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The rural and urban community perceptions of ecosystem goods and services in the semi-arid reservoirs landscape

Lívia Maria Osório de Sousa[1*], Dalescka Barbosa de Melo[2], Lucianna Marques Rocha Ferreira[2,3] and Joseline Molozzi[4]

ABSTRACT

Ecosystem goods and services (EGS) are the contributions that ecosystems provide to human well-being. The reservoir landscape, an artificial ecosystem, offers a wide range of ecological and socioeconomic functions for local populations, such as potable water, irrigation, and plants for food purposes. This study aimed to assess the perception of EGS provided by the reservoir landscapes of rural and urban populations. Research was conducted with residents around reservoirs in the Paraiba Basin of Brazil, specifically in the cities of Camalaú and Boqueirão. Socioeconomic information and population perceptions were obtained using semi-structured forms and participatory mapping, respectively. Based on analyses using PERMANOVA and Mann-Whitney statistical tests, it was found that rural people and men perceived and cited a higher number of EGS. Responses varied with different education levels (Illiterate, Primary School Incomplete, Primary School Complete, High School Incomplete, High School Complete, and University Degree Complete), with provisioning services being more easily perceived and mentioned by the interviewees. People in direct contact with the natural environment were more likely to perceive EGS than those without such contact. However, the importance of EGS was recognised by both rural and urban populations, as these services are essential for their well-being. Perceptions of riverside populations are important for conservation efforts because they provide valuable information about ecosystems based on their experiences within these ecological systems.

Keywords: Ecosystem benefits; Freshwater ecosystem; Riverine population; Social perception; Valorisation.

1 Laboratório de Ecologia de Bentos, Universidade Estadual da Paraíba - UEPB, Rua Baraúnas, 351, Universitário, Campina Grande, PB, CEP: 58429-500, Brazil.

2 Programa de Pós-graduação em Ecologia e Conservação, Universidade Estadual da Paraíba - UEPB, Rua Baraúnas, 351, Universitário, Campina Grande, PB, CEP: 58429-500, Brazil.

3 Departamento de Biologia, Universidade Federal do Amazonas - UFAM, Avenida General Rodrigo Octávio, 6200, Coroado I Campus Universitário Senador Arthur Virgílio Filho, Setor Sul, Bloco 1, ICB, 3° andar, CEP 69080-900, Manaus, AM, Brazil.

4 Departamento de Biologia, Universidade Estadual da Paraíba - UEPB, Rua Baraúnas, 351, Universitário, Campina Grande,PB, CEP: 58429-500, Brazil.

* Corresponding author ✉. E-mail address: LMOS (liviaosorio.tn@gmail.com), DBDM (dalescka@gmail.com), LMRF (lucianna.mrf@gmail.com), JM (jmolozzi@gmail.com)

SIGNIFICANCE STATEMENT

This study examined the perceptions of rural and urban riverside communities on ecosystem goods and services (EGS) and their level of importance in the reservoir landscape in a semi-arid region. We found that people living in rural areas identified a higher number of EGS than those in urban areas. Gender, education level, and occupation were sociodemographic factors influencing personal experiences of EGSs in the reservoir landscape. Both rural and urban populations often attributed a "very high" importance to perceived EGS, particularly provisioning services. Understanding the riverside community's perception of the ecosystem benefits of the reservoir landscape is important for shaping public policy and targeting reservoir management based on community experiences and needs. This will enable the creation of policies to ensure sustainable use of EGSs.

INTRODUCTION

Building reservoirs in Brazil's semi-arid region through river damming is beneficial to local populations. This region experiences variable rainfall and prolonged drought, leading to conflicts of interest among its water users (Nunes et al. 2016). This reservoir landscape, comprising reservoirs and their surrounding areas, provides drinking water and supports agricultural and fish farming activities (Chellappa et al. 2009). These socioeconomic benefits are called ecosystem goods and services (EGS), and reflect the contributions of the ecosystem's structure and function to human well-being, whether natural or artificial. The interactions between species, populations, communities, and physical and chemical environments are of great importance for reservoir ecology, which promotes the EGS in this region (Azevêdo 2018). Due to the constant water scarcity in the region, the population depends on the EGS provided by the landscape of these reservoirs for survival (Jones et al. 2019).

According to the Common International Classification of Ecosystem Services (CICES), EGS are classified as provisioning (products essential to life obtained directly from ecosystems, such as food, fibres, genetic resources, water, and wood), regulation and maintenance (regulating ecological processes, such as air quality, pollination, disease control, and natural damage mitigation), and cultural (spiritual and religious values, leisure, and the generation of knowledge from biotic and abiotic ecosystems) (Haines-Young and Potschin-Young 2018). Among the services offered by reservoirs, provisioning services encompass food production and freshwater supply. They also provide regulation and maintenance services through climate regulation and cultural services such as tourism, landscape observation, and other recreational benefits for local inhabitants (Azevêdo 2018; Cardinale et al. 2012; Guedes et al. 2014; Jones et al. 2019; Medeiros de et al. 2015).

Analysing people's perceptions of EGS is challenging because individuals attribute particular meanings and values to ecosystem functions, which vary based on their knowledge, relationships, and responsibilities with nature (Arias-Arévalo et al. 2018; Costanza et al. 2017; de Groot et al. 2002). Over time, the use and valuation of EGS change as environmental conditions and human lifestyles evolve (Friess 2017; Jiang et al. 2013; Thiagarajah et al. 2015; Tomscha et al. 2016). These environmental changes are often associated with urbanisation, which tends to cause a loss of biodiversity (Aronson et al. 2014; Seto et al. 2012). However, it is essential to ensure that the human population can use natural resources sustainably (Arruda 1999).

