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Management and time preferences for lakes restoration in Brazil

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HIGHLIGHTS

- Household preferences for the restoration of five lakes in Brazil are investigated.
- A mixed logit model was estimated in willingness-to-pay space.
- Willingness to pay decays with restoration time in a non-linear fashion.
- Non-governmental management is preferred over the municipal government.

GRAPHICAL ABSTRACT

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ABSTRACT

As in many developing countries, the eutrophication of lakes has become one of the most severe environmental problems in Brazil. We implemented a choice experiment to investigate local preferences for the restoration of five lakes in the city of Campos dos Goytacazes, Brazil. This study focuses on two attributes of the proposed environmental project: 1) the delay in reaching the targeted level of water quality and 2) the institution that would manage the lakes restoration project. Choice responses are analyzed using a mixed logit model to control for potential heterogeneity among respondents. Results show that the willingness to pay for lakes restoration decays with restoration time in a non-linear fashion. Findings also indicate that respondents would prefer an interinstitutional, non-governmental committee over the municipal government to manage the lakes restoration project.

1. Introduction

Hydrological ecosystems such as rivers and lakes have the potential to contribute to the development of communities in developing nations due to the multiple services they can provide (e.g. drinking water, irrigation, fