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# ECOSYSTEM SERVICES VALUATION AS MOTIVATION IN FAVOR OF CREATING A PROTECTED AREA IN AN ATLANTIC RAINFOREST REMNANT IN BRAZIL

# VALORAÇÃO DE SERVIÇOS ECOSSISTÊMICOS COMO MOTIVAÇÃO EM PROL DA CRIAÇÃO DE UMA UNIDADE DE CONSERVAÇÃO EM UM REMANESCENTE DE MATA ATLÂNTICA NO BRASIL

# LA VALORACIÓN DE LOS SERVICIOS ECOSISTÉMICOS COMO MOTIVACIÓN A FAVOR DE LA CREACIÓN DE UN ÁREA PROTEGIDA EN UN REMANENTE DE LA SELVA ATLÁNTICA EN BRASIL

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## ABSTRACT

Ecosystems support human life and its varied activities through the provision of ecosystem services, such as support, provision, regulatory, and sociocultural services. There is a consensus in several scientific circles about the importance of the economic values of ecosystem services to support environmental management, decision-making, and public policy. The general purpose of this research was to evaluate ecosystem services in the context of creating a Protected Area (PA), in a subtropical Atlantic rainforest remnant, in Brazil, through a case study of Saí Springs Wildlife Refuge. Using online stakeholder surveys to enable social participation during the pandemic, in conditions of social isolation, we identified 15 ecosystem services provided by the study area and estimated the economic value of eight of them based on two economic valuation methods: market pricing and benefit transfer. The estimated total economic value of ecosystem services was over US$ 14,000,000.00, with considerable relevance to the contribution of sociocultural services. Through interviews with the local population, we evaluated the salience indices for the categories of ecosystem services and their respective economic values and, in the context of creating a PA, we identified the increase in salience for the economic value of all categories and more significantly for sociocultural services. The results demonstrate a correlation between the economic value and the importance given by the interested parties and point to the useful potential of the economic valuation of ecosystem services as an instrument to support the creation of a PA in a subtropical Atlantic rainforest remnant.

**Keywords:** Total Economic Value. Economic Valuation. Salience Index. Social Participation. Market Prices. Transfer of Benefits.

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**RESUMO**
Os ecossistemas sustentam a vida humana e suas diversas atividades por meio da provisão de serviços ecossistêmicos, tais como serviços de suporte, provisão, regulação e socioculturais. Existe um consenso em diversos meios científicos sobre a importância dos valores econômicos dos serviços ecossistêmicos para subsidiar a gestão ambiental, a tomada de decisão e as políticas públicas. O objetivo geral desta pesquisa foi avaliar os serviços ecossistêmicos no contexto da criação de uma Unidade de Conservação (UC) em um remanescente de Mata Atlântica subtropical, no Brasil, por meio de um estudo de caso do Refúgio de Vida Silvestre das Nascentes do Saí. Utilizando pesquisas online com as partes interessadas — viabilizando a participação social durante a pandemia, em condições de isolamento social —, identificamos 15 serviços ecossistêmicos providos pela área de estudo e estimamos o valor econômico de oito deles com base em dois métodos de valoração econômica: preços de mercado e transferência de benefícios. O valor econômico total estimado dos serviços ecossistêmicos superou US$ 14.000.000,00, destacando-se a contribuição dos serviços socioculturais. Por meio de entrevistas com a população local, avaliamos os índices de saliência para as categorias de serviços ecossistêmicos e seus respectivos valores econômicos; no contexto da criação de uma UC, observamos um aumento na saliência atribuída ao valor econômico de todas as categorias, sendo esse incremento mais expressivo no caso dos serviços socioculturais. Os resultados demonstram uma correlação entre o valor econômico e a importância atribuída pelas partes interessadas, evidenciando o potencial da valoração econômica de serviços ecossistêmicos como um instrumento de apoio à criação de uma Unidade de Conservação em um remanescente de Mata Atlântica subtropical.

**Palavras-chave:** Valor Econômico Total. Valoração Econômica. Índice de Saliência. Participação Social. Preços de Mercado. Transferência de Benefícios.

**RESUMEN**
Los ecosistemas sustentan la vida humana y sus diversas actividades mediante la provisión de servicios ecosistémicos, tales como servicios de soporte, aprovisionamiento, regulación y socioculturales. Existe un consenso en diversos ámbitos científicos sobre la importancia de los valores económicos de los servicios ecosistémicos para respaldar la gestión ambiental, la toma de decisiones y las políticas públicas. El objetivo general de esta investigación fue evaluar los servicios ecosistémicos en el contexto de la creación de un Área Protegida (AP) en un remanente de bosque atlántico subtropical en Brasil, a través de un estudio de caso del Refugio de Vida Silvestre de Saí Springs. Mediante encuestas en línea dirigidas a las partes interesadas —lo que permitió la participación social durante la pandemia, en condiciones de aislamiento social—, identificamos 15 servicios ecosistémicos proporcionados por el área de estudio y estimamos el valor económico de ocho de ellos utilizando dos métodos de valoración económica: precios de mercado y transferencia de beneficios. El valor económico total estimado de los servicios ecosistémicos superó los 14 000 000,00 USD, destacando la contribución significativa de los servicios socioculturales. A través de entrevistas con la población local, evaluamos los índices de relevancia (salience indices) para las categorías de servicios ecosistémicos y sus respectivos valores económicos; en el contexto de la creación de un AP, observamos un aumento en la relevancia atribuida al valor económico de todas las categorías, siendo este incremento especialmente notable en el caso de los servicios socioculturales. Los resultados demuestran una correlación entre el valor económico y la importancia otorgada por las partes interesadas, y señalan el potencial de la valoración económica de los servicios ecosistémicos

como una herramienta útil para respaldar la creación de un Área Protegida en un remanente de bosque atlántico subtropical.

**Palabras clave:** Valor Económico Total. Valoración Económica. Índice de Relevancia. Participación Social. Precios de Mercado. Transferencia de Beneficios.

## 1 INTRODUCTION

Ecosystems provide a range of services that are of fundamental importance to the human well-being, health, livelihood, and survival, such as direct provision of water and food; processes such as maintaining air quality, climate regulation, and waste treatment; generating benefits from recreation, aesthetics and spiritual aspects; and cognitive development (Costanza et al. 1997; de Groot et al. 2002; MEA 2005).

A better understanding of the role of ecosystem services emphasizes and includes our natural assets as critical components of wealth, well-being, and sustainability. This reformulation of the way we look at “nature,” with a broad recognition of ecosystem services and the relationship between human beings and the elements of nature, is essential to address the problem of how to build a sustainable and desirable future for humanity (Bailly et al. 2021; Costanza et al. 2014; Velasco-Muñoz et al. 2022; Wang et al. 2021).

Given the importance of services generated by ecosystems for human well-being and for supporting life on the planet, the need to value them is undeniable (Costanza et al. 2014; de Groot et al. 2002; Taye et al. 2021). For the purposes of policies that aim to address changes associated with the use of natural resources, it is ultimately necessary to know how changes in the flows of ecosystem services impact human capacity to achieve their ultimate goals related to their material or not (Coelho-Junior et al. 2021; Martín-López et al. 2014; Santos Vieira et al. 2021).

Estimates of ecosystem services book value in currency units play a key role in raising awareness and identifying the importance of ecosystem services in relation to other contributing factors to sustainable human well- being (Islam et al. 2019). Identifying and quantifying ecosystem services is increasingly important for establishing public policies, planning land-use, decision-making, and ecosystem management (Gaitán-Cremaschi et al. 2017; Kantharajan et al. 2022; Li et al. 2020; Petroni et al. 2022).

Despite their relevance, natural environments and – consequently – ecosystem services have been continuously degraded across the planet as a result of the global population increase and economic growth (MEA 2005). The implementation of protected areas is one of the main strategies to minimize this negative influence of human activities on biodiversity (Bailly et al. 2021; Llopis et al. 2021; Watson et al. 2014). However creation processes of Protected Areas in Brazil require an approach that is technically adequate, so that they are not determined exclusively by opportunity and convenience factors (Baldi et al. 2017; Figueiroa et al. 2020).

In this context, ecosystem services valuation has been proposed as a potentially useful argument to integrate the social dimension more comprehensively into decision-making in protected areas and to increase support for conservation (Považan et al. 2021). Thus, the approach to ecosystem services is integrated as a contribution to the process of creating a PA, aiming to benefit society through the maintenance of services from nature, fundamental to the quality of life and human well-being (Baldi et al. 2017; Chen, 2021; Coelho-Junior et al. 2021; Figueiroa et al. 2020).

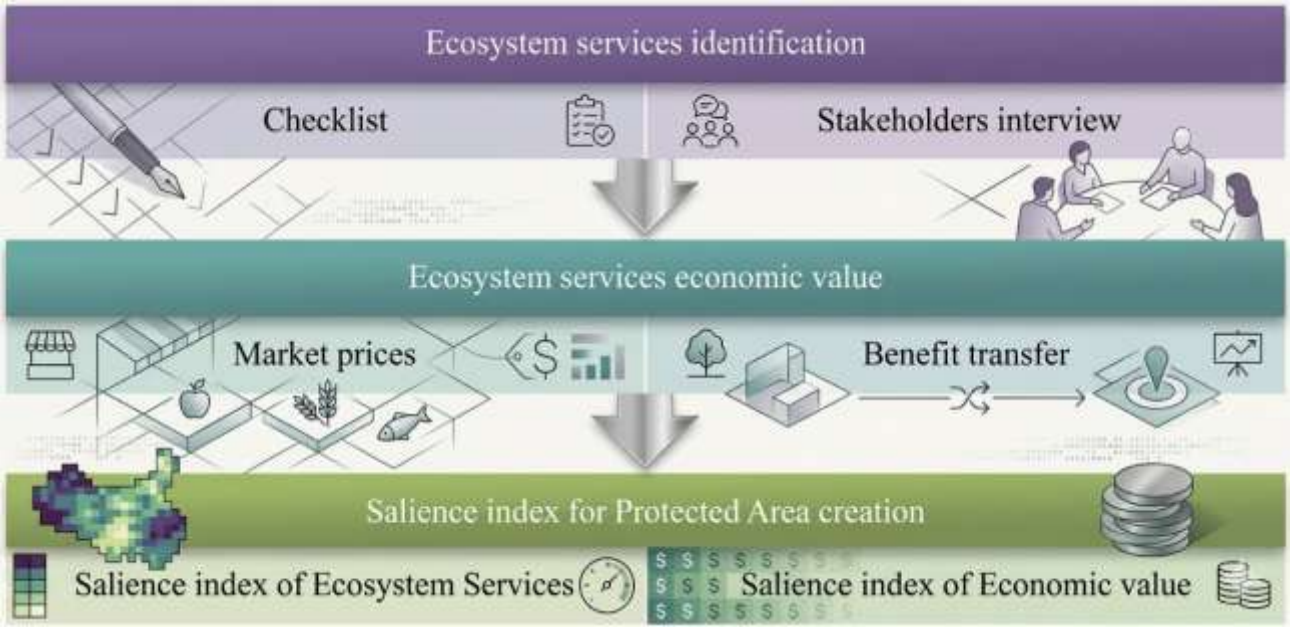
Although many studies have evaluated ecosystem services in PA that have already been created, as far as we know, there are no studies correlating economic valuation in this process. In this context, the present study aimed to identify and evaluate the main ecosystem services in the context of creating a PA. For this purpose, we performed a case study in an Atlantic rainforest remnant in Santa Catarina, south of Brazil. Through literature and surveys with interested parts, we were able to assess the various ecosystem services provided by the rainforest. By assigning economic values to these services, we were able to demonstrate the potential economic benefits of creating a PA in this region

## 2 MATERIALS AND METHODS

This paper was developed in three stages (Fig. 1). The first stage aimed at the participatory identification of ecosystem services provided by the study area. In the second, different techniques were applied to obtain the economic values of ecosystem services. The third stage evaluated the Total Economic Value (TEV) on the salience index of ecosystem services for creation a PA in the study area.

**Figure 1**

*Methodology flow diagram.*



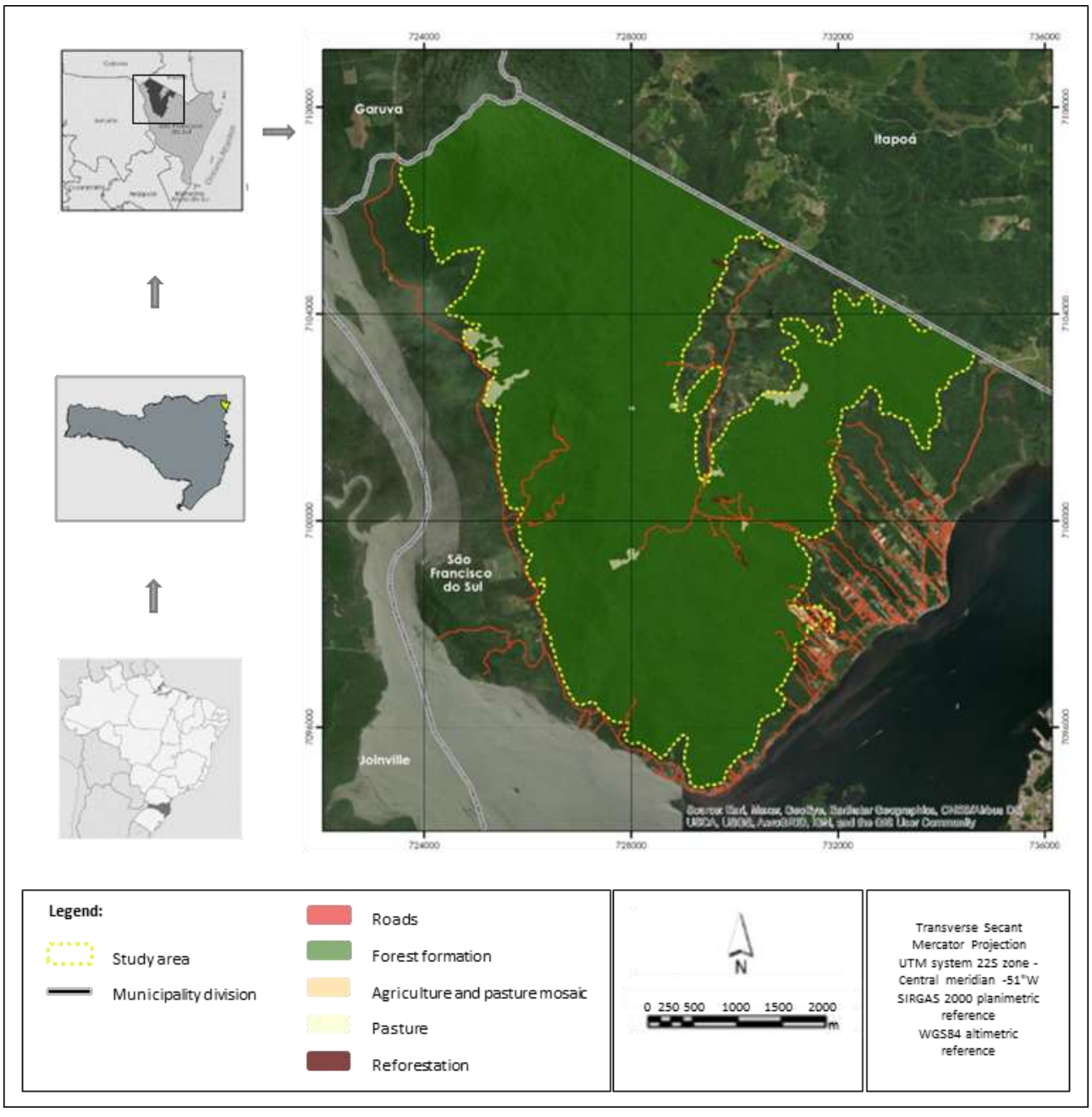

2.1 STUDY AREA

The present study is part of the “Socio-environmental Diagnosis for the Creation of a Protected Area in *Vila da Glória*, municipality of *São Francisco do Sul* - SC” project (*Nascentes do Saí* project), which carried out a diagnosis with the collection of primary data from several thematic areas, aimed at protecting the remaining local Atlantic forest. The territory called *Saí* District is located on the mainland of the municipality of São Francisco do Sul (Latitude 26°14’38’’ South, Longitude 48°38’18’’ West), on the northern coast of Santa Catarina state, Brazil (Fig. 2).

The study area refers to a 6,702.20 hectares territorial area constituted by the area of hills previously designated for the creation of a PA (Fig. 2). This entire area belongs to the Atlantic Rainforest biome and presents a landscape characterized by a natural matrix, with patches of urban occupation and rural production, with road corridors where urban patches are concentrated. The natural matrix is characterized by the subtropical Atlantic Rainforest in an advanced stage of regeneration, indicated as “forest formation” in the land cover and use map (Fig. 2). Much of the biodiversity is present in this forest formation, including 252 species of birds and endangered species of flora and fauna. In addition to contributing to the conservation of water resources, this area attracts local visitors and tourists looking for contact with nature and contemplation of the landscape (UFSC 2021).

**Figure 2**

*Location of the study area, municipality of São Francisco do Sul, state of Santa Catarina, based on UFSC (2021).*




The Demographic Censuses of Instituto Brasileiro de Geografia e Estatística (IBGE 2000, 2010) showed a total population of 1,366 and 1,625 inhabitants, respectively in 2000 and 2010 for the *Saí* District, which represents a 18.96% growth, which is less than the municipal average for the same period. IBGE estimates point to a population of 2,745 inhabitants for 2040 (IBGE 2010).

The productive areas are relatively small and with limited production. Data referring to *Saí* District from the 2017 Agricultural Census (IBGE 2017) indicate that within the agricultural activities carried out in the establishments, 39.6% is related to livestock, highlighting the creation of cattle and poultry, and 22.9% to the production of annual crops. It is also important to highlight that 14.6% of agricultural activities in *Saí* District are related to the production of exotics for the use of wood (IBGE 2017).

## 2.2 ECOSYSTEM SERVICES SELECTION

The process of identifying the ecosystem services (ES) of study area, started from a checklist of ecosystem services listed in TEEB (2010) and Haines-Young and Potschin (2018), which was a basis for consultation with the local community (residents) and experts (interested parts). For this consultation, an online survey questionnaire was used to identify and evaluate the ecosystem services of the study area for the creation of a PA. The research instrument consisted of a form sent to the participants of a governance group with 78 people, to discuss the creation of a PA in the study area. The governance group is made up of residents, researchers, and visitors, as well as stakeholders from the public government and the private initiative. The questionnaire was sent by Google Forms in May 2021 and the responses were collected until August 2021. Due to the restrictive measures imposed to fight COVID-19 pandemic, it was not possible to apply the questionnaire in person (face to face). By the other hand, the use of electronic form ensures the participation of many social actors even during social isolation period.

The first section of the questionnaire explained the purpose of the study, the context in which it was being carried out, and the questionnaire structure. The second section collected the respondent's identifying information, such as name, link to the place (if researcher, visitor, or resident) and age. Only responses from people over 18 years old were considered. The third section was built on the checklist of previously selected ecosystem services. For each ecosystem service, this section had an adapted translation of TEEB (2010) and Haines-Young and Potschin (2018) in simple terms and language accessible to the lay public, but without losing the meaning, which was aided by images that referred to the ecosystem service in question, to further facilitate the respondent's understanding.

Then there were two questions for each ecosystem service. In the first, the interviewees were asked if they recognized the presence of that service in the study area for the creation of a PA (yes or no). To avoid forced answers, the “I don't know” option was also

provided. Then, respondents were invited to indicate the degree of importance they gave to a given ecosystem service, based on a 5-point Likert scale question, whose categories were: (1) not at all important, (2) not very important, (3) neutral, (4) important, and (5) very important. Finally, respondents were able to count on a space to discuss their answers and the service in question, as well as identify and recognize other types of services absent from the list presented.

After consulting with the local community, the interpretation of the questionnaires results was carried out to correlate the answers with the ecosystem services identified by TEEB (2010), thus making their categorization.

## 2.3 VALUATION

Two economic valuation techniques were applied, following the recommendations of de Groot et al. (2012) and Turner et al. (2015). The valuation technique based on market prices allows the valuation of ecosystem services that have real data available specifically for the study area, such as water supply and science and education services. The benefit transfer technique, on the other hand, allows the valuation of other ecosystem services from a simplification based on coefficients for land-use and land cover classes (Costanza et al. 2014).

Only ecosystem services identified as very important by at least two-thirds of respondents to the stakeholder survey were considered for the economic valuation. For the economic calculation of all services, the base year 2019 was used and the value was expressed in dollars (USD) per year.

### 2.3.1 Market prices

This method was used for water supply (supply) and science and education (sociocultural) services, considering the real market price of drink water and the budget of scientific projects. The value of the water supply service was calculated from the volume produced in the study area in 2019 and the average water tariff in the same year. The data on the contribution of the study area to the total production of water supply in the municipality of São Francisco do Sul were collected with information from the Intermunicipal Sanitation Regulatory Agency, which is operated by the Water Supply Company concessionaire (ARIS, 2015). The data on the total water production of ASFS and the average tariff charged to users were obtained from data from the National Sanitation Information System (SNIS), of the

Ministry of Regional Development (BRASIL, 2021). The value was converted to dollars, based on the exchange rate recorded on the last day of the year 2019 (Exchange-rates, 2021).

For the science and education ecosystem service, the budget of the *Nascentes do Saí* project (UFSC, 2021) was considered, through a simplification, that only this project has promoted scientific research in the last 5 years in the study area. It should be noted that although there were few research projects and technical studies in the study area, is the only project one focused on the study area, with available information on budget values. Therefore, these values were used to calculate the annual value of the science and education ecosystem service.

### 2.3.2 Benefits transfer

To assign values for ecosystem services to land-use classes identified in the study area, estimates calculated by Costanza et al. (2014) were used. Although the types of use present in the cited work do not directly correspond to the categories present in the study area (Table 1), the most representative biomes were used as a proxy for the value of each type of land cover.

**Table 1**

*Land cover and use classes and territorial extension in study area, based on UFSC (2020) and Costanza et al. (2014).*

| Land-use classes (UFSC, 2021) | Equivalent class (Costanza et al. 2014) | Area (ha) | % |
|---|---|---|---|
| Forest formation | Tropical forest | 6,584.58 | 98.25 |
| Reforestation | Forest | 21.11 | 0.31 |
| Pasture | Grass/Rangelands | 90.03 | 1.34 |
| Agriculture and pasture mosaic | Grass/Rangelands | 1.71 | 0.03 |
| Roads | Urban | 4.77 | 0.07 |
| Total | | 6,702.20 | 100 |

Values were expressed in 2019 US dollars per hectare per year, that is, the values calculated by Costanza et al. (2014) were converted to 2019 USD based on Consumer Price Index (U.S. BLS, 2022). Given the coefficients of the ecosystem services values by category of use, presented in Table 2, we obtained the aggregate value of the ecosystem services identified, which provided individual monetary estimates by type of land cover. The equation used for this calculation is presented in equation $ESVf = \Sigma A_k * VCf_k$; where: $ESVf$ = estimated

value of the ecosystem service *f* (in USD); $A_k$ = area of *k* land use category (in ha); $VCf_k$ = coefficient for *f* ecosystem service in *k* category (in USD $ha^{-1}$ $y^{-1}$).

**Table 2**

*Coefficients of the values of ecosystem services by land-use category in study area, based on Costanza et al. (2014).*

| Ecosystem Services | 2019 USD $ha^{-1}$ $y^{-1}$ | | | | |
|---|---|---|---|---|---|
| | Forest formation | Reforestarion | Pasture | Agriculture and pasture mosaic | Roads |
| Atmospheric regulation | 14.88 | 4.39 | 11.26 | 11.26 | 0.00 |
| Soil Retention | 418.43 | 123.54 | 54.56 | 54.56 | 0.00 |
| Pollination | 37.20 | 10.98 | 42.78 | 42.78 | 0.00 |
| Habitat for species | 48.36 | 767.59 | 1,505.36 | 1,505.36 | 0.00 |
| Recreation and leisure | 1,075.08 | 1,181.70 | 32.24 | 32.24 | 7,117.53 |
| Cultural Heritage and Identity and Aesthetic Beauty[1] | 2.57 | 1.63 | 207.08 | 207.08 | 0.00 |

[1] Jointly valued as a sociocultural service by Costanza et al. (2014).

## 2.4 SALIENCE

To assess the economic value of ecosystem services in the context of creating a PA in the study area, a social survey questionnaire with 14 questions was developed, which was applied online and through face-to-face interviews.

It is important to highlight that the participants were trained through mini-courses and workshops on ecosystem services. In this way, the community was empowered for decision-making, improving the performance of the applied survey forms. The mini-courses were carried out by video classes recorded and disseminated in the community, but also the learning monitoring with individual and collective assistance was made.

The online survey instrument consisted of a Google Forms form and was sent to the participants of the governance group created to discuss the creation of a PA in the study area, composed of 78 members including residents, researchers, and visitors, as well as stakeholders from the public government and private initiative. The face-to-face interviews were carried out in *Saí* District, with local residents and visitors, in places with large circulation of people. The social survey questionnaire was carried out in September and October 2021.

The questionnaire, after a previous presentation about the topic and the research stage and the concepts related to the questions, was divided into two parts. The first, with eight questions, had the function of identifying the interviewee's link with the study area

(residents or non-residents) and collecting information for the socioeconomic profile, in addition to identifying their degree of involvement in the face of local environmental issues, especially about the creation of a PA. The second part of the questionnaire consisted of two questions to analyze the importance of each ecosystem service for the total number of respondents, in order to enable the application of the Smith and Borgatti Salience Index to free lists (Smith and Borgatti, 1997). The salience index is designed to take into account the frequency and sort order of items in lists. The salience of ecosystem services (first question) and economic values (second question) for creating a UC in the study area was calculated as equation: $S = ((\Sigma(L - R_j + 1)) / L) / N$; where: S = the average rank of an item across all lists in the sample, weighted by the lengths of the lists in which the item occurs; L = the length (number of items) of a list; $R_j$ = the rank of item j in the list (first = 1); N = the number of lists in the sample. The calculation was performed with Anthropac 4.98 software, using the results of the two questions. The salience (S) scores range from 0 (no salience for the ecosystem service and the assessed user) to 1 (total salience for the ecosystem service and the assessed user).

In the first list, respondents indicated the ecosystem services they considered most important for the creation of a PA in the study area. Respondents had as support the list of ecosystem services obtained in the previous stages of the research (identification and valuation of ecosystem services) and could indicate from 1 to 8 services. The data were used to calculate the Salience Index for these different ecosystem services and the average for each category of ecosystem services (provision, regulation, habitat, and sociocultural). After the responses to the first listing for ecosystem services, respondents were asked to make a new list of importance for the four categories of ecosystem services, however, considering the economic value found in the valuation stage, which was presented along with the categories.

## 3 RESULTS

### 3.1 ECOSYSTEM SERVICES IDENTIFIED

Initially, 13 ecosystem services were identified for the creation of a PA and evaluated by the respondents, who also identified two more ecosystem services through open questions. As a result, all 15 ecosystem services are listed in Table 3, which shows the percentage of respondents who identified ecosystem services on the maximum scale of importance for the creation of a PA.

We obtained 35 valid responses (45% response rate), with 51.4% of respondents being local residents and the rest being non-residents (28.6% researchers, 17.1% visitors, and 2.9% are representatives of the municipal government) (Fig. 3). The average age of respondents was 44 years. The minimum age of the respondents was 19 and the maximum was 74 years old.

The importance results comprised a scale from 1 (not at all important) to 5 (very important). “Blank” answers – when a respondent went on to the next question without choosing one of the importance scores for a given ecosystem service – were not considered valid and, therefore, were not analyzed. As seen in Table 3, the percentage of responses on the maximum scale of importance ranged from 97% for water supply to 45% for raw material supply.

**Table 3**

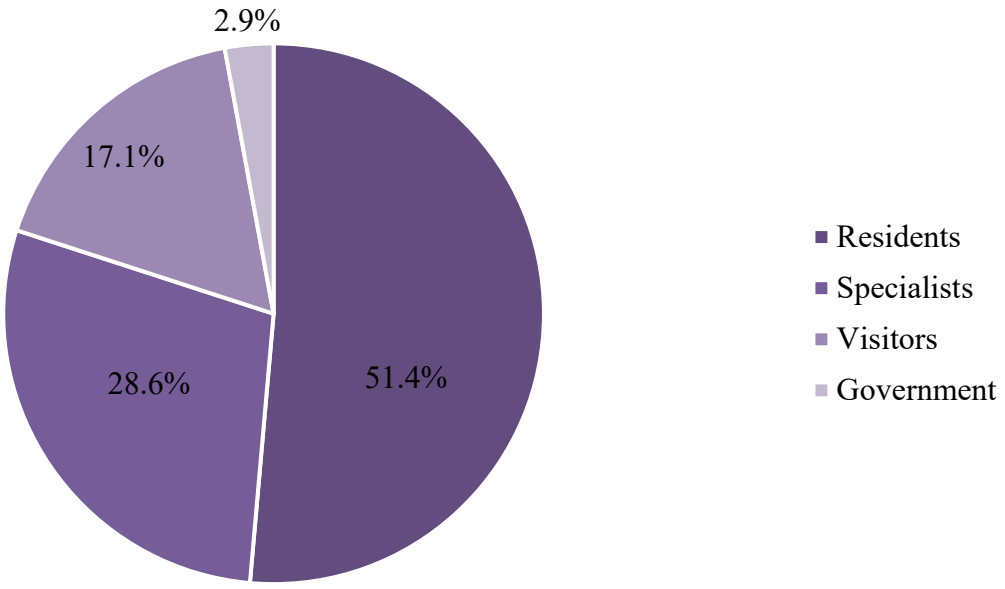
*List of ecosystem services and respective percentage of respondents (n = 35) who identify each ecosystem service as very important.*

| Ecosystem Service | Category | Percentage of responses on the maximum importance scale | Weighted average |
|---|---|---|---|
| Water supply | Provision | 97% | 4.97 |
| Habitat for species | Support | 91% | 4.89 |
| Pollination | Regulation | 89% | 4.86 |
| Aesthetic beauty | Sociocultural | 88% | 4.88 |
| Soil retention | Regulation | 86% | 4.74 |
| Leisure and recreation | Sociocultural | 86% | 4.80 |
| Heritage and cultural identity | Sociocultural | 83% | 4.83 |
| Atmospheric regulation | Regulation | 80% | 4.77 |
| Science and education | Sociocultural | 79% | 4.62 |
| Pollution reduction | Regulation | 65% | 4.29 |
| Food supply | Provision | 57% | 4.31 |
| Genetic resources | Provision | 55% | 3.97 |
| Raw material | Provision | 45% | 3.91 |
| Water regulation * | Regulation | - | - |
| Climate regulation * | Regulation | - | - |

* Identified later through the open questions.

**Figure 3**

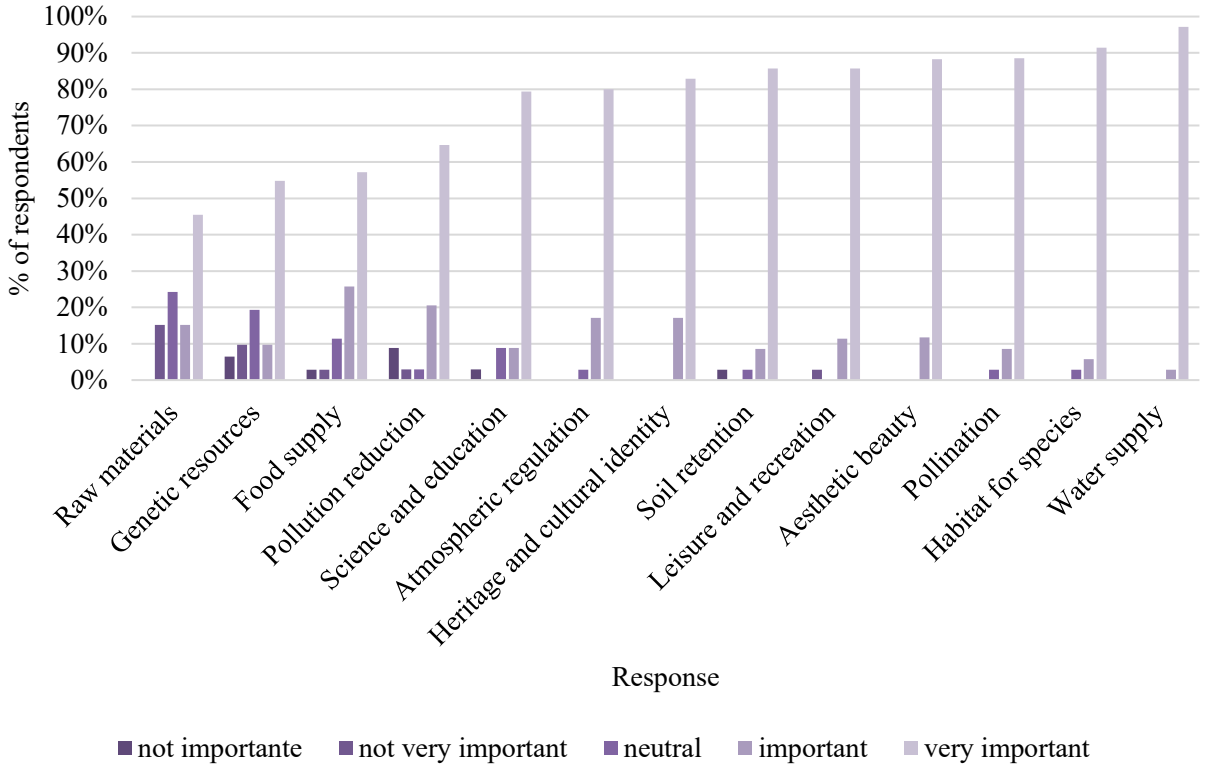
*Characteristics of the respondents in relation to the study area.*




The top four “very important” ecosystem services were water supply, habitat for species, pollination, and aesthetic beauty. More than 88% of people believed that these services were very important. The three ecosystem services that most respondents said were “not important at all” were raw materials (45%), genetic resources (55%), and food supply (57%). Four ecosystem services (heritage and cultural identity, leisure and recreation, aesthetic beauty and water supply) were considered important or very important by 100% of the respondents (Fig. 4).

**Figure 4**

*Results for the respondents' importance assessment.*




Less than two thirds of the respondents who evaluated the services of pollution reduction, food supply, genetic resources, and raw materials attributed the maximum scale of importance and, therefore, they were not valued economically in the next stage, as well as the identified services only through open questions. Although these benefits promoted by the ecosystem are present and directly or indirectly enjoyed by the different stakeholders, their economic values were not considered relevant for the estimation of the VET of the study area.

## 3.2 ECONOMIC VALUE

According to data (ARIS, 2015), water production in *Saí* District (municipal continental area) is 135 liters per second, which represents 60% of the water treated and distributed in São Francisco do Sul, whose total was 5,396,850 cubic meters in the year 2019. The average tariff per cubic meter was BRL 4.93, totaling a value for this ecosystem service of BRL 15,963,882.30 per year – or USD 3,972,133.19 converted into US dollars at a 0.24882 rate.

The value of the contract signed between UFSC and the City Hall for the execution of *Nascentes do Saí* project was BRL 556,528.00, with no budget information from other research, focusing on the region covered, in the last 5 years. Thus, considering *Nascentes*

*do Saí* as the only value produced in science and education in the last 5 years, the annual value produced in research was BRL 111,305.60 per year. Converting into 2019 dollars, the value of the ecosystem service is USD 27,695.06 per year.

The transfer of benefits assumed a constant unit value per hectare per land cover class (Table 2), based on Costanza et al. (2014), and multiplied this value by the area of each type in the study area (Table 1) to arrive at the aggregate totals, presented in Table 4.

**Table 4**

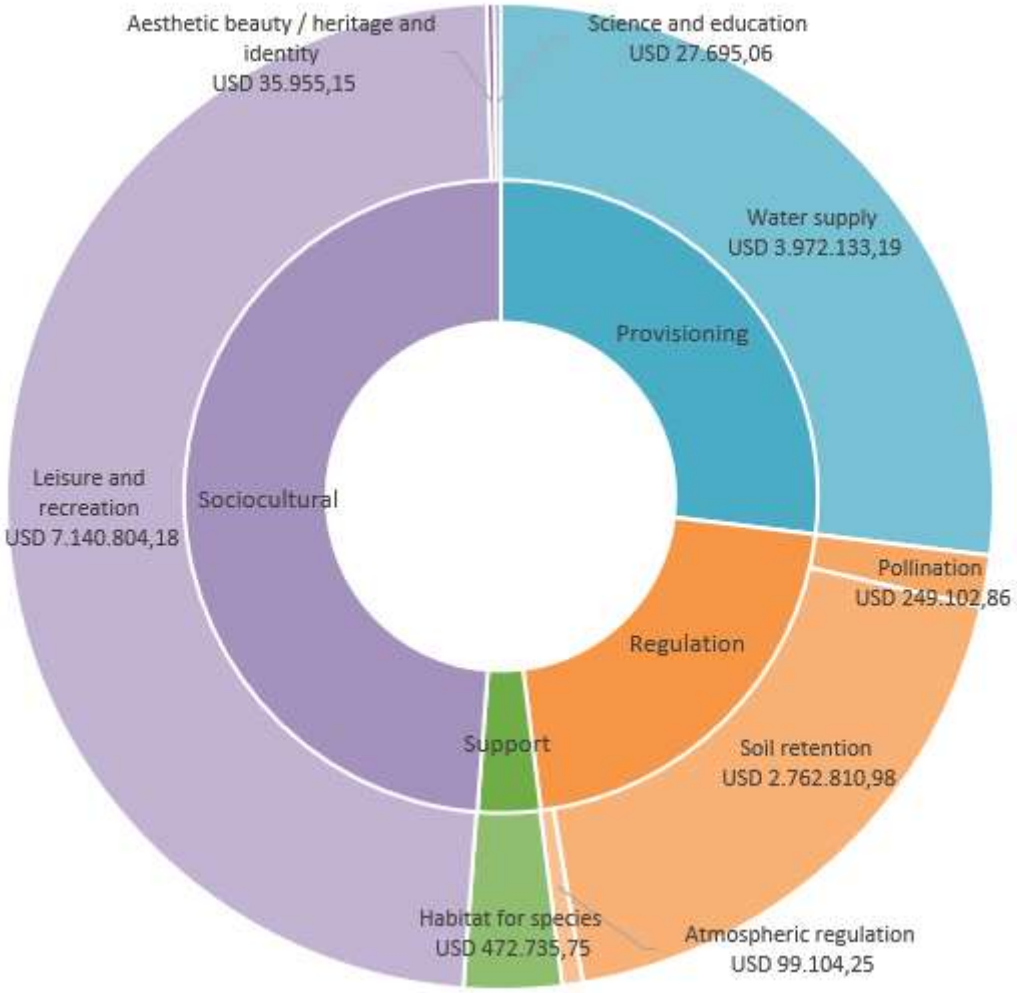
*Economic value of ecosystem services by the benefit transfer technique.*