Therefore, this study aimed to assess the perceptions of rural and urban populations regarding the EGS provided by reservoir landscapes. Our hypotheses were as follows: (i) Men, individuals with higher levels of education, those with occupations involving direct contact with the reservoir ecosystem, and those with higher average monthly income perceive a higher number of EGS. This means that socioeconomic factors influence the population's perception of the number and types of EGS (provisioning, regulation and maintenance, and cultural) the reservoir landscape offers. (ii) The rural population perceives and attributes a higher level of importance to the EGS provided by the reservoir landscape than the urban population.

MATERIAL AND METHODS

Study area

The study was carried out in the Camalaú and Epitácio Pessoa reservoirs, located in the Paraíba River Hydrographic Basin (Paraíba, Brazil, Figure 1). These reservoirs support multiple economic activities in the region (such as tourism, livestock, industry, aquaculture, agriculture, and recreation) and are used for human and animal water supply (AESA 2022), making them essential for the survival of the region's population.

The Camalaú reservoir, built in 1986 (Santos 2018), has a storage capacity of 46,437,520 m^3, is the main water supply for the municipality of Camalaú. It is located in Paraíba's Agreste Mesoregion of Paraíba and it occupies approximately 0.007% of the northeastern territory, bordered by the municipalities of Campina Grande, Esperança, Massaranduba, Matinhas, Puxinanã, São Sebastião de Lagoa de Roça,

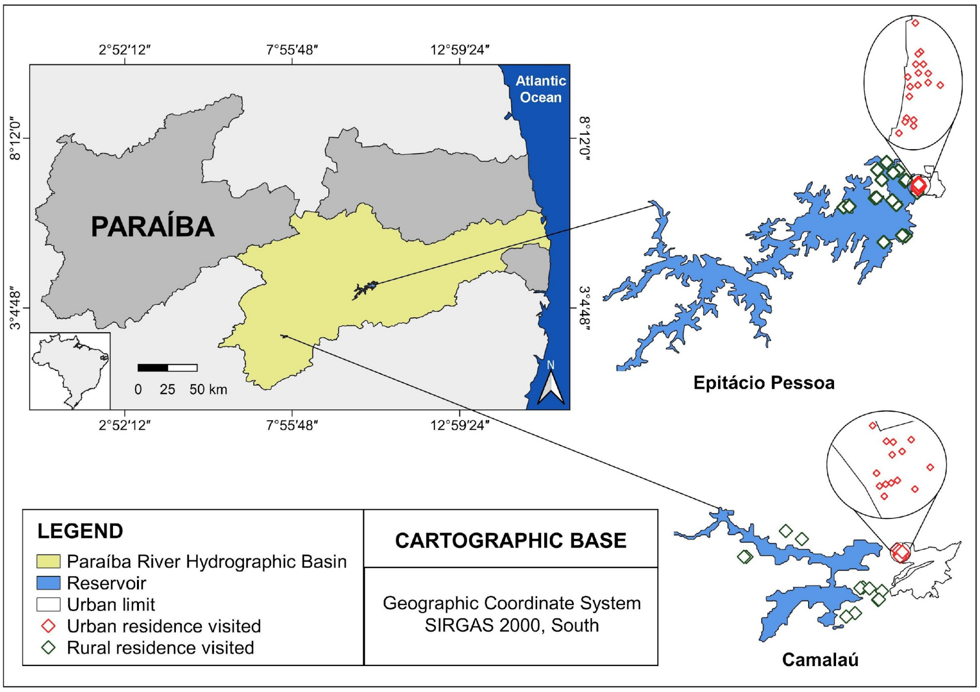

Figure 1. Location of the Camalaú and Epitácio Pessoa reservoirs in the Paraíba River Hydrographic Basin (Paraíba, Brazil).

and Serras (Souto et al. 2017). The Epitácio Pessoa Reservoir, built in 1957 (BRASIL 2023), has a storage capacity of 466,525,964 m^3 and is located in the Boqueirão municipality of Paraíba. It is the primary water source for Paraíba's second-largest city, Campina Grande, and other neighbouring municipalities, serving more than 700,000 people (da Silva Filho et al. 2020).

According to the thematic map generated by the MAPBIOMAS project (Souza et al. 2020) for Brazil in 2022, the land use and land cover within a 200 m radius of the Camalaú reservoir (area: 127.82 ha, perimeter: 19,170.87 m) and the Epitácio Pessoa reservoir (area: 1,758.40 ha, perimeter: 14,113.75 m) include forest formations, water bodies, a mosaic of agriculture and livestock uses, pasture, non-vegetated areas, and urban areas.

Rural areas were delineated by widely spaced residences interspersed with vegetated areas and activities characteristic of rural settings, such as agriculture and livestock rearing. Urban areas were defined by higher population densities, commercial and urban centres, public lighting, and paved roads (IBGE 2023).

Because it covers 38% of Paraíba's territory, the Paraíba River Hydrographic Basin is the state's second largest and one of the most important in the northeastern semi-arid region (AESA 2022). It includes the two largest and most densely populated urban centres in Paraíba State: João Pessoa and Campina Grande (AESA 2022).

The reservoirs studied are located in the Upper Paraíba River Hydrographic region, which is divided into hydrographic regions according to altitude, covering the Taperá River sub-basin and upper, middle, and lower Paraíba hydrographic regions (AESA 2022). The climate of the region is hot dry semi-arid (BSh) according to the Köppen-Geiger classification (Alvares et al. 2013; Kottek et al. 2006). Maximum monthly temperatures range from 28°C to 31°C in November and December, and minimum temperatures range from 18°C to 22°C in July and August (AESA 2022). The rainy season is from February to May, with an average precipitation of 400 mm/year, while the dry season is from August to October (Marengo et al. 2011; Velloso et al. 2002). The vegetation in this region consists of hyperxerophilous Caatinga type, deciduous, and sub-deciduous forest, and the predominant soil type is Chromic Luvisolo (AESA 2022).

Methodological procedure

Interviews were carried out with the riverine population living around the reservoirs to assess their perception of EGS considering the following parameters: socioeconomic information (gender, age, education level, family monthly income, and occupation in direct contact with the reservoir landscape) and the importance level the population attaches to EGS. These interviews were conducted in December 2021 and January 2022 using semi-structured form and participatory mapping. This study was approved by the Ethics Committee of Universidade Estadual da Paraíba (UEPB), opinion number: 5.053.838).

To enable participants to identify and classify the importance level of the EGS provided by the reservoir landscape, the following inclusion criteria were used: living within 200 m of the reservoir and assuming that people living within this radius have greater contact with the reservoir landscape (Azevêdo et al. 2022). In the Camalaú 70 houses were visited while in the Boqueirão 468 houses, which corresponds to all houses within a 200m radius of the reservoirs. The interviewees were of legal age and voluntarily agreed to participate in this study. Those who did not meet the inclusion criteria were excluded from the study.

The first method involved one-to-one door-to-door interviews using a semi-structured socioeconomic form (Azevêdo et al. 2020). Initially, the interviewer explained the purpose of the research and presented an Informed Consent Form (ICF). After the interviewee signed the ICF, the interviewer briefly explained the concept of EGS and provided examples. The length of the interviews varied according to the dialogue and the expressions of each participant.

The second method was based on participatory mapping (Palomo et al. 2013; Wolff et al. 2015) to obtain specific and contextual primary information from a defined geographical area about the perceived supply of EGS by the participant. In this method, participants responded to the following questions: (i) "What benefits does nature provide to people?" and voluntarily indicated on an A4-sized thematic map with images of the reservoir and its surroundings taken from Google Earth, the location that provides a particular ecosystem good or service; (ii) "What is their level of importance to people?" rating the importance of this ecosystem good or service as very low, low, medium, high, or very high.

The Common Classification of Ecosystem Services (CICES), version 5.1, was used as a classification system for the categorisation of EGS cited by participants. This system groups EGS provided by nature into three sections: provisioning, regulation and maintenance, and culture. These sections were organised in a cascade structure into five subdivisions: section, division, group, class, and class type. CICES also distinguishes between EGS provided by biota and the physical environment, differentiating the final good or service to avoid double counting (Haines-Young and Potschin-Young 2018).

Data analysis

Descriptive analyses of the socioeconomic data and interviewees' perceptions of EGS provided by the reservoir landscape and their importance levels were carried out. To analyse whether there were differences between the perceptions of the rural and urban populations, accounting for socioeconomic variables, area (rural or urban), EGS number, EGS number per section (provisioning, regulation and maintenance, and cultural), and the importance level of EGS, a Permutation Multivariate Analysis of Variance (PERMANOVA) was performed (Anderson 2001). Subsequently, a post-hoc pairwise test was carried out for significant interactions (Anderson 2001).

Differences between rural and urban perceptions of EGS were assessed using the Mann-Whitney nonparametric test (Mann and Whitney 1947). Given the non-normal distribution of our data and the failure to meet the assumptions required for t-tests on independent samples, we utilized the Mann-Whitney nonparametric test (Mann and Whitney 1947), which better accommodates analyses with smaller samples and potential outliers. Statistical tests were performed using R version 4.1.3 (RStudio Team 2021) and PRIMER + PERMANOVA software (Anderson 2008), with a significance level of 5% (0.05) for all tests.

RESULTS

Relationship between socioeconomics characteristics and EGS

A total of 64 people were interviewed, with 38 living in urban areas and 26 in rural areas. Of the participants, 42.2% (21.9% male and 20.3% female) lived around the Camalaú reservoir (9 individuals in rural areas and 18 in urban areas), while 57.8% (25% male and 32.8% female) lived around the Epitácio Pessoa reservoir (17 individuals in rural areas and 20 in urban areas). Participants ranged from 19 to 79 years, with the majority in urban areas aged 31 to 45 (20.3%) and in rural areas aged 46 to 58 (14.1%). The minority in both areas were over 70 years old (Table 1).

In terms of education level, the majority of those interviewed had incomplete primary education (28.1% in urban areas and 21.9% in rural areas). Only a few female interviewees had incomplete (3.1% in urban areas), complete (1.6% in urban areas), or postgraduate degrees (1.6% in rural areas).

Regarding monthly family income, most interviewees (35.9% in urban areas and 21.9% in rural areas) earned between one and two minimum wages (US$207.68 to US$415.36 per month). Furthermore, 26.6% of the interviewees lived on less than US$207.68 per month. The predominant occupation among the interviewees was farming, with 32.8% in urban areas and 29.7% in rural areas.

The interviewees identified 32 classes of EGS provided by the reservoir landscape. Of a total of 382 EGS citations made by all interviewees, the rural population identified 18 classes with an average of 10.5±12.5 EGS in 189 citations, while the urban population identified 14 classes with an average of 13.8±14.2 EGS in 193 citations. Inhabitants in the rural area of the Epitácio Pessoa Reservoir indicated a higher number of classes than those in the same area of the Camalaú Reservoir. In urban areas, the population living around the Camalaú Reservoir had more classes than those around the Epitácio Pessoa Reservoir.

There were no significant differences in the interaction between socioeconomic variables (gender, age, education level, family monthly income, and occupation), area (urban or rural), and number of EGS (Additional File 1). There were also no differences in the number of EGS per section (provisioning, regulation and maintenance, and cultural) (Additional File 2). However, men identified more EGS than women (PERMANOVA, $F_{1,63} = 5.6$; $r^2 = 0.07$; $p = 0.02$, Figure 2). Men identified the provisioning section of EGS more frequently than women (PERMANOVA, $F_{1,63} = 9.1$; $r^2 = 0.11$; $p = 0.005$, Figure 2) and people whose occupations involved direct contact with nature (PERMANOVA, $F_{1,63} = 5.8$; $r^2 = 0.07$; $p = 0.024$). There were also differences in the education level and number of EGS identified for provisioning services (PERMANOVA, F7,63= 4.5; $r^2 = 0.32$; $p = 0.004$) and regulation and maintenance services (PERMANOVA, F7,63= 3.2; $r^2 = 0.27$; $p = 0.05$), indicating that people with different education levels (Illit., PSI, PSC, HSI, HSC, and UDC) identified EGS in different ways (Additional File 3).

