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CITIZEN PARTICIPATION FOR THE MONITORING AND INTEGRAL VALUATION DESTINATION: THE CASE OF THE LAGUNA NEGRA WETLAND IN COLOMBIA

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Abstract

This study was conducted in the Laguna Negra wetland located in Villamaría, Caldas, Colombia, in order to determine indicators for monitoring, the integral valuation in the wetland and support its conservation. The dynamics of the water mirror was analyzed, finding that between the years 2015 - 2019 it had an increase, which is reported to the community to generate a space for citizen participation and to know their opinions on the ecosystem services of the same. An analysis of the carrying capacity was also conducted, obtaining a real carrying capacity of 5.5 people per day simultaneously. The ecosystem services were defined by the community living near the wetland, based on a participatory methodology. On the other hand, to calculate the WTP for the conservation of the site, an instrument was applied to the tourists, the results of which allowed a valuation of the cost of the trip and a contingent valuation considering the WTP. With the results of the instrument and the application of an econometric model, a model was proposed to calculate the probability of success associated with WTP, which according to the model is directly related to educational level and socioeconomic stratum.

***Keywords**: Ecotourism; Wetland; Integral valuation; Travel cost; Contingent valuation; High Andean wetland*

Introduction

Ecotourism arises as a response to the need for an environmentally responsible tourism system in order to avoid and mitigate the effects of this activity on the environment. This is because it is necessary to manage and conserve resources, thus orienting tourism to sustainble issues [1], one of the principles of ecotourism being the utilization and conservation of natural resources and human interaction. On the other hand, ecotourism, thanks to the fact that it is carried out in open spaces with little agglomeration, has emerged as an important strategy to strengthen the tourism sector after the negative impact that the COVID - 19 pandemic caused on the sector, which is estimated at a loss of US 40 billion [2, 3]. One of the open spaces where ecotourism is

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carried out are the wetlands thanks to the ecosystem services they offer, such as: flora and fauna, transportation, recreation, fishing, swimming and contemplation.

Accordingly, it is necessary to carry out valuation processes of ecotourism ecosystem services in order not only to recognize the local ecosystem and its potential, but also to generate planning processes for the conservation of ecosystems. In China, several studies have been developed to quantify the economic values of wetlands, one of them economically valuing the bird resources in the Futian wetland of Shenzhenen Bay [4]. On the other hand, in the Cuihucon wetland park, the assessment has been carried out based on an analysis of strengths, weaknesses, opportunities and threats (SWTO) [5]. Another example of economic valuation in Chinese wetlands is Zhejiang Province, a coastal type ecosystem, with an area of 5,742.54ha, obtaining a tourism value of 54,636 × 10^8CNY/year [6].

Another strategy for wetland valuation is the application of contingent valuation methods. In this regard, in Korea, in the Anmyenondo tidal wetlands, a double-bounded dichotomous choice model (DBDC), classified under contingent valuation methods, was applied to analyze the economic values of the ecosystem service of ecotourism [7]. In Trinidad and Tobago, a cost-benefit analysis was applied to the Nariva Swamp on the island of Trinidad in the Caribbean, where the benefits of wetland conservation were measured using the contingent valuation method. The results of the analysis showed that ecotourism is a feasible use of the ecologically fragile resources of this wetland [8]. A study conducted in Florida, in which the authors designed structured surveys and conducted a multiple linear regression analysis, taking into account factors such as: economic benefits, socio-cultural benefits, conservation benefits and conservation behaviors, among others, showed that ecotourism generates great interest in the different stakeholders to invest in wetland conservation and influences the environmentally responsible behavior of tour operators [9]. In Colombia, in the city of Bogotá, which has 14 wetlands [10] built a framework for the study of wetlands taking into account analyses of political, economic, socio-cultural, and technological changes in a business environment, as well as different considerations for the industry. On the other hand [11], also in Bogotá, in the Santa María del Lago, Córdoba and Guaymaral wetlands, have applied contingent valuation processes.

Some of the studies previously presented make use of the contingent valuation technique, which has some advantages, for its ease of being applied to measure any good without the need to resort to observable behavior or data, making it useful in the measurement of non-use values, and also allowing the experiment to be carried out at two different times (before and after obtaining the change in welfare). Among the disadvantages in its application is the exhaustive amount of surveys and previous tests that must be carried out, thus generating a high economic cost in its implementation, as stated by Birol [12]. Currently, the estimation of the availability to pay (WTP) is widely used to estimate the use and non-use values of ecosystem goods and services of wetlands that do not have a defined market, being one of the most effective methods to estimate the real total economic value of ecosystems [13]. The cost of individual travel is estimated by applying a direct survey to visitors to the site, with the aim of discovering information on the costs incurred to enter the natural area, socioeconomic characteristics of the individual or their family nucleus, as well as the number of visits they make to the site per year. This allows the area under the demand curve to be calculated and the consumer surplus to be calculated by integration [14].

Given the above, this article presents an application of economic valuation methods and econometric models to determine the willingness to pay of people who visit wetlands to conserve them. Also, the possibility of establishing an access fee will be explored, as well as the willingness to pay for the preservation of the site. For this purpose, the carrying capacity was determined for the sustainability of the wetland and thus avoid impacts on them by the anthropic action generated by tourist visits, in this sense, both the physical carrying capacity (PCC) and the real carrying capacity (RCC) were calculated.

Experimental part

Study zone

This research was developed in the wetland called "Laguna Negra" originated by the glacial melting of the Nevado del Ruiz Volcano located at 3853m.a.s.l., in the jurisdiction of the departments of Caldas and Tolima, being part of the buffer zone of the Los Nevados National Natural Park [15]. The lagoon is an important source of water because it is part of the source of the Chinchiná River, one of the main water sources in the south-central region of the department of Caldas, on the other hand, this wetland is important for tourism. Due to its location and proximity to some population and production centers, the lagoon has a high degree of vulnerability to anthropogenic action and is located in a fragile ecosystem such as the Nevado del Ruiz paramo [16].

As for the tourist services offered by the lagoon, it should be noted that it is immersed in a theme park called "Laguna Negra", with an area of 1.6ha and 1000m long, the lagoon is open to the public every day of the year, except 24, 25, 31 December and 1 January. The opening hours are at 8:00 A.M. and the closing time is at 6:00 p.m., thus having 10 hours of service per day. The owners of the property where the lagoon is located offer a tourist service tour of the lagoon, which takes a total of 4 hours, and therefore only 2 tours are available, one in the morning and one in the afternoon with approximately 15 people per tour.

Data sources

In this research it was necessary to have perception data from the community living near the wetland, as well as from the tourists who use the tourism services offered in the area. The sources of the mentioned data can be visualized in

Table 1.

Table 1. Sources of data required for the research

Data type	Source	Date(Year)
Satellite image	Landsat 7	2015 – 2019
Ecosystem services	Structured interview	2020
Cost of travel	Structured interview	2020

The satellite images listed in

Table 1 were used to determine the multitemporal variation of the surface area covered by the wetland's water mirror, in order to socialize with the target population (inhabitants and tourists) the variation of the water mirror, and thus generate awareness of the need to carry out a wetland conservation process. Once this information is socialized with the community through different workshops, interviews are conducted to establish the ecosystem services that the population considers are offered by the wetland, and to calculate the cost of travel that tourists are willing to pay so that this cost is transferred to the wetland conservation strategies.

Multitemporal analysis of the wetland water mirror

The images listed in

Table 1 were used to analyze the multitemporal dynamics of the wetland's water mirror. The images were segmented into two polygons surrounding the wetland, on which a classification of water bodies was made to calculate the area covered by water (Fig. 1).

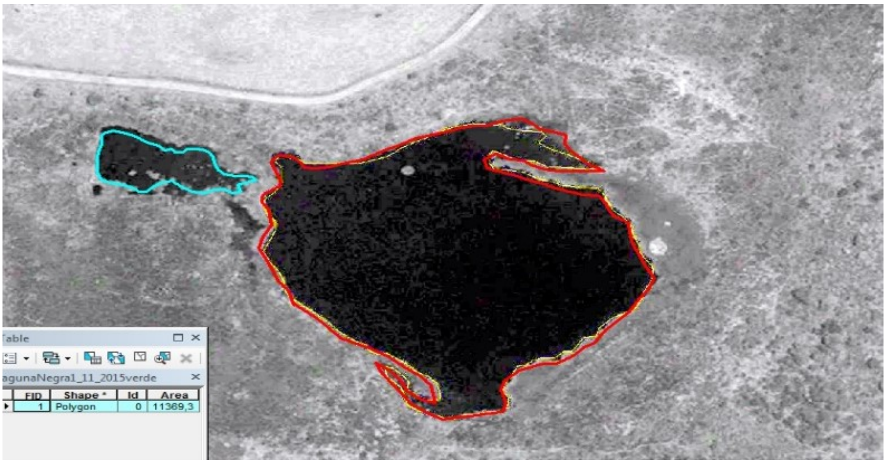

Fig. 1. View of the lagoon and the polygons.
In magenta color the polygon 0 and in red color the polygon 1