| Ecosystem Service | Value of Ecosystem Services – 2019 USD/year |
|---|---|
| Leisure and recreation | 7,140,804.18 |
| Aesthetic beauty / heritage and identity | 35,955.15 |
| Habitat for species | 472,735.75 |
| Soil retention | 2,762,810.98 |
| Pollination | 249,102.86 |
| Atmospheric regulation | 99,104.25 |

Total Economic Value (TEV) is a way of converting ecosystem services into economic value. The TEV principle establishes that the value of an environmental resource can be obtained by the sum of the goods and services provided by it, regardless of whether its benefits receive market prices. For the study area, it was assumed that the evaluated ecosystem services embody the most important use and non-use values of the site. The values are presented in Fig. 5.

**Figure 5**

*Total Economic Value (TEV) of ecosystem services in the study area.*




3.3 SALIENCE

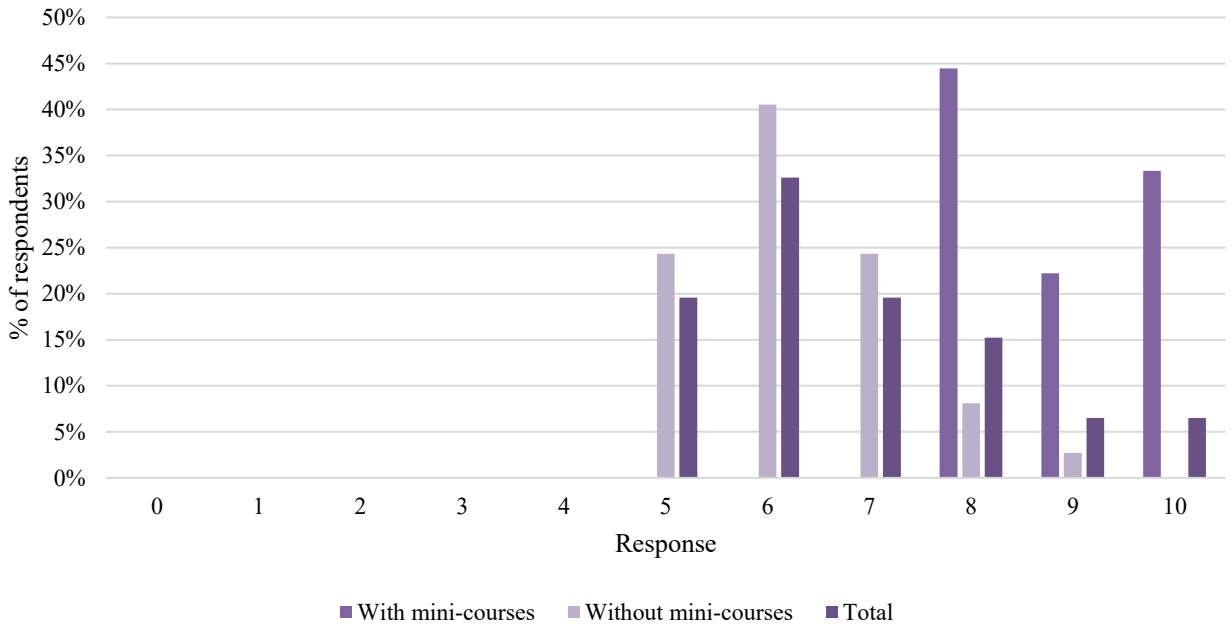
The salience index assessment questionnaire was applied to 46 people (33 in face-to-face interviews and 13 online), with 43.5% of the respondents being local residents and the rest being non-residents (researchers or visitors). The female gender was declared by 54.3% of the respondents and the rest declared themselves to be male. The age most declared by the respondents, with 26%, was between 35 and 44 years old, and no respondent was 75 years old or older.

Only nine respondents claimed to have participated in the training mini courses of the *Nascentes do Saí* project. These are the ones who consider themselves more sensitive to socio-environmental causes, with an 8.89 average (the average of those who did not participate in the mini-courses was 6.22). The general average for self-declaration of

sensitivity to socio-environmental causes was 6.74. No respondent declared himself below 5 and 7% of respondents declared himself in the maximum score (Fig. 6).

**Figure 6**

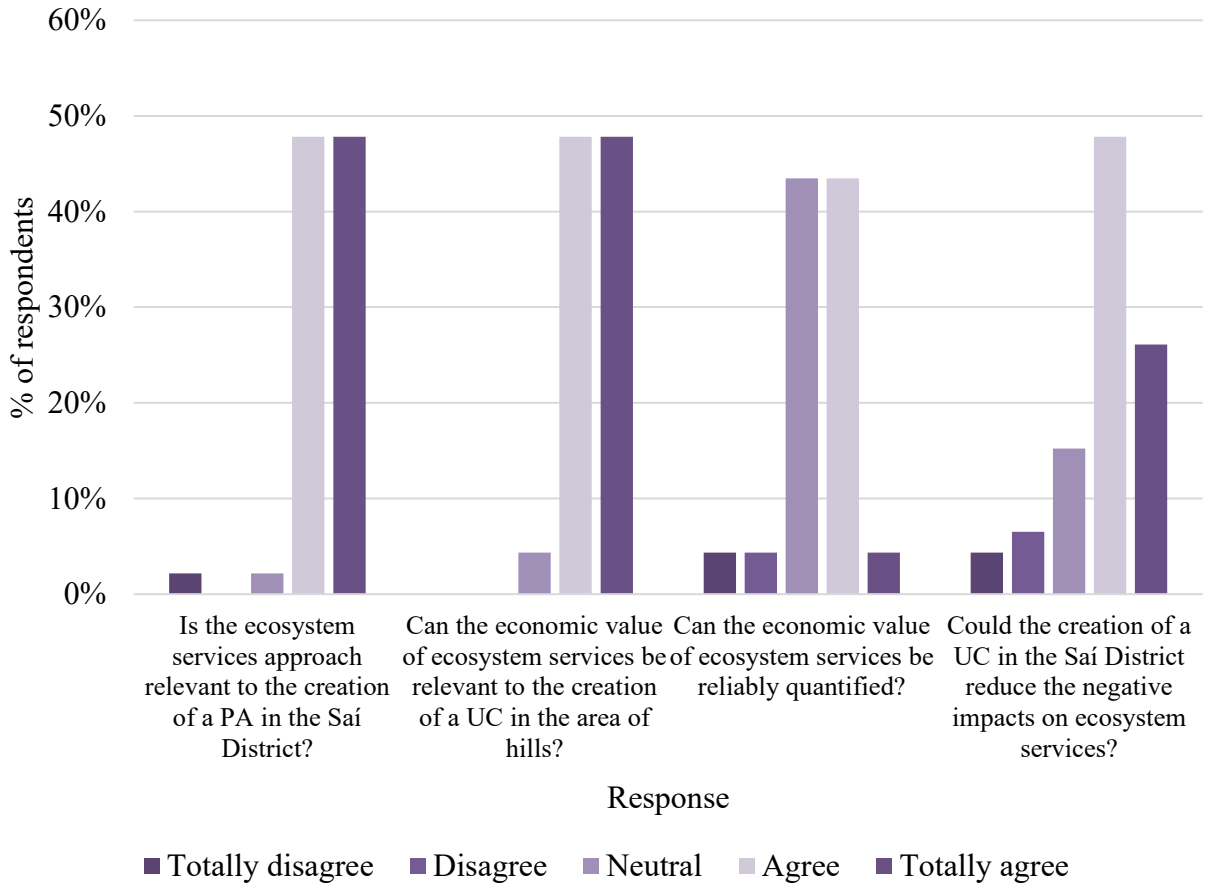
*Results obtained for the question: "From 0 to 10, how do you declare yourself sensitive to socio-environmental causes?"*




As for the outcome variables surveyed, the relevance of the ecosystem services approach to the creation of a PA, were confirmed by 96% of the responses that agree or totally agree with the variable, as well as the relevance of the economic value. The reliability of the economic valuation methods was confirmed by 47% of the responses, who agreed or totally agreed with the variable, but with an emphasis on 43% of the people who were neutral. As for the variable of reducing negative impacts on ecosystem services through the creation of a PA, the responses of 74% of people confirmed the variable, with 11% of negative responses (disagree or totally disagree) (Fig. 7).