Rural and urban community perceptions about EGS

There was a significant difference between rural and urban community perceptions of the EGS provided by reservoirs and their surroundings (Mann-Whitney bicaudal, U=735; $p = 0.009$, Figure 3). Provisioning services were perceived most by both rural and urban people, although the rural population cited more provisioning EGS than the urban population

Table 1. Socioeconomic profile of interviewees living in urban and rural areas around reservoirs in Paraíba, Brazil.

Socioeconomic Profile					
Gender	**Rural**	**Urban**	**Age**	**Rural**	**Urban**
Female	14.00%	39.10%	19 to 30 years	4.70%	10.90%
Male	26.60%	20.30%	31 to 45 years	9.40%	20.30%
Education level	**Rural**	**Urban**	46 to 58 years	14.10%	10.90%
Illiterate (Illit.)	4.70%	7.80%	61 to 69 years	9.40%	10.90%
Primary school incomplete (PSI)	21.90%	28.20%	>70 years	3.20%	6.20%
Primary school complete (PSC)	6.2%	-	**Monthly Family Income**	**Rural**	**Urban**
High school incomplete (HSI)	3.1%	10.9%	<1 minimum wage	12.5%	14.0%
High school complete (HSC)	3.1%	7.8%	1 to 2 minimum wages	21.9%	35.9%
University degree incomplete (UDI)	-	3.1%	3 to 4 minimum wages	1.6%	4.7%
University degree complete (UDC)	-	1.6%	Uncertain	3.1%	1.6%
Postgraduate (PG)	1.6%	-	Did not know	1.6%	3.1%
Occupation	**Rural**	**Urban**	**Occupation**	**Rural**	**Urban**
Community health worker	1.6%	-	Unemployed	-	3.1%
Farming	20.3%	26.6%	Housewife	-	9.4%
Retired	-	4.7%	Student	-	3.1%
Retired and farming	9.4%	6.2%	Fishing	7.9%	-
Retired and bricklayer	-	1.6%	Teacher	1.6%	1.6%
Seamstress	-	1.6%	Public server	-	1.6%

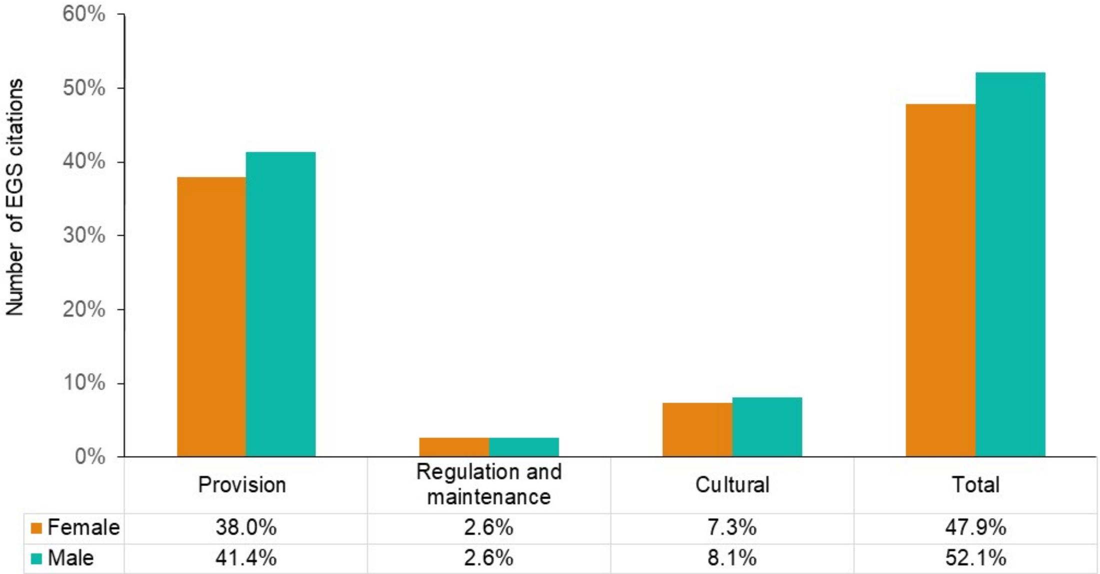

Figure 2. The percentage of EGS cited according to gender (female and male).

on average (PERMANOVA, $F_{1,63}$= 9.2; r^2 = 0.12; $p = 0.004$, Figure 3). Additionally, rural people cited more regulation and maintenance as well as cultural services compared to urban people (PERMANOVA, $F_{1,63} = 6.4$; $r^2 = 0.09$; $p = 0.02$).

EGS perceived exclusively by the rural population included provisioning services such as fibres and wild plants for direct use or processing (excluding genetic material) and regulation services such as water cycle and flow regulation (evaporation from plants). Other perceived services were dilution by freshwater ecosystems (fisheries cleaning), weathering and its effects on soil quality (soil quality for planting), and regulation of atmospheric chemical composition, all of which belong to the regulation and maintenance section. On the other hand, the provisioning service of animals reared for food purposes through in situ aquaculture (fish farming) was perceived only by the urban population (Additional File 4).

