therefore, it can be inferred that, in the context of land use and occupation, the region suffers from conflicts uses, which gradually lead to the deterioration of the natural

environment exposed to intense urban use (MENDES et al., 2018; MORELLI et al., 2002).

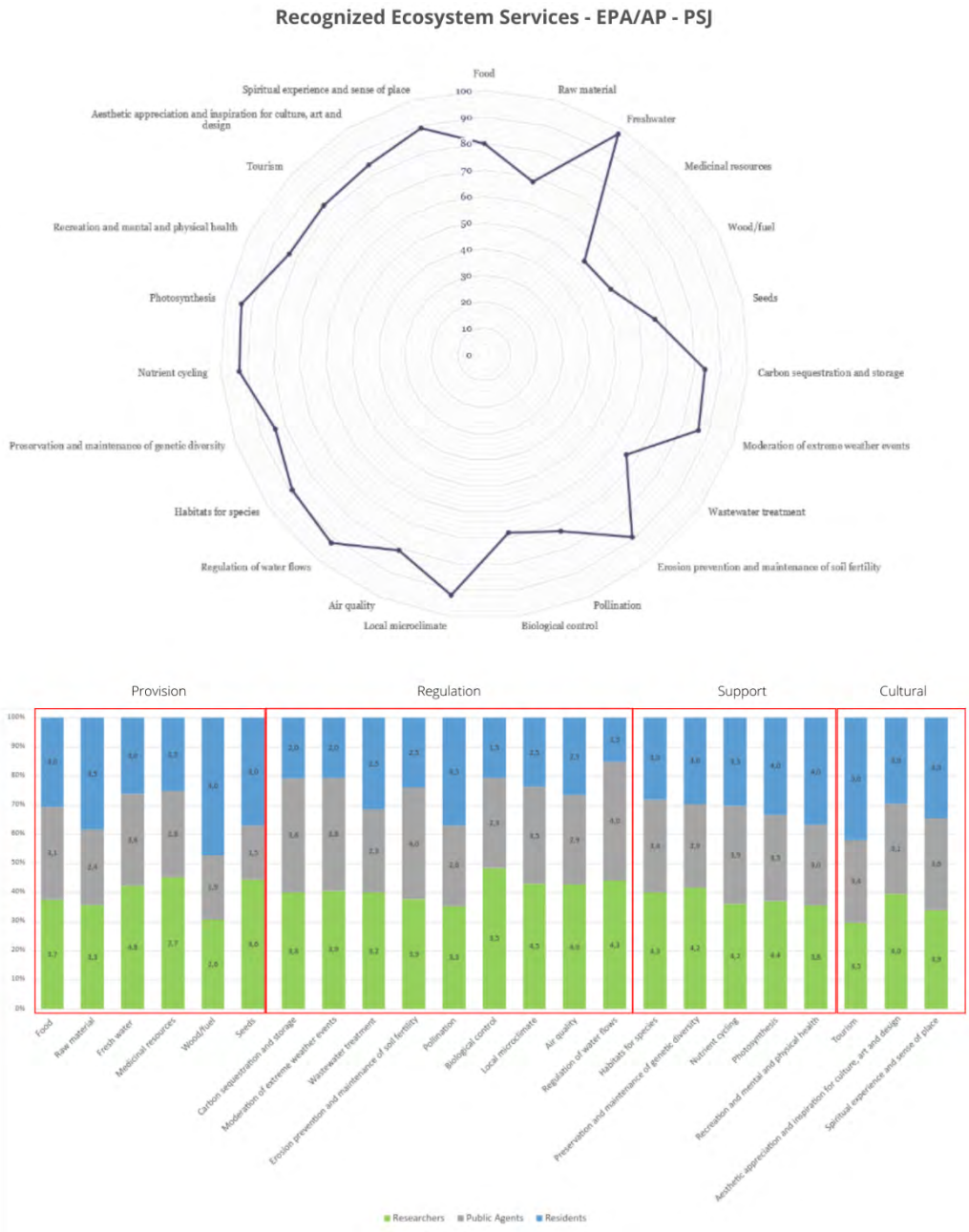
According to Morelli et al. (2002), the characteristic vegetation of the region was initially occupied by Seasonal Semideciduous Alluvial Forests, Atlantic Forest Biome, in the floodplains of the Paraíba do Sul River, secondary, that is, the one that regenerated after the succession processes.

It's important to point out that, even though it is classified as a conservation unit for sustainable use, the existence and conservation is associated with the environmental movement for the protection of the Banhado as it restrained some usages incompatible with the characteristics of its environment, such as exacerbated urbanization and the extraction of sand, standard in floodplain areas of other municipalities permeated by the Paraíba do Sul River (SANTOS et al., 2015).