**Figure 7**

*Results of outcome variables for ecosystem services assessment.*




The Smith salience index of each ecosystem service in study area is presented in Table 5. It is noted that the water supply service was the most salient (with a 0.719 index) for the creation of a PA, followed by the habitat service for species (a 0.572 index).

**Table 5**

*Smith's Salience Index for ecosystem services in the context of creating a PA in the study area.*

| Item | Salience |
|---|---|
| Water supply | 0.719 |
| Habitat for species | 0.572 |
| Soil retention and landslide protection | 0.412 |
| Atmospheric regulation and air purification | 0.301 |
| Science and education | 0.296 |
| Pollination | 0.286 |
| Leisure and recreation | 0.250 |
| Cultural-historical heritage | 0.252 |

Looking at the salience averages for the ecosystem service categories and the salience of their respective economic values, the results were considerably different. The salience indices of economic values for all categories had a positive variation, with a relative increase between 11.13% and 92.11% (Table 6). Sociocultural services showed a significant increase in salience, going from 0.266 to 0.511 with economic valuation, which represents about 92% of relative increase. Regulatory services also had an important relative increase in salience with economic valuation, with an almost 55% relative increase. The economic valuation of support services showed a relative increase of more than 17% in the salience index. The economic value of provision services remained the most salient for the creation of a PA, with 0.799 and represented the smallest relative increase in salience, with around 11%.

**Table 6**

*Comparison of salience indices of ecosystem services and their respective economic values.*

| Category | Salience | | Relative increase |
|---|---|---|---|
| | Ecosystem services | Economic value | |
| Provision | 0.719 | 0.799 | 11.13% |
| Habitat | 0.572 | 0.674 | 17.83% |
| Regulation | 0.333 | 0.516 | 54.95% |
| Sociocultural | 0.266 | 0.511 | 92.11% |

## 4 DISCUSSION

### 4.1 ECOSYSTEM SERVICES DESCRIPTION AND INTERPRETATION

The 13 ecosystem services pre-identified for the creation of a PA were evaluated by the respondents, who also identified two more ecosystem services through open questions. These additions to the ecosystem services list reflect the importance of covering different stakeholders in the ecosystem services assessment process. With the inclusion of different stakeholders in the context of creating a PA, our research is compatible with the results of Boeraeve et al. (2018), who claim that the identification and selection of ecosystem services are critical steps that directly influence the relevance for decision-making (Sheng et al. 2019).

Regarding the questionnaire used to identify ecosystem services, the response rate obtained was considered satisfactory, compared to the literature. As examples, Posner et al. (2016), evaluating the importance of ecosystem services as a resource for decision makers, obtained a 16% response rate for electronically administered questionnaires in two counties in California (USA); Ndebele and Forgie (2017), administering questionnaires delivered home by mail, obtained a 42% response to estimate the economic value of wetland restoration in New Zealand. In face-to-face interviews, Feng et al. (2018) obtained a 92% response to value

ecosystem services through contingent valuation, in the watershed of the Miyun Reservoir (source of water supply in the municipality of Beijing, China). Considering the restrictions imposed by the Covid-19 pandemic during the present study, the electronic questionnaire used proved to be effective in obtaining the results and helped to ensure the safety of both researchers and participants. This approach highlights the importance of adapting research methods according to the circumstances to achieve the goal.

We found that the water supply was the ecosystem service considered most important by researchers and the local community, with a significant 97% of people indicating this service as very important. As previously reported, the study area has water supply sources responsible for supplying not only the local residents but also part of the island population of São Francisco do Sul, making it possible to carry out its commercial and industrial economic activities. The high impact that the water supply has had on both researchers and the local community emphasizes the importance of preserving and protecting the area and this essential ecosystem service for future generations.

Also noteworthy are the habitat for species, pollination, and aesthetic beauty with high percentage values. Thus, the four ecosystem services most rated as very important represent the four categories established in TEEB (2010), in the following order: provision, support, regulation, and sociocultural. These results fit with the proposal to create a Wildlife Refuge in the study area, as recommended by São Francisco do Sul (2022). It is important to note that the ecosystem service “genetic resources” was perceived as less relevant by the local population. This may stem from the abstract nature of the concept for the general public. Many respondents interpreted genetic resources as elements associated with human use through genetic engineering, rather than as the preservation of phenotypic diversity, which is essential for biodiversity and ecosystem resilience (Uggeldahl et al. 2025). This may stem from the abstract and less observable nature of such services, which are often poorly understood by the general public and frequently misinterpreted (e.g.,). In particular, more complex dimensions of biodiversity, such as genetic diversity, are rarely recognized compared to more tangible aspects like species diversity (Lima and Bastos, 2019).

## 4.2 ASPECTS OF ECOSYSTEM SERVICE ECONOMIC VALUATION

First, it should be noted that expressing the value of ecosystem services in monetary units does not mean that they should be treated as commodities that can be traded in private markets. Many ecosystem services are public goods or the product of common goods that

cannot (or should not) be privatized. Even if water and other provision services enter the market as private goods, the ecosystems that produce them are common goods.

The TEV used in the study area to create a PA in currency units is an estimate of its benefits to society expressed in units that communicate with a broad audience. This can help raise awareness of the importance of ecosystem services to society and serve as a communication tool to support better and more balanced decisions about sustainable development (Rode et al. 2016).

According to the chosen criteria, the economic value of the provision services in the study area was represented only by the water supply service and represent 27% of the TEV. Added to the fact that the service is considered very important by the largest number of people, this service deserves special attention for the process of creating a PA in the study area. Its economic value has the potential to be even greater than what we have calculated using conservative information. Depending on their contribution to the municipal water supply system, the economic activities developed in the municipality may be incorporated as dependent on the contribution of the water supply of the study area and these values, easily measurable, can be accounted for as indirect use value of ecosystem service. The price of water currently practiced was used as a proxy for the economic valuation and represented about 1/4 of the total economic value. For the calculation, we chose to use conservative data, such as the lowest flow values produced in the study area and higher in other areas, in order to find a percentage of the study area contribution lower than what possibly occurs in reality.

Sociocultural services have relevant values for the study area, representing about 49% of TEV. This value is mainly composed of the value of the leisure and recreation service. In this case, factors such as income levels and other socioeconomic conditions, price levels, population density, distances between beneficiaries and the resource, and accessibility and presence of substitute and complementary sites were not controlled. An adequate characterization of the context of valued ecosystems is a problematic task that has been investigated in different meta-analyses of sociocultural service values (Quintas-Soriano et al. 2016; Reynaud and Lanzanova, 2017). It should be noted that valuation techniques based on market price, travel cost and contingent valuation can add to the assessment of the study area, recommending that a more detailed investigation to be carried out in the future using these methods.

In the literature, many case studies of valuation of ecosystem services are found, where one of the approaches corresponds to the research of their economic values. Although

each one has a different objective, using different methods, for comparison purposes, four studies were arbitrarily selected (Carrilho and Sinisgalli 2018; Lin et al. 2021; Liu et al. 2017; Wei et al. 2018), who found the TEV of different ecosystem services in a given study area, using at least two valuation techniques. The results showed that the highest values were found by Wei et al. (2018) and Lin et al. (2021), who studied significantly large areas in China and Taiwan, respectively. The studies showed no pattern when comparing the TEV per hectare. For purposes of comparison with the present study, converting the results of the studies to 2019 dollars exchange rate, the highest ratios found were USD 14,047.22 by Lin et al. (2021) and USD 7,330.46 by Carrilho and Sinisgalli (2018). The present study found a relationship of USD 2,202.31 for the Atlantic Rainforest study area, which was closer to the studies by Liu et al. (2017) and Wei et al. (2018). As already highlighted, each of the analyzed studies was carried out with different objectives and using different methods, in addition to being inserted in different geographic, economic, and cultural contexts. None of the studies analyzed evaluated ecosystem services during the process of creating a PA and, to the best of our knowledge, there are no specific studies that make this relationship.

For comparison purposes, we analyzed the TEV in relation to the Gross Domestic Product (GDP) of the continental area of municipality, through population and GDP per capita data provided by IBGE for the year 2010 (IBGE 2010, 2022). Converting the TEV to Brazilian Reais, on the last day of the year 2019 (Exchange-rates 2021) and considering a rate of change of the present value equal to the general price index–market (IGP–M) from 2010 to 2019 (FGV 2022), the total economic value of the study area corresponded, in 2010, to BRL 35,189,367.76. These values indicate that the relationship between the TEV and the GDP of the *Saí* District would be 53% for the year 2010.

It is understood that estimates of the relationship between TEV and GDP in the study area can be improved in two ways. The first with the improvement of techniques and increased availability of data for local economic valuation (travel cost and contingent value). The other is with the use of GDP data effectively for the continental area of São Francisco do Sul. However, this data is not currently available, for which we recommend a specific survey. If they were, they could already be minimally confronted with the value of market prices for a real relationship between the TEV and the GDP of the study area, as suggested by Remme et al. (2015) and Paulin et al. (2020).

In global terms, calculated by Costanza et al. (2014), the value of global ecosystem services is significantly greater than GDP, demonstrating that ecosystem services are much

more important for human well-being than conventional economic indicators demonstrate. For this reason, according to the authors, the contribution of unaccounted services to human well-being is ignored in public policies. Given the enormous uncertainties involved in economic valuation, we may never have a very accurate estimate of the value of ecosystem services. However, even the initial rough estimate presented is a useful starting point and demonstrates the need for further studies. Through further studies, we can improve our estimates and ensure that the importance of these services is recognized and considered in public policy and environmental conservation decisions.