The classes most perceived by the population were surface water for drinking purposes, surface water used as a material (non-drinking purposes) for personal hygiene, aquatic wild animals and their products used for food purposes, and cultivated terrestrial plants (including fungi and algae) for food purposes. These classes are part of the provisioning section. The least perceived classes were wild terrestrial plants (including fungi and algae) used as an energy source (provisioning section), temperature and humidity regulation, including ventilation and transpiration (regulation and maintenance section), and the characteristics of living systems that enable activities that promote financial security (cultural section) (Additional File 4).

Importance level attributed to EGS

There was a difference between the importance levels and the number of EGS (PERMANOVA, $F_{4,99}$ = 13.01; r^2 = 0.32; p = 0.0001, Figure 4A), with the 'very high' importance level being the most used to value the services cited (Additional File 5). However, there was no difference between populations of the different areas in terms of the importance level applied to the EGS (PERMANOVA, $F_{4,99} = 2.40$; $r^2 = 0.06$; $p = 0.07$, Figure 4B)

The main classes for which the population in both areas attributed the highest importance as "very high" were surface water for drinking purposes, surface water used as material (non-drinking purposes) for personal hygiene, cultivated terrestrial plants (including fungi and algae) for food purposes, and aquatic wild animals and their products used for food purposes, all of which belong to the provisioning section.

DISCUSSION

The interviewees' perceptions of EGS are linked to their interactions with the benefits provided by ecological systems, such as where they live, their occupation, and their relationship with reservoirs (de Juan et al. 2017). Although the majority of interviewees were from urban people with higher education levels and monthly family incomes, we found that the rural population perceived more ecosystem services provided by the reservoir landscape. Furthermore, provisioning services are most valued by people, followed by cultural services, partly confirming our hypotheses

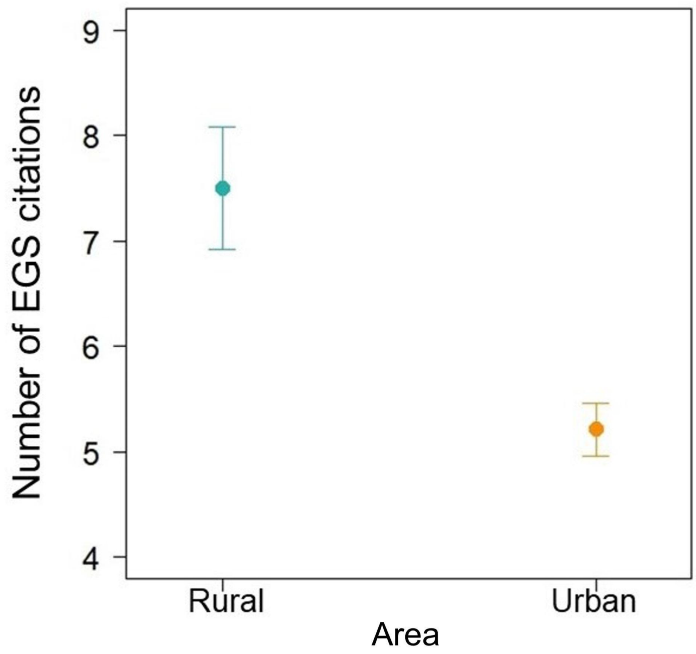

Figure 3. EGS numbers according to rural and urban areas (Paraíba, Brazil).

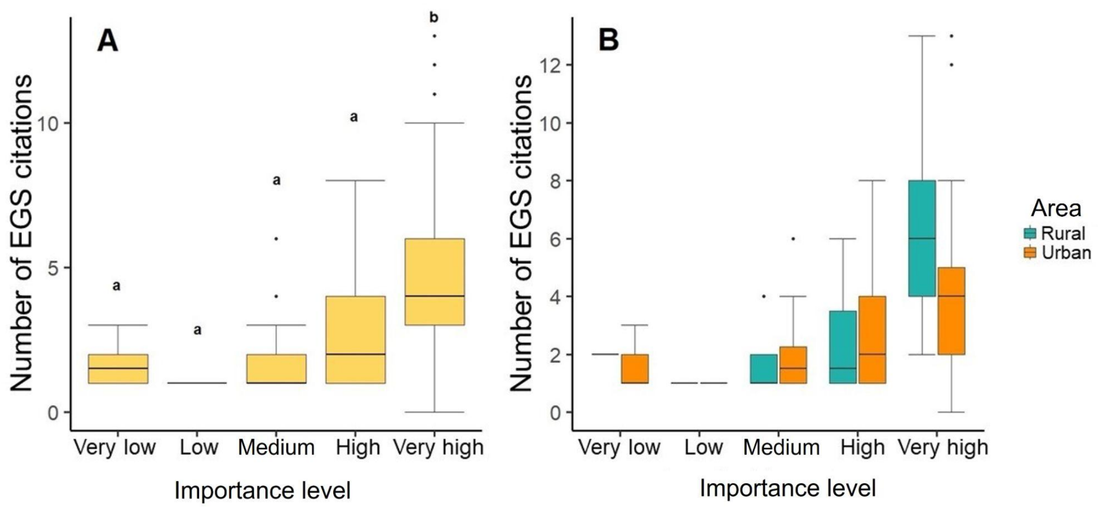

Figure 4. Importance level given to EGS by (A) all interviewees and (B) each person according to the area (rural and urban) where they reside around Camalaú and Epitácio Pessoa reservoirs (Paraíba, Brazil).

one and two.

In our study, men and farmers cited more provisioning services, in contrast to observations in other studies (e.g., Zoderer et al. 2016a). The authors assessed the perceptions of 470 tourists, linked to their sociodemographic background, regarding EGS offered by the landscapes of larch meadows, fir forests, and hay meadows in South Tyrol, Italy, using sociocultural questionnaires and photographs of landscapes with ecosystem service data. Paudyal et al. (2018) found that women valued ecosystem services more than men due to their connection to natural landscapes and the provision of services in the Lake Phewa hydrographic basin in Nepal. Their study analysed the perceptions of 60 people living around the Lake Phewa hydrographic basin, including farmers, women, indigenous people, and marginalised people, as well as ten people from companies that can influence the provision of ecosystem services in this basin and ten experts working in this basin.