Environmental perception and prioritization of ES by local key actors

The questionnaire sent to key actors proved to be an agile and consistent communication tool. In total, 22 responses were collected, of which 54% were from researchers (12 replies), 36% from public officials (8 replies), and 9% from residents (2 replies). Notably, this last group was less representative due to the small presence of people within the EPA/AP-PSJ, about 300 families, in extreme vulnerability, which resulted in low adherence to the research. Another critical point to be highlighted is that the set of key actors with interaction or in-depth knowledge about the area is small. Figure 3 shows the global score for ecosystem services and the average obtained from the group.

Figure 3: Global and average ecosystem services score by the stakeholder group



Source Prepared by the author.

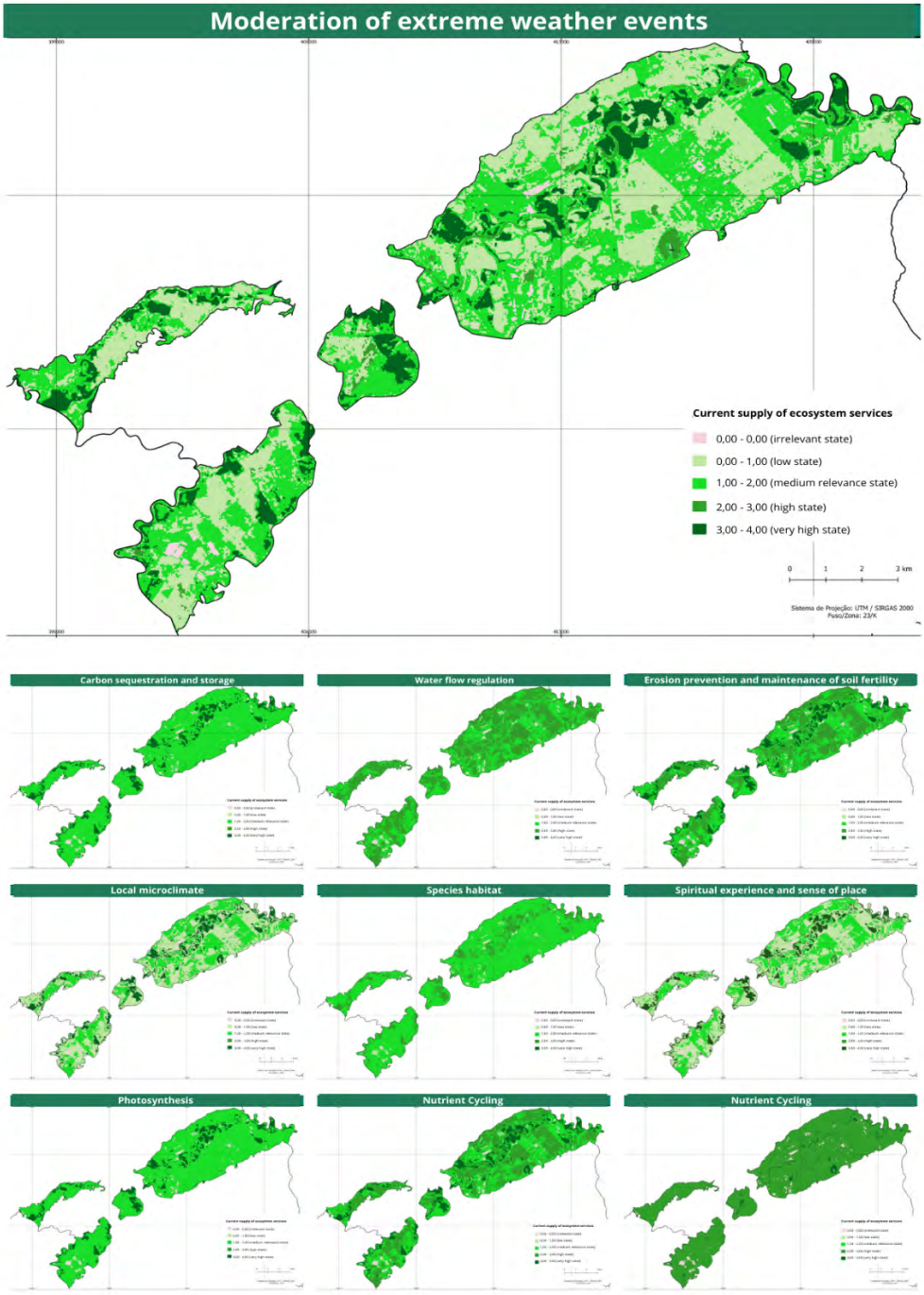
From the data and information obtained in the questionnaire, the top ten Ecosystem Services considered priority were identified, namely:

1. Freshwater;
2. Photosynthesis;
3. Nutrient cycle;
4. Local microclimate;
5. Regulation of water flows;
6. Prevention of erosion and maintenance of soil fertility;
7. Habitats for species;
8. Spiritual experience and sense of place;
9. Moderation of extreme weather events;
10. Carbon sequestration and storage.