Method for determining the load capacity

To obtain the Carrying Capacity (CC) of the wetland, the methodology proposed by [17] was applied. In order to accurately determine the CC, it is necessary to know the biophysical and management conditions of the wetland, and with these data calculate both the Physical Carrying Capacity (PCC) and the Real Carrying Capacity (RCC). To obtain PCC, the maximum number of daily visits to the wetland was considered, as well as the schedules and duration of visits. The following formulas were applied to calculate the available spaces and the demand by tourists, respectively:

$$NV = H_v/T_v \quad (1)$$

$$CF = \frac{S}{S_p} * NV \quad (2)$$

where: S - area available for the lagoon tour (m); S_p - surface occupied by a person (m^2); NV - number of times per day that the lagoon can be visited by the same person; H_v - lagoon opening time for visitors (minutes); T_v - time needed for the wetland tour (minutes).

To calculate RCC, it was necessary to consider the number of visits obtained with equation (1), and the following correction factors: social factors (FCsoc), precipitation factors (FCpre), vegetation factor (FCveg), sunshine factor (FCsol). The correction factors were calculated with the following equation [17]:

$$FC_x = 1 - \frac{ML_x}{MT_x} \quad (3)$$

where: FC_x - variable correction factor x; ML_x: - limiting variable magnitude x; MT_x: total magnitude of the variable x.

Since there are 4 factors, equation (3) must be adjusted for the calculation of each of the factors, the explanation and the way to calculate each of the factors is presented in

Table 2. Correction factors

Correction factor	Explanation	Equation	Equation variables
Social Factor (CF_{soc})	Allows to indicate the limit of the number of people that can pass through the wetland at the same time, without altering the quality of the visit.	$FC_{soc} = 1 - \frac{ML}{MT}$	$ML = MT - P$, P number of people that can be simultaneously in the wetland Mt: length of the wetland
Precipitation factor (FC_{pre})	Is calculated taking into account the maximum precipitation values for the time of the year in which the work is being carried out.	$FC_{pre} = 1 - \left(\frac{HL}{HT}\right)$	hl: Limiting rainfall hours per year ht: Hours a year that the wetland is open
Vegetation factor (FC_{veg})	Vegetation that will be affected by the widening of roads for visitors' movement	$FC_{veg} = 1 - \left(\frac{ML}{MT}\right)$	Ml: meters of vegetation to be affected Mt: total meters of the wetland.
Sunshine factor (FC_{sol})	Refers to the intense sunshine, with which the walk generates fatigue in visitors because there is no vegetation cover to cast shade on the wetlands.	$FC_{sol} = 1 - \left(\frac{HSL}{HT}\right)$	hsl: limiting hours of sunshine (depending on the season) ht: hours in the summer season when the Wetland is open

Once the correction factors were calculated, it was possible to define the CCR based on the formula proposed by [17]:

$$RCC = FCC\left(FC_{soc}FC_{pre}FC_{veg}Fc_{sol}\right) \quad (4)$$

Method for calculating travel cost and contingent valuation

In order to determine the cost of travel and carry out a contingent valuation of the wetland, two instruments were constructed and validated to determine the valuation that both tourists and inhabitants give to the wetland. One of the instruments was directed to the inhabitants of the area of influence of the wetland to identify the ecosystem services of the wetland (instrument 1) and the other instrument was directed to the tourists to know the value they assign to the ecosystem services of the wetland and to establish the cost of the trip they would be willing to pay (instrument 2). The instruments were validated by experts in the area, and a pilot test was conducted to determine which questions were not pertinent and which should be organized to avoid ambiguities and adjust the ranges used for the valuation.

In instrument 1, the following classification of ecosystem services was presented to the inhabitants: provisioning services, cultural or recreational services, and regulation and support services. The instrument asked people if they used each service and if they considered that this service had been lost over the years, in order to determine the variations or dynamics that the wetland has had with respect to the supply of ecosystem services. After identifying the ecosystem services, the contingent valuation and the valuation by travel cost were carried out, for which instrument 2 was applied, which was a structured interview directed to tourists using the categorical scheme shown in Fig. 2.

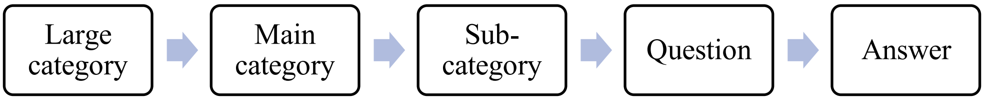

Fig. 2. Category scheme. Source: Own elaboration

- **Large category:** Four broad categories were defined. The first related to general information on the place and date of the evaluation, the second related to the demographic characterization of the wetland tourists, the third related to information to determine the cost of the trip, and the fourth related to information for the contingent valuation of the ecosystem service provided by the wetland to tourists.
- **Main category and subcategory:** These were broken down into each of the major categories that allow us to obtain detailed values for the cost of travel and contingent valuation.

With the respective analysis of the previously mentioned categories, the estimation of the contingent valuation of the wetland was carried out. These analyses also make it possible to determine the WTP for the service provided by the wetland and the WTP for wetland conservation. In order to obtain the WTP values, an econometric model was applied that allows, in addition to obtaining estimates of the probability of an event, to identify the risk factors that determine these probabilities, as well as the influence or relative weight they have on them [18], [19]. This model allows correlating the different variables [20]. The variables associated with this study are presented in Table 3.

Table 3. Variables and units of measurement, Source: Own elaboration

Variables	Units
DAPS: price determined by visitors to each of the wetlands	COP$
AGE: Age range of visitors to each of the wetlands	Number of years
ESTSE: Socio-economic stratum of visitors to each of the wetlands	Stratum level (1-6)
EST: Level of education of respondents to each of the wetlands	Level of study
ING: Income level of respondents from visitors to each of the wetlands	United States Dollar (USD) range
PERVIS: Perception of the visit by visitors in each of the wetlands	Perception level

Finally, to calculate the probability associated with tourists' willingness to pay, the following expressions proposed by (Vargas, 2009) are applied, for a linear probability model and another for a Logit model, respectively:

$$PI(DAP) = B1 + B2DAPS + B3EDAD + B4ESTSE + B5EST + B6ING + B7PERVIS \quad (4)$$

$$Li(DAP) = B1 + B2DAPS + B3EDAD + B4ESTSE + B5EST + B6ING + B7PERVIS \quad (5)$$

where:

$$L_i = Ln\left(\frac{P_i}{1-P_i}\right). \quad (6)$$

Results and discussion

The evaluation of the multitemporal dynamics (years 2015 - 2019) of the wetland, in terms of the area covered by the water mirror, showed that during this time there was a gain in this area, as shown in Table 4. This gain may be associated with the release of retention water generated in the vegetation, which reaches the wetland in the form of runoff. On the other hand, water from the Ruiz glacier reaches the Laguna Negra through runoff and infiltration into the ground, since the wetland is supplied by groundwater [21].

Table 4. Multitemporal dynamics surface area covered by the water mirror.
Source: Own elaboration

Year 2015		Year 2019	
Polygon	Area (m^2)	Polygon	Area (m^2)
0	1527	0	1610
1	11369	1	11788

Table 5 shows the calculation of the PCC considering the area available for walking in meters (S), area occupied per person (Sp), number of times the wetland can be visited by one person (NV), visiting hours (Hv) and time needed to walk through the wetland (Tv). The result obtained for PCC was 2500 people.

Table 5. Calculation of Physical Load Capacity "Laguna Negra". Source: Own elaboration

Calculation of Physical Load Capacity (PCC)						
S (m)	Sp (m)	NV=Hv/Tv	Hv (m)	Tv (m)	Equation	Result
1000	1	2,5	600	240	$CF = \frac{S}{Sp} \, x \, NV$	2500

To calculate the RCC it is necessary to calculate the correction factors, for this it is necessary to define the values for the variables that are required in each of the mathematical expressions to calculate the correction factors. The values of the variables are presented in Table 6. The values for the correction factors are calculated with the expressions presented in Table 2 and the values obtained are presented in Table 7.

Table 6. Variables for the calculation of correction factors

Variables	Symbol/equation	Value
Wetland length	Mt	1000
Number of people that can be simultaneously in the wetland	P	15
Limiting magnitude	$\mathrm{Ml} = \mathrm{Mt} - \mathrm{P}$	985
Hours of limiting rainfall per year	Hl	1830
Hours a year that the wetland is open	ht	3610
Limiting sunshine hours (depending on time of year)	Hsl	1820
Hours in the summer season that the wetland is open	Ht	3610
Meters of vegetation to be affected	Mv	400
Total wetland meters	Mt	1000

Table 7. Values obtained for correction factors

Factor	Value
Social Correction Factor	0,015
Precipitation Factor	0,49307479
Solar Brightness Factor	0,49584488
Vegetation Factor	0,6

With the values obtained for the correction factors, and the PCC value previously calculated, it is possible to calculate the RCC with equation (3), obtaining a value of 5.5 people per day simultaneously, a value justified by the vulnerability of the ecosystem.

To define the ecosystem services of the wetland by the population, instrument 1 was applied to all the families living in the vicinity of the lagoon. In

Fig. 3 shows the ecosystem services that were defined for the wetland by the population. According to the figure, the ecosystem services defined by a large part of the population are as follows:

- Cultural and recreational services: landscape appreciation, ecotourism, recreation, spiritual significance, historical heritage.
- Regulatory and support services: habitat maintenance.

Other ecosystem services are used, but not in the same percentage as the previous ones. These services are hydrological regulation, air regulation and climate regulation, and to a lesser extent soil retention. Regarding provisioning services, only the provision of medicinal plants was considered to be used and, to a lesser extent, the service of water for livestock. The perception of the loss of ecosystem services is low. On the other hand, it is necessary for the population living in the surrounding areas to receive more environmental education and information on the care and ecosystem services related to wetlands.

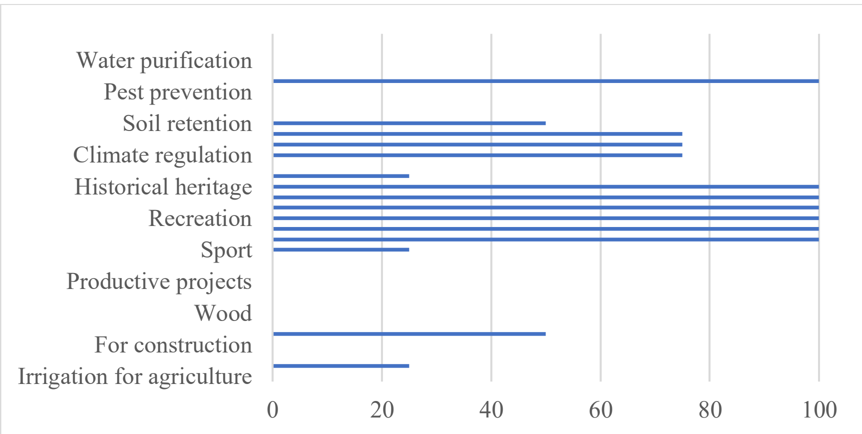

Fig. 3. Percentage of population making use of ecosystem services

The valuation of the cost of the trip based on the application of instrument 2 to tourists revealed that they are willing to pay US$14.67 for the first visit, which is higher than the US$6.104 they actually pay. The difference between the maximum amount consumers are willing to pay for the product and the amount they pay is called consumer surplus (CS). In relation to the number of visits and the cost they pay, it is possible to define four types of visitors: The first group are the low frequency - low cost, who seek to get to know the area, travel by motorcycle and go camping, make one visit per year and their minimum cost is US$14.42. A second group is the high frequency - high cost group, generally family tourism groups, they recognize the scenic value of the area and stay in hotels in the area, travel in their own car, they have made up to three visits to the place and their cost can reach a maximum of US$59.10. These first two groups form a positive trend line in which the higher the visitation, the higher the costs, i.e., those who visit the wetland more are willing to pay more (higher WTP). This contradicts the economic theory on the law of demand, and even if there is a consumer surplus this does not apply in reality due to the above. There are also two other groups, but their representativeness is not as significant as the other two groups, these are: High frequency, low cost and Low frequency, high cost, this can be seen in Fig. 4.

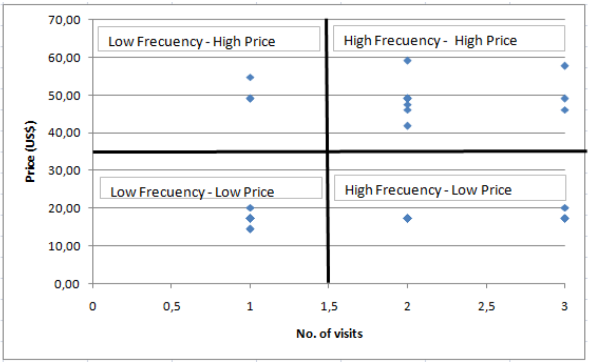

Fig. 4. Ratio vs Number of visits/Cost in the "Laguna Negra" Wetland. Manizales (Caldas) 2020

$$Pi(WTP) = B1 + B2Sex + B3Age + B4Stratum + B5Education + B6Income \quad (7)$$

Table 8. Selection of variables for the calculation of the Consumer Surplus for the availability to pay (DAP) in the "Laguna Negra" Wetland. Manizales (Caldas) 2020. Source: Own elaboration

Variable	Description	Minimum	Maximum
DAP	Affordability to pay	US$13.51	US $55.40
SEX:	Tourist gender	1: Male	2: Female
AGE	Tourist age	21 (years)	55
ESTR:	Socioeconomic stratum	2	6
NEST:	Study Level	2: High School	3: Undergraduate
INC:	Income level	1: 1-2 N.M.W.	3: 5 or more N.M.W*

* N.M.W (National Minimum Wage) of 2020

The model made it possible to determine the probability that a tourist will pay (probability of success Pi) or not (probability of failure 1-Pi) a sum greater than US$1.35 for entry to the wetland. The Logistic model allowed calculating the parameters of the proposed model, which are listed in Table 9.

Table 9. Parameters of the econometric model for the calculation of the affordability to pay (DAP) in the "Laguna Negra" Wetland. Manizales (Caldas) 2020. Source: Own elaboration

Variable	parameter	Standard error	Chi square	Significance
Intercept	-514507	830.1	0.0038	0.9506
Sex	-23157	15762	21584	0.1418
Age	-0.0873	0.0799	11940	0.2745
Stratum	28865	1,4234	41126	0.0426
Studies	138059	207,5	0.0044	0.9470
Incomes	104022	207,5	0.0025	0.9600

Finally, the data in Table 9 showed that socioeconomic stratum, level of education and income have a directly proportional relationship with WTP. In general, the results of the model indicate that the probability of paying an entrance fee greater than US$1.35 is 73.11% and that of not paying is 26.89%, this for the group of people who agree to pay the WTP. The probability of paying increases to 88.08% in young people who have professional education levels, especially women.

Conclusions

This study, based on a participatory methodology, made it possible to have the community's appreciation of the wetland's ecosystem services and thus achieve a valuation that can be more transparent than valuations that are not participatory. In order to motivate the community to participate, a multitemporal study was presented on the variation of the water mirror of the wetland, which indicated a slight increase for the years of observation, generated by the water infiltrations generated from the Nevado del Ruiz glacier and also thanks to the restoration processes that are being carried out. With this result of the slight increase in the water mirror, the community and tourists understood the need to continue generating conservation strategies and that it is therefore necessary to have additional economic resources to sustain them. These additional economic resources can be generated from the calculated travel cost values. To obtain these values it was necessary to know the real carrying capacity of the wetland, which had a relatively low value given that the area is highly vulnerable because it is a páramo ecosystem, which is highly fragile.

Regarding the valuation by travel cost, the frequency of travel has a directly proportional relationship between the cost of travel and the number of visits to the wetland, the consumer surplus has a much higher value for people who visit the wetland more frequently. Young people and professionals are those who have a higher WTP for wetland conservation, and there is also a direct relationship between WTP and socioeconomic strata.

The results of this study will allow continuing with conservation and restoration processes of fragile ecosystems such as the one presented in this article, which are of vital importance in terms of water resource conservation and the ecotourism services they can offer. Therefore, it is expected that these results may represent a valuable input for the formulation of public policies on environmental governance and sustainable ecotourism in fragile ecosystems.

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