In the present study, the greater perception of EGS by men and farmers was related to their involvement in rural activities, such as agriculture, which requires more physical effort and contact with nature (Altea 2020; Funatsu et al. 2019; Mohammed and Abdulquadri 2012). Men tend to perceive EGS more easily, particularly those related to their quality of life (Rodríguez et al. 2006).

Social aspects, such as gender and occupation, significantly influence individuals' perceptions of EGS (Paudyal et al. 2018; Zoderer et al. 2016b). Contrary to Zoderer et al. (2016b) and Paudyal et al. (2018), who found that females tended to value provisioning and cultural services more, our results suggest that men in the studied regions are more closely tied to field activities (such as agriculture) because of the physical exertion required and the importance of the reservoir landscape for farming practices, irrigation, and crop maintenance (Greenland-Smith et al. 2016).

The rural population's higher average citation of provisioning and regulation and maintenance services is related to their contact with reservoirs and the natural landscape. These people also perceive regulation and maintenance services that are not perceived by the urban population, such as services related to flood control and weathering processes and their effects on soil quality. This suggests that the urban area probably has not experienced these natural processes and is largely a built-up area (Yang et al. 2019).

Studies indicate that education level can influence attitudes and knowledge related to the environment (Barradas and Ghilardi-Lopes 2020), as demonstrated in this study. The results indicated that different education levels (Illiterate, Primary School Incomplete, Primary School Complete, High School Incomplete, High School Complete and University Degree Complete) showed differences in perceptions of EGS, with people with lower education levels citing more EGS than those with higher education levels, corroborating other studies (Martín-López et al. 2012; Zoderer et al. 2016a). This shows that education influences people's perceptions of EGS. Individuals with higher education tend to work in urban or built-up areas, which limits their direct contact with the natural environment. The different interactions individuals have with the reservoir landscape suggest that integrating formal and informal knowledge is crucial for the valorisation of EGS (Gonzalez et al. 2009).

Provisioning services, especially those related to water, were categorised as "high" and "very high", followed by cultural services, showing that human well-being services are more important and, therefore, receive more attributions. The high value placed by interviewees in both areas on surface water for drinking purposes may also be related to the exposure of the population to prolonged drought cycles, which are common in the semi-arid region of Brazil (Marengo et al. 2011; Melo et al. 2022). This suggests a high degree of dependence on these ecological systems and the EGS they provide for human well-being.

Reservoir landscapes are of great importance to the populations living around them, as they provide socioeconomic development by offering a wide range of EGS that support the livelihoods of many people (e.g., fishing, agriculture, and recreation). A better understanding of the EGS offered by the reservoir landscape, based on the perception of local people, is important for obtaining information about the ecosystem. This understanding shows that the experiences of people in an ecosystem are relevant to its conservation. Therefore, combining interviewees' perceptions with scientific studies is valuable in developing actions to demonstrate that these goods and services can be used sustainably and must be conserved.

CONCLUSION

Direct contact with native vegetation, reservoirs, and agricultural activities makes it easier for people to perceive EGS, as opposed to the reduced contact with the natural landscape that a built environment offers. Thus, the perception of EGS offered by the reservoir landscape does not depend on whether people live in rural or urban areas but on their contact with the landscape's natural elements. The perception of EGS is related to the socioeconomic characteristics of the population, especially gender, education level, and direct contact of their occupation with the reservoir environment and its surroundings.

The EGS most frequently mentioned and valued by people are related to human well-being, such as water, animals, and plants for food purposes, irrespective of the area where they live. People tend to mention services that are important to them, which is why provisioning services were the most perceived.

This study can inform the development of public policies by providing insight into the perceptions of populations living around reservoirs. This information is crucial for integrating sociodemographic components and improving water management. Participatory management is vital in maintaining reservoirs and offering EGS. This enables direct or indirect contact with these systems to develop and conserve EGS provided by the reservoir landscape.

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DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon request.

CONFLICT OF INTEREST

Have no conflicts of interest.

CONTRIBUTION STATEMENT

Conceived of the presented idea: LMOS, LMRF, JM
Carried out the experiment: LMRF
Carried out the data analysis: LMOS, LMRF and DBDM
Wrote the first draft of the manuscript: LMOS
Review and final write of the manuscript: LMOS, DBDM, LMRF and JM
Supervision: LMRF and JM

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Additional Files

Add File 1. PERMANOVA results for socioeconomic variables, area, and number of EGS.

Variables	R^2	F	P
Gender			
Number of EGS and gender	0.07210	5.6430	0.0214
Number of EGS and area	0.15966	12.4965	0.0009
Number of EGS, gender, and area	0.00164	0.1285	0.7259
Age			
Number of EGS and age	0.00653	0.1141	0.9774
Number of EGS and area	0.21748	15.2007	0.0002
Number of EGS, age, and area	0.00339	0.0592	0.9934
Education level			
Number of EGS and education level	0.19799	2.3064	0.0726.
Number of EGS and area	0.14780	12.0527	0.0007 ***
Number of EGS, education level, and area	0.01652	0.4492	0.7047
Family monthly income			
Number of EGS and income	0.01538	0.2888	0.8770
Number of EGS and area	0.23969	18.0037	0.0002 ***
Number of EGS, income, and area	0.02600	0.4883	0.6965
Occupation			
Number of EGS and occupation (interaction with the reservoir or not)	0.01914	1.4974	0.2327
Number of EGS and area	0.19744	15.4427	0.0003 ***
Number of EGS, occupation (interaction with the reservoir or not), and area	0.01630	1.2745	0.2423

Legend: '***' = 0 (very significant); '**' = 0.001 (significant); and '*' = 0.01 (significant).