### 4.3 ECONOMIC VALUE FOR CREATING A PROTECTED AREA

Regarding the research to formulate the salience indices, the choice to carry out face-to-face interviews proved to be correct, since the online engagement of this stage was actually lower compared to the questionnaire for identifying ecosystem services, as predicted by the researchers. The online form was made available to the same group of people who are directly connected with the creation of the PA study, including residents, visitors, and researchers. The response rate in this case was 16.67%.

The comparison between salience indices can be interpreted as a virtual way to observe differences. Evidently the results are influenced by methodological options. The individual lists were conducted within some options, but with different sizes, even though they can be freely indicated. The smaller lists, with 4 positions, resulted in higher rates for the evaluation of ecosystem services, which can be positive in terms of communication and environmental protection. However, when comparing the categories of ecosystem services, there was no change in the ordering of the salience indices. In both lists, the order from most salient to least remained as Provision, Support, Regulation, and Sociocultural. What is also observed is the decrease in the difference of the indexes between the categories, given the inversion of the same in the order of the relative increase.

These results demonstrate that the use of economic valuation contributes to increasing the salience of ecosystem services in the context of creating a PA in the study area, especially of sociocultural services, which showed a significant increase in salience in this context (from 0.266 to 0.511). Sociocultural services have already been reported as clearly of enormous potential importance for generating and maintaining public interest in natural areas (Khosravi Mashizi and Sharafatmandrad 2020; Vieira et al. 2018). However, they are necessarily difficult to measure and translate into quantitative and/or monetary values, as this process is

firmly rooted in the normative values of cultures that benefit from ecosystems, emerging from the complex history of interactions between people and the environment (MEA 2005). Therefore, we highlight the importance of promoting discussions linking natural areas and ecological functions with values and benefits for society. This contributes to political decision-making at different scales, as well as to increasing public awareness and knowledge of the ecosystem services role in contributing to human well-being.

Indeed, salience index scores provide good insights into the recognition of ecosystem services in the context of creating a PA and can be explored with other analytical approaches. However, the salience index approach of our study can be easily replicated and applied both to support PA planning and management decisions and to improve public support for protected areas, contributing to their social resilience (Cumming 2016). Therefore, responding to assessments of the value of ecosystem services can internalize at least part of their economic importance in decision-making, economic accounting, and policy responses, whether using economic incentives, spatial planning, or other regulatory responses (de Groot et al. 2012).

## 5 CONCLUSIONS

We use participatory methods and reveal the population's interests in ecosystem services in the context of creating a PA. With the social participation, represented through different stakeholders, two ecosystem services were added to the others identified with a literature review. The water supply service is especially important in the context of creating a PA in the study area. Due to the fact that it is distributed to part of the urban population of São Francisco do Sul, a Payment for Environmental Services program can be designed and implemented to meet the wishes of stakeholders to ensure the protection of this common good.

We assess ecosystem services classified into four categories using different accounting approaches, aggregating local values, through market prices, and values in the global context (benefit transfer). The total economic value of ecosystem services (over USD 14,000,000.00) was estimated using data to avoid overvalued results, considering that valuation methods are constantly improving. With adequate resources, future studies can apply other methods in the study area to estimate new values, such as contingent valuation, travel cost, scenario modeling and choice experiments.

Finally, we demonstrate that economic valuation increases the relevance of ecosystem services in the context of creating a PA, especially the relevance of sociocultural services. In conclusion, we hope that our initial study will contribute to the development of a Payment for Environmental Services program in the area of a PA creation and fill a current gap in the valuation of ecosystem services, providing an informative reference for society and public policy makers.

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## AUTHORS CONTRIBUTION

All authors reviewed the manuscript. MMB wrote the main manuscript text, applied the methodology, processed the results, and developed the discussion. LCIOF contributed to the revisions and discussion. RAM revised the manuscript, contributed to the discussion, and supervised the research.

## CONFLICT OF INTEREST

The authors state that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## DATA AVAILABILITY STATEMENT

Additional information regarding data not showed in the article can be requested to the corresponding author.

## REFERENCES

ARIS (2015) Relatório Técnico Gerencial – RTG Resumo da Proposta Técnica (TOMO I) do Consórcio Água e Esgoto do Município de São Francisco do Sul/SC (RTG ARIS/2015-São Francisco do Sul). https://www.aris.sc.gov.br/uploads/edital/1590/C74MWMJehQNKtCamTH8OsUzFeC2Fy8KI.pdf. Accessed 01 March 2024

Bailly D, Batista-Silva VF, Cassemiro FAS, Lemes P, da Graça WJ, de Oliveira AG, do Couto EV, Delconte Ferreira JH, Reginaldo R, Rangel TF, Agostinho AA (2021) The conservation of migratory fishes in the second largest river basin of South America depends on the creation of new protected areas. Aquat Conserv: Mar Freshw Ecosyst 31:2515–2532. https://doi.org/10.1002/aqc.3594

Baldi G, Texeira M, Martin OA, Grau HR, Jobbágy EG (2017) Opportunities drive the global distribution of protected areas. PeerJ 5:e2989. https://doi.org/10.7717/peerj.2989

Boeraeve F, Dufrene M, de Vreese R, Jacobs S, Pipart N, Turkelboom F, Verheyden W, Dendoncker N (2018) Participatory identification and selection of ecosystem services: Building on field experiences. Ecol Soc 23:27. https://doi.org/10.5751/ES-10087-230227

Brasil (2019) Sistema Nacional de Informações sobre Saneamento: 25º Diagnóstico dos Serviços de Água e Esgotos. Ministério do Desenvolvimento Regional/Secretaria Nacional de Saneamento Brasília

Carrilho CD, Sinisgalli PAA (2018) Contribution to Araçá Bay management: The identification and valuation of ecosystem services. Ocean Coast Manag 164:128–135. https://doi.org/10.1016/j.ocecoaman.2018.03.023

Chen H (2021) The ecosystem service value of maintaining and expanding terrestrial protected areas in China. Sci Total Environ 781:146768. https://doi.org/10.1016/j.scitotenv.2021.146768

Coelho-Junior MG, de Oliveira AL, da Silva-Neto EC, Castor-Neto TC, Tavares AAO, Basso VM, Turetta APD, Perkins PE, de Carvalho AG (2021) Exploring plural values of ecosystem services: Local peoples' perceptions and implications for protected area management in the atlantic forest of Brazil. Sustainability 13:1019. https://doi.org/10.3390/su13031019

Costanza R, d'Arge R, Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, Oneill RV, Paruelo J, Raskin RG, Sutton P, van den Belt M (1997) The value of the world's ecosystem services and natural capital. Nature 387:253–260. https://doi.org/10.1038/387253a0

Costanza R, de Groot R, Sutton P, van der Ploeg S, Anderson SJ, Kubiszewski I, Farber S, Turner RK (2014) Changes in the global value of ecosystem services. Global Environ Change 26:152–158. https://doi.org/10.1016/j.gloenvcha.2014.04.002

Cumming GS (2016) The relevance and resilience of protected areas in the Anthropocene. Anthropocene 13:46–56. https://doi.org/10.1016/j.ancene.2016.03.003

de Groot R, Brander L, van der Ploeg S, Costanza R, Bernard F, Braat L, Christie M, Crossman N, Ghermandi A, Hein L, Hussain S, Kumar P, McVittie A, Portela R, Rodriguez LC, ten Brink P, van Beukering P (2012) Global estimates of the value of ecosystems and their services in monetary units. Ecosyst Serv 1:50–61. https://doi.org/10.1016/j.ecoser.2012.07.005

de Groot RS, Wilson MA, Boumans RMJ (2002) A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecol Econ 41:393–408. https://doi.org/10.1016/S0921-8009(02)00089-7

Exchange-rates (2021) Brazilian Real (BRL) To US Dollar (USD) Exchange Rate History for December 31, 2019. https://pt.exchange-rates.org/Rate/BRL/USD/31-12-2019. Aaccessed 31 December 2019

Feng D, Liang L, Wu W, Li C, Wang L, Li L, Zhao G (2018) Factors influencing willingness to accept in the paddy land-to-dry land program based on contingent value method. J Clean Prod 183:392–402. https://doi.org/10.1016/j.jclepro.2018.02.142

FGV (2022) FGV Dados. Séries Institucionais. https://extra-ibre.fgv.br/IBRE/sitefgvdados/default.aspx. Accessed 15 March 2022

Figueiroa AC, de Lima AS, Scherer MEG, Bonetti J (2020) How to choose the best category for a protected area? A multicriteria analysis method based on ecosystem services conservation. Environ Monit Assess 192:416. https://doi.org/10.1007/s10661-020-08333-y

Gaitán-Cremaschi D, Palomo I, Baraibar Molina S, de Groot R, Gómez-Baggethun E (2017) Applicability of economic instruments for protecting ecosystem services from cultural agrarian landscapes in Doñana, SW Spain. Land Use Policy 61:185–195. https://doi.org/10.1016/j.landusepol.2016.11.011

Haines-Young RH, Potschin MB (2018) Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Fabis Consulting Ltd [In English]. https://cices.eu/content/uploads/sites/8/2018/01/Guidance-V51-01012018.pdf. Accessed 15 March 2022

IBGE (2000) Censo Demográfico 2000. Caracteíricas da População e dos domicílios. https://censo2010.ibge.gov.br/. Accessed 15 March 2022

IBGE (2010) Censo Demográfico 2010. Caracteíricas da População e dos domicílios. https://censo2010.ibge.gov.br/. Accessed 15 March 2022

IBGE (2017) Censo Agropecuário 2017. https://censos.ibge.gov.br/agro/2017/. Accessed 15 March 2022)

IBGE (2022) Portal Cidades e Estados. São Francisco Do Sul. https://www.ibge.gov.br/cidades-e-estados/sc/sao-francisco-do-sul.html. Accessed 15 March 2022

Kantharajan G, Kumar Yadav A, Chandran R, Singh RK, Mohindra V, Krishnan P, Kumar K, Shukla SP, Lal KK (2022) Impact of terrestrial protected areas on the fish diversity and habitat quality: Evidence from tropical river Pranhita, India. J Nat Conserv 68:126187. https://doi.org/10.1016/j.jnc.2022.126187

Khosravi Mashizi A, Sharafatmandrad M (2020) Assessing ecological success and social acceptance of protected areas in semiarid ecosystems: A socio-ecological case study of Khabr National Park, Iran. J Nat Conserv 57:125898. https://doi.org/10.1016/j.jnc.2020.125898

Li S, Zhang H, Zhou X, Yu H, Li W (2020) Enhancing protected areas for biodiversity and ecosystem services in the Qinghai–Tibet Plateau. Ecosyst Serv 43:101090. https://doi.org/10.1016/j.ecoser.2020.101090.

Lima FP, Bastos RP (2019) Perceiving the invisible: formal education affects the perception of ecosystem services provided by native areas. Ecosyst Serv 40:101029. https://doi.org/10.1016/j.ecoser.2019.101029

Lin J-C, Chiou C-R, Chan W-H, Wu M-S (2021) Valuation of forest ecosystem services in Taiwan. Forests 12:1694. https://doi.org/10.3390/f12121694

Liu P, Jiang S, Zhao L, Li Y, Zhang P, Zhang L (2017) What are the benefits of strictly protected nature reserves? Rapid assessment of ecosystem service values in Wanglang Nature Reserve, China. Ecosyst Serv 26:70–78. https://doi.org/10.1016/j.ecoser.2017.05.014

Llopis JC, Chastonay JF, Birrer FC, Bär R, Andriatsitohaina RNN, Messerli P, Heinimann A, Zaehringer JG (2021) Year-to-year ecosystem services supply in conservation contexts in north-eastern Madagascar: Trade-offs between global demands and local needs. Ecosyst Serv 48:101249. https://doi.org/10.1016/j.ecoser.2021.101249

Martín-López B, Gómez-Baggethun E, García-Llorente M, Montes C (2014) Trade-offs across value-domains in ecosystem services assessment. Ecol Indic 37:220–228. https://doi.org/10.1016/j.ecolind.2013.03.003

MEA (2005) Ecosystems and Human Well-Being: Synthesis. Island Press, Washington.

Ndebele T, Forgie V (2017) Estimating the economic benefits of a wetland restoration programme in New Zealand: A contingent valuation approach. Econ Anal Policy 55:75–89. https://doi.org/10.1016/j.eap.2017.05.002

Paulin MJ, Remme RP, van der Hoek DCJ, de Knegt B, Koopman KR, Breure AM, Rutgers M, de Nijs T (2020) Towards nationally harmonized mapping and quantification of ecosystem services. Sci Total Environ 703:134973. https://doi.org/10.1016/j.scitotenv.2019.134973

Petroni ML, Siqueira-Gay J, Gallardo ALCF (2022) Understanding land use change impacts on ecosystem services within urban protected areas. Landsc Urban Plann 223:104404. https://doi.org/10.1016/j.landurbplan.2022.104404

Posner S, Getz C, Ricketts T (2016) Evaluating the impact of ecosystem service assessments on decision-makers. Environ Sci Policy 64:30–37. https://doi.org/10.1016/j.envsci.2016.06.003

Považan R, Kadlečík J, Affek A, Aranyi I, Černecký J, Ďuricová V, Favilli F, Lehejček J, Mederly P, Švajda J (2021) The Carpathian Ecosystem Services Toolkit. Interreg CENTRAL EUROPE project Centralparks “Building management capacities of Carpathian protected areas for the integration and harmonisation of biodiversity protection and local socio-economic development”, Deliverable D.T3.1.3. State Nature Conservancy of the Slovak Republic, Banská Bystrica

Quintas-Soriano C, Martín-López B, Santos-Martín F, Loureiro M, Montes C, Benayas J, García-Llorente M (2016) Ecosystem services values in Spain: A meta-analysis. Environ Sci Policy 55:186–195. https://doi.org/10.1016/j.envsci.2015.10.001

Remme RP, Edens B, Schröter M, Hein L (2015) Monetary accounting of ecosystem services: A test case for Limburg province, the Netherlands. Ecol Econ 112:116–128. https://doi.org/10.1016/j.ecolecon.2015.02.015

Reynaud A, Lanzanova D (2017) A Global Meta-Analysis of the Value of Ecosystem Services Provided by Lakes. Ecol Econ 137:184–194. https://doi.org/10.1016/j.ecolecon.2017.03.001

Rode J, Wittmer H, Emerton L, Schröter-Schlaack C (2016) ‘Ecosystem service opportunities’: A practice-oriented framework for identifying economic instruments to enhance biodiversity and human livelihoods. J Nat Conserv 33:35–47. https://doi.org/10.1016/j.jnc.2016.07.001

Santos Vieira FA, Vinhas SantosDT, Bragagnolo C, Campos-Silva JV, Henriques Correia RA, Jepson P, Mendes Malhado AC, Ladle RJ (2021) Social media data reveals multiple cultural services along the 8.500 kilometers of Brazilian coastline. Ocean Coast Manag 214:105918. https://doi.org/10.1016/j.ocecoaman.2021.105918

Sheng HX, Xu H, Zhang L, Chen W (2019) Ecosystem intrinsic value and its application in decision-making for sustainable development. J Nat Conserv 49:27–36. https://doi.org/10.1016/j.jnc.2019.01.008

Smith JJ, Borgatti SP (1997) Salience counts and so does accuracy: correcting and updating a measure for free-list-item salience. J Linguist Anthropol 7:208–209. https://doi.org/10.1525/jlin.1997.7.2.208

Taye FA, Folkersen MV, Fleming CM, Buckwell A, Mackey B, Diwakar KC, Le D, Hasan S, Ange CS (2021) The economic values of global forest ecosystem services: A meta-analysis. Ecol Econ 189:107145. https://doi.org/10.1016/j.ecolecon.2021.107145

TEEB (2010) The Economics of Ecosystems and Biodiversity: Economic and Ecological Foundations. Manag Environ Qual 22:65–72. https://doi.org/10.1108/meq.2011.08322bae.003

Turner KG, Anderson S, Gonzales-Chang M, Costanza R, Courville S, Dalgaard T, Dominati E, Kubiszewski I, Ogilvy S, Porfirio L, Ratna N, Sandhu H, Sutton PC, Svenning JC, Turner GM, Varennes YD, Voinov A, Wratten S (2015) A review of methods, data, and models to assess changes in the value of ecosystem services from land degradation and restoration. Ecol Model 319:190–207. https://doi.org/10.1016/j.ecolmodel.2015.07.017

Uggeldahl K, Olsen SB, Lundhede T, Jacobsen JB (2025) Public perceptions of biodiversity and the value of its conservation. Ecol Econ 236:108681. https://doi.org/10.1016/j.ecolecon.2025.108681.

U.S. BLS (2022) CPI Inflation Calculator. Data Tools. https://www.bls.gov/data/inflation_calculator.htm. Accessed 01 December 2019

UFSC (2021) Diagnóstico Socioambiental Nascentes do Saí, São Francisco do Sul-SC Universidade Federal de Santa Catarina, Florianópolishttps://nascentesdosai.paginas.ufsc.br/files/2021/09/Relat%C3%B3rio_SFS_Final_2021_08_30.pdf. Accessed 01 December 2021

São Francisco do Sul (SC) (2022) Decreto nº 3.841, de 03 de fevereiro de 2022. Dispõe acerca da criação da Unidade de Conservação de Proteção Integral "REVIS Nascentes do Saí". Prefeitura Municipal, São Francisco do Sul. https://leismunicipais.com.br/a/sc/s/sao-francisco-do-sul/decreto/2022/385/3841/decreto-n-. Accessed 01 March 2022

Velasco-Muñoz JF, Aznar-Sánchez JA, Schoenemann M, López-Felices B (2022) An Analysis of the Worldwide Research on the Socio-Cultural Valuation of Forest Ecosystem Services. Sustainability 14:2089. https://doi.org/10.3390/su14042089

Vieira FAS, Bragagnolo C, Correia RA, Malhado ACM, Ladle RJ (2018). A salience index for integrating multiple user perspectives in cultural ecosystem service assessments. Ecosyst Serv 32:182–192. https://doi.org/10.1016/j.ecoser.2018.07.009

Wang B, Zhang Q, Cui F (2021) Scientific research on ecosystem services and human well-being: A bibliometric analysis. Ecol Indic 125:107449. https://doi.org/10.1016/j.ecolind.2021.107449

Watson JEM, Dudley N, Segan DB, Hockings M (2014) The performance and potential of protected areas. Nature 515:67–73. https://doi.org/10.1038/nature13947

Wei F, Costanza R, Dai Q, Stoeckl N, Gu X, Farber S, Nie Y, Kubiszewski I, Hu Y, Swaisgood R, Yang X, Bruford M, Chen Y, Voinov A, Qi D, Owen M, Yan L, Kenny DC, Zhang Z, Hou R, Jiang S, Liu H, Zhan X, Zhang L, Yang B, Zhao L, Zheng X, Zhou W, Wen Y, Gao H, Zhang W (2018) The Value of Ecosystem Services from Giant Panda Reserves. Curr Biol 28:2174-2180.e7. https://doi.org/10.1016/j.cub.2018.05.046