Thematic map of ES supply estimation by land use

The maps with the ten prioritized ES are presented in Figure 4. The darker the shade of green in the legend, the more the land use class can offer the priority ecosystem service.

Figure 4: Result of mapping ecosystem services for EPA Municipal Alluvial Plains of the Paraíba do Sul and Jaguari Rivers



Source: Prepared by the author.

From the maps, it is possible to identify where the supply and provision of ES are more expressive. For the ecosystem service of photosynthesis and nutrient cycling, the highest supply occurs in native vegetation fragments, followed by agriculture and pasture. In the nutrient cycle, freshwater also scores high due to the aquatic dynamics of nutrient cycling.

'Spiritual experience and sense of place' presented a heterogeneous score according to land-use class. Vegetation, water, and agriculture present the highest offers of this ES (highest associated scores), as they are the three types of landscape that best characterize the EPA/AP-PSJ as a landscape, giving the place a sense of place.

In the general mapping, it is observed that urban pressure and exposed soil obtained zero scores in ecosystem services. The ES of 'Moderation of Extreme Weather Events' and 'Carbon Sequestration/Storage' deserves special attention due to the role played for city resilience given the new global climate reality (JOLY et al., 2019). From the map, it can be seen that green areas have a high or very high supply of these services.

Discussion

The characterization of the area indicated that the EPA confronts anthropic pressure in most of its extension but still has some fragments of riparian vegetation. With the control of the flow in 1971, after the construction of the Paraibuna, Paraitinga, Santa Branca, Jaguari and Funil dams (BITTENCOURT; BATISTA, 2009), the banks of the Paraíba do Sul River were no longer flooded, which facilitated human settlement. This fact contributed to the development of subsistence activities (e.g., agriculture and livestock); however, the natural environment of floodplains was modified, and, therefore, the specific ES provided by this ecosystem.

This result is similar to Gomes (2019) obtained, who developed participatory mapping with the community and identified agriculture and livestock as ES. However, despite being the ES with greater recognition, these also directly relate to the region's environmental degradation, as their practices occur traditionally, without specific care for the environment.

Urban pressure in the study area can affect the supply of ecosystem services. Therefore, to continue their supply potential, it is vital to have a critical look and control for this type of land use in the EPA/AP-PSJ. However, it's necessary to emphasize that the presence of people inside an environmental preservation area is not always damaging since traditional populations resident for long periods in the environment may be able to promote the preservation of the local ecosystem due to the knowledge acquired over time on the dynamics of ecosystem services and biodiversity at the area (HILL et al., 2019).

The environmental perception survey proved to be a valid alternative for society's participation in creating a consensus around the definition of priority ES, but the online questionnaire did not present the expected responses. For future work, prior social communication and face-to-face meetings with key actors are recommended to increase

engagement, as well done by Darvill and Lindo (2015).

Of the top ten ecosystem services scored as priorities, it is noted that half are regulation, followed by support - with three ES -, cultural and provision with one each. This result highlights the importance of the EPA to ensure environmental quality in its area of influence. The prioritized ES generates benefits that serve as a basis for the quality of life and well-being in multiple aspects, which, according to Zardo et al. (2017), range from improving the healthiness of the population, through making the city more resilient, to reducing energy costs, due to the alleviation of heat arising from existing green areas in cities (ZARDO, GENELETTI, et al., 2017).

The results also indicated that the ES offered by the EPA had been recognized as the most relevant: maintenance of the soil's productive capacity (fertility), erosion control, and the ability to self-regulate climate and ecosystem flow. In this way, it can be seen that the area potentially guarantees protection against climatic risks, acts as a buffer against natural disasters, and prevents their possible damage.

The EPA/AP-PSJ was also recognized for its support capacity as a place where the maintenance of the fundamental life cycles to maintain ecosystems is guaranteed, enabling primary production (photosynthesis) and the nutrient cycle, in addition to the ES of *habitat* for species. This attribute means its recognition as a space where fauna and flora can live and reproduce and, consequently, protect and promote biodiversity. According to Bartkowski et al. (2015), this support capacity plays a series of roles in ecosystems and, therefore, influences well-being differently, reinforcing its relevance to the territory.

The only recognized supply service - freshwater, converges with the main characteristic of the EPA: the protection of the alluvial plains of the Paraíba do Sul River and Jaguari River. Finally, the cultural ecosystem service with the highest score reflected the importance that the EPA/AP-PSJ has for the residents of the municipality, especially concerning the sense of place and belonging that the José community attributes to the region since it is constantly recognized as one of the main postcards of the city (PMSJC, 2016).

From the analysis of the different groups of key actors, it is noticed that there is a difference concerning the scores attributed by them. While the researchers showed the more homogeneous trend in the score, resulting in the highest averages for ES, probably due to the previous understanding of their relevance, the public agents transmitted more variable and heterogeneous responses, which may reflect a disparity in the knowledge of the concept and importance of the ES by them, in addition to different perceptions about the relevance of the area for the municipality. Such disparity evidences the disproportion of knowledge of those who legislate and make decisions directly affecting the EPA. Notably, as explained by Garcia (2019), communication between decision-makers and society is associated with the effectiveness of territory management.

Residents attributed the lowest scores to the ES, in a heterogeneous way, with the regulatory services presenting the lowest averages. This result is highly relevant, as it reflects that the actors with more significant contact with the region still do not recognize its ES. This fact may be associated with residents' lack of knowledge about the concept of

ES (which was briefly presented to them through the questionnaire) or due to their daily contact with the area over the years, allowing them to perceive the anthropic pressure in a more pronounced way, which reduces the quality of the ecosystems and the ability to offer services. This perception is different from that verified by Canova et al. (2019) because, in their results, the authors identified more significant recognition of regulation ES by Brazilian rural landowners, with permanent contact with the environment.

In brief, the researchers attributed the highest global average to the support ES, public agents, regulatory services, and residents to cultural services, expressing the difference in the perception of each group of key actors concerning ecosystem services.

Part of the EPA is located in the central area of the municipality, which contributes to the region being a fundamental point in air purification dynamics due to the vegetation cover's capacity to absorb and filter a large part of particulate materials and toxic elements from the air. Additionally, according to TEEB (2010), green areas provide microclimatic stability in several aspects, such as the reduction of heat, wind speed, and greater air humidity. These factors directly benefit the population's quality of life in the surroundings.

The proximity of green areas also brings multiple physical, psychological, and mental health benefits, functioning as a place for leisure/recreation/social interaction, physical activity, and promoting social interaction (GÜNTHER; GIULIO, 2018). Recently, the city hall of São José dos Campos revitalized the central area of the municipality, with the assembly of decks to contemplate the edge of Banhado, whose limits are covered by the EPA/AP-PSJ, which improved these benefits (PMSJC, 2016b).

Thematic maps proved to be a valuable way of spatial visualization of sensitive areas and those with maximum potential to supply ES. Therefore, they can be used in different scopes within the municipality, for example, in environmental education activities in schools and communities and territorial planning, as they help recognize the importance of the EPA landscape, as noted in GIZ and MMA (2018).

As in the project developed in Duque de Caxias, this research supports a better understanding of land use in the region, as they allow the association of the environmental perceptions of key actors and the current supply of ecosystem services prioritized them. It can be appropriated as a tool for managing existing conflicts and supporting measures that maximize natural capital preservation.

The identified ecosystem services also reinforce the importance of municipal public policies, with a direction towards mitigation and adaptation to the impacts of climate change, focusing on increasing these services in the city. Since the EPA/AP-PSJ has a strategic location, integrated into the urban fabric of São José dos Campos, the maintenance and conservation of uses that favor the provision of these services must be prioritized, with the main focus on increasing native vegetation, since this land-use scored higher in the provision of ecosystem services.

Among the public policies that can be applied in this context are: the payment of environmental services (PES) to rural producers in the EPA, focusing on the restoration of degraded areas and reforestation of legal reserves and permanent preservation areas, and the National Agricultural Plan of Low Carbon (ABC Plan), whose main measures are

to encourage the recovery of degraded pastures, the Integrated Crop-Livestock-Forestry (ICLF) and Agroforestry Systems, aiming at the development of low carbon policies (MAPA, 2020).

When comparing the results obtained in the present study to those resulting from the mapping carried out in Duque de Caxias, it's verified that in both it was evidenced that the urban infrastructure has less relevance in the supply of ES, while areas of forest or another type of vegetation cover have medium to high relevance for most services. The aquatic environments, reflected here by the river floodplains, and thereby the marine ecosystem and wetlands, are extremely important for regulating the local climate and controlling floods and natural inundations (GIZ; MMA, 2018).

Another relevant result obtained converges with the one obtained in the Perception of Ecosystem Services in Urban Green Areas in Curitiba/PR, Panasolo et al., 2019, where the analysis indicates that the ES analyzed, especially those that regulate the local climate and habitat are considered as non-replaceable in the case of suppression of green areas, evidencing that they should be the main focus of conservation policies.

Conclusions

The participatory approach methodology proved to be an effective and democratic tool, suitable for use in protected areas with multiple governance challenges, as it is capable of integrating the different perceptions of the territory's social actors, such as the local population, experts, and public managers, including expressing the difference in the environmental perception of each evaluated group. It is also possible to identify the public policies necessary for valuing the territories and training the general agents themselves.

The mapping of the EPA/AP-PSJ landscapes relating to the ability to provide ecosystem services presents a current overview of the region's potential to benefit and impact, directly and indirectly, an area of influence. Its results can be appropriate as a starting point for municipal public policies that largely depend on their supply (e.g., tourism, air quality) or affect the potential to provide them (e.g., allow the use of pesticides).

The research presented here can be considered a reference for the continuous monitoring of the perceptions of social actors about the territory studied. Among the challenges ahead, there is a need to deepen the concept and importance of ES with social actors better understand the environmental perception and increase the number of external experts to evaluate the current offer.

Furthermore, the methodology can contribute to understanding the value of nature in the local community and developing public policies that promote sustainable development. Territorial planning based on these principles brings particularly positive benefits since the protection of natural resources, often seen as an impediment to local development, can enhance it. Therefore, the results can support more efficient public policies for territories that demand a systemic approach in the political and economic field and the socio-environmental sphere.

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Mapeamento dos Serviços Ecossistêmicos providos pela Área de Proteção Ambiental do Rio Paraíba do Sul

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Fabiana Alves Fiore
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Resumo: Serviços ecossistêmicos (SE) são todos os benefícios fornecidos pelos ecossistemas essenciais à subsistência, bem-estar humano e desenvolvimento econômico e, por consequência, seu reconhecimento é fundamental para o planejamento territorial sustentável. Com objetivo de identificar os SE prioritários fornecidos pela APA das Planícies Aluvionares do Rio Paraíba do Sul e Jaguari, região totalmente integrada à malha urbana de São José dos Campos (SP), realizou-se um estudo colaborativo visando obter a percepção ambiental de atores-chave locais - agentes públicos, pesquisadores e moradores da APA. A análise foi desenvolvida a partir da interpretação de mapas de uso e ocupação do território e adaptação da metodologia Diagnóstico Rápido Participativo (DRP) preconizada no contexto TEEB Regional/Local. Os resultados reiteraram a importância da região, já protegida legalmente, para assegurar a qualidade ambiental local e identificou que os SE prioritários são: água doce, fotossíntese, ciclo de nutrientes, microclima local e regulação dos fluxos d'água.

Palavras-chave: Serviços ecossistêmicos, estudo colaborativo, Área de Proteção Ambiental, políticas públicas e meio ambiente, planejamento territorial.

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Artigo Original

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Mapeo de servicios de ecosistemas proporcionados por el APA del río Paraíba do Sul

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Artículo original

Resumen: Los servicios ecosistémicos (SE) son todos los beneficios que arreglan los ecosistemas esenciales para los medios de vida, el bienestar humano y el desarrollo económico. En consecuencia, su reconocimiento es fundamental para la planificación territorial sostenible. Con el fin de identificar los SE prioritarios proporcionados por la APA de las Llanuras Aluviales del Paraíba do Sul y Jaguari Río, que son totalmente integrada con el tejido urbano de São José dos Campos (SP), se realizó un estudio colaborativo para obtener la percepción ambiental de las partes interesadas: agentes públicos, investigadores y vecinos de la APA. El análisis se desarrolló a partir de la interpretación de mapas de uso y ocupación del territorio y la adaptación de la metodología de Diagnóstico Rápido Participativo promovida en el contexto TEEB regional/local. Los resultados reiteraron la importancia de la región para asegurar la calidad ambiental local y identificaron que los tres SE prioritarios eran: agua dulce, fotosíntesis y ciclo de nutrientes.

Palabras-clave: Servicios Ecosistémicos, Estudio Colaborativo, Área de Protección Ambiental, Políticas Públicas y Medio Ambiente, Participación Pública, Planificación Territorial.