Add File 2. PERMANOVA results for socioeconomic variables, area, and number of EGS by section (provision, regulation and maintenance, and cultural).

Variables	R^2	F	P
Gender			
Number of provisioning services and Gender	0.11554	9.0922	0.0050 **
Number of provisioning services and area	0.11749	9.2461	0.0035 **
Number of provisioning services, gender, and area	0.00453	0.3568	0.5530
Age			
Number of provisioning services and age	0.04242	0.7598	0.5507
Number of provisioning services and area	0.18148	13.0026	0.0004
Number of provisioning services, age, and area	0.02242	0.4016	0.8067
Education level			
Number of provisioning services and education level	0.32823	4.5073	0.0004 ***
Number of provisioning services and area	0.12286	11.8099	0.0010 ***
Number of provisioning services, education level, and area	0.00796	0.2552	0.8538
Family monthly income			
Number of provisioning services and income	0.05421	1.0965	0.3582
Number of provisioning services and area	0.18267	14.7796	0.0004 ***
Number of provisioning services, income, and area	0.09570	1.9358	0.1168
Occupation			
Number of provisioning services and occupation (interaction with the reservoir or not)	0.07723	5.8367	0.0199 *
Number of provisioning services and area	0.12159	9.1898	0.0041 **
Number of provisioning services, occupancy (interaction with the reservoir or not), and area	0,00729	0,5509	0,4608
Gender			
Number of regulation and maintenance services and gender	0.00073	0.0488	0.7405

Continua...

Variables	R^2	F	P
Number of regulation and maintenance services and area	0.09472	6.3676	0.0122 *
Number of regulation and maintenance services, gender, and area	0.01201	0.8076	0.3824
Age			
Number of regulation and maintenance services and age	0.00073	0.0488	0.7405
Number of regulation and maintenance services and area	0.09472	6.3676	0.0122 *
Number of regulation and maintenance services, age, and area	0.01201	0.8076	0.3824
Education level			
Number of regulation and maintenance services and education level	0.26971	3.2263	0.0461 *
Number of regulation and maintenance services and area	0.08007	6.7045	0.0117 *
Number of regulation and maintenance services, education level, and area	0.02922	0.8157	0.4519
Family monthly income			
Number of regulation and maintenance services and income	0.07654	1.4903	0.1984
Number of regulation and maintenance services and area	0.11325	8.8203	0.0034 **
Number of regulation and maintenance services, income, and area	0.11690	2.2762	0.1395
Occupation			
Number of regulation and maintenance services and occupation (interaction with the reservoir or not)	0.00250	0.1778	0.5933
Number of regulation and maintenance services and area	0.12255	8.7042	0.0028 **
Number of regulation and maintenance services, occupancy (interaction with the reservoir or not), and area	0.03017	2.1426	0.1193
Gender			
Number of cultural services and gender	0.00554	0.3426	0.5839
Number of cultural services and área	0.02048	1.2663	0.2718
Number of cultural services, gender, and area	0.00360	0.2229	0.6476
Age			
Number of cultural services and age	0.03806	0.5603	0.7137
Number of cultural services and area	0.02490	1.4662	0.2372

Continua...

Variables	**R^2**	**F**	**P**
Number of cultural services, age, and area	0.01999	0.2942	0.8686
Education level			
Number of cultural services and education level	0.25104	2.6284	0.0699
Number of cultural services and area	0.01508	1.1056	0.3006
Number of cultural services, education level, and area	0.02439	0.5958	0.5740
Family monthly income			
Number of cultural services and income	0.05113	0.8713	0.4299
Number of cultural services and area	0.03554	2.4229	0.1315
Number of cultural services, income, and area	0.12116	2.0647	0.1406
Occupation			
Number of cultural services and occupations (interaction with the reservoir or not)	0.00130	0.0851	0.7375
Number of cultural services and area	0.03574	2.3344	0.1349
Number of cultural services, occupancy (interaction with the reservoir or not), and area	0.04436	2.8975	0.0874

Legend: '***' = 0 (very significant); '**' = 0.001 (significant); and '*' = 0.01 (significant).

Add File 3. Pairwise results for the education level variables.

Education level	**T**	**P(perm)**	**Perms**
PSI and Illit.	0.4768	0.6307	9820
PSI and PSC	2.8438	0.0063	9848
PSI and HSC	1.4297	0.1559	9824
PSI and HSI	1.0187	0.3145	9822
PSI and UDC	2.6278	0.0199	8420
PSI and UDI	0.54745	0.6013	9619
PSI and PG	No test. df = 0		
Illit. and PSC	3.0315	0.0175	6989
Illit. and HSC	2.4495	0.0299	5170
Illit. and HSI	0.33166	0.7463	9755
Illit. and UDC	2.1958	0.0884	81
Illit. and UDI	Negative		
Illit. and PG	No test. df = 0		
PSC and HSC	0.46291	0.6824	912
PSC and HSI	4.4009	0.0019	9330
PSC and UDC	8	0.0522	12
PSC and UDI	3.5	0.1537	23
PSC and PG	No test. df = 0		
HSC and HSI	0.33029	0.7604	9821
HSC and UDC	4.3301	0.0268	335
HSC and UDI	1.7823	0.1261	2354
HSC and PG	2.4495	0.0722	40
HSI and UDC	2.0702	0.0881	63
HSI and UDI	0.41404	0.6443	1181
HSI and PG	No test, df = 0		
UDC and UDI	No test		
UDC and PG	No test, df = 0		
UDI and PG	No test		

Add File 4. Number of EGS (N) by classes of EGS identified by interviewees and their respective percentages (%) separated by area (rural and urban) and reservoirs (Epitácio Pessoa and Camalaú).

Ecosystem Goods and Services			Reservoirs					
			Epitácio Pessoa		Camalaú		Total	
		Rural						
Section	**Group**	**Class**	**N**	**%**	**N**	**%**	**N**	**%**
Provision	Surface water used for nutrition, materials or energy	Surface water for drinking purposes.	30	7.85	17	4.45	47	12.30
		Surface water used as material (non-potable purposes) for hygiene	16	4.19	7	1.83	23	6.02
		Surface water used as material (non-potable purposes) for irrigation	14	3.66	7	1.83	21	5.50
	Aquatic wildlife used for nutritional, material or energy purposes	Aquatic wild animals and their production used for nutritional purposes	14	3.66	6	1.57	20	5.24
	Terrestrial animals raised for nutrition, materials, or energy	Terrestrial animals raised for nutritional purposes	1	0.26	3	0.79	4	1.05
	Wild terrestrial plants for nutrition, materials or energy	Fibers and other materials from wild terrestrial plants for direct use or processing (excluding genetic materials)	-	-	1	0.26	1	0.26
		Wild terrestrial plants (including fungi. algae) used as an energy source	1	0.26	-	-	1	0.26
	Terrestrial plants grown for nutrition, materials, or energy	Cultivated terrestrial plants (including fungi. algae) for nutritional purposes	17	4.45	9	2.36	26	6.81
Regulatory and maintenance	Composition and atmospheric conditions	Regulation of the chemical composition of the atmosphere	1	0.26	1	0.26	2	0.52
		Regulation of temperature and humidity, including ventilation and perspiration	2	0.52	1	0.26	3	0.79
	Maintenance of the life cycle, protection of the habitat and gene pool	Maintain populations and habitats in nurseries (including gene pool protection)	4	1.05	2	0.52	6	1.57
	Mediation of waste, toxic and other nuisances by non-living processes	Dilution by freshwater ecosystems	1	0.26	-	-	1	0.26
	Regulation of baseline flows and extreme events	Hydrological cycle and water flow regulation (including flood control and coastal protection)	1	0.26	1	0.26	2	0.52
	Soil quality regulation	Weathering processes and their effects on soil quality	-	-	1	0.26	1	0.26

Continua...

Section	Group	Class	N	%	N	%	N	%
Cultural	Physical and experiential interactions with natural abiotic components of the environment	Natural and abiotic features of nature that enable active or passive physical and experiential interactions	8	2.09	-	-	8	2.09
	Physical and experiential interactions with the natural environment	Characteristics of living systems that enable health-promoting, recovery, or enjoyment activities through active or immersive interactions	16	4.19	-	-	16	4.19
	Intellectual and representational interactions with the natural environment	Characteristics of living systems that enable aesthetic experiences	4	1.05	1	0.26	5	1.05
		Characteristics of living systems that enable activities that promote financial security	2	0.52	-	-	2	0.52
Urban								
Provision	Surface water used for nutrition, materials or energy	Surface water for drinking purposes.	17	4.45	23	6.02	40	10.47
		Surface water used as material (non-potable purposes) for hygiene	18	4.71	18	4.71	36	9.42
		Surface water used as material (non-potable purposes) for irrigation	3	0.79	4	1.05	7	1.83
	Aquatic animals raised for nutrition, materials, or energy	Animals raised by in situ aquaculture for nutritional purposes	-	-	1	0.26	1	0.26
	Aquatic wildlife used for nutritional, material or energy purposes	Aquatic wild animals and their production used for nutritional purposes	18	4.71	15	3.93	33	8.64
	Terrestrial animals raised for nutrition, materials, or energy	Terrestrial animals raised for nutritional purposes	4	1.05	6	1.57	10	2.62
	Wild terrestrial plants for nutrition, materials or energy	Wild terrestrial plants (including fungi. algae) used as an energy source	2	0.52	2	0.52	4	1.05
	Land plants grown for nutrition, materials, or energy	Cultivated land plants (including fungi. algae) for nutritional purposes	16	4.19	13	3.40	29	7.59
Regulatory and maintenance	Composition and atmospheric conditions	Regulation of temperature and humidity, including ventilation and perspiration	1	0.26	1	0.26	2	0.52
	Maintenance of the life cycle, protection of the habitat and gene pool	Maintain populations and habitats in nurseries (including gene pool protection)	3	0.79	-	-	3	0.79
Cultural	Physical and experiential interactions with natural abiotic components of the environment	Natural and abiotic features of nature that enable active or passive physical and experiential interactions	2	0.52	11	2.88	13	3.40

Continua...

Section	Group	Class	N	%	N	%	N	%
	Physical and experiential interactions with the natural environment	Characteristics of living systems that enable health-promoting, recovery, or enjoyment activities through active or immersive interactions	7	1.83	4	1.05	11	2.88
	Intellectual and representational interactions with the natural environment	Characteristics of living systems that enable aesthetic experiences	2	0.52	-	-	2	0.52
		Characteristics of living systems that enable activities that promote financial security	2	0.52	-	-	2	0.52

Add File 5. Pairwise results for the importance level variable.

Importance level	**T**	**P(perm)**	**Perms**
Very high and high	4.0542	0.0001	71
Very high and medium	4694	0.0001	65
Very high and low	2.8465	0.0111	31
Very high and very low	3.1356	0.0046	40
High and medium	1.3538	0.2159	38
High and low	1.6205	0.1317	17
High and very low	1.3855	0.1923	23
Medium and low	1.2133	0.2971	12
Medium and very low	0.65455	0.6046	15
Low and very low	1125	0.4662	4

Average distance between/within groups

	Very high	**High**	**Medium**	**Low**	**Very low**
Very high	2.7029				
High	3.0673	2.0797			
Medium	3.4279	1.8229	1.5083		
Low	4.1923	1.8333	1.0625	0	
Very low	3.6615	1.7167	1.1625	0.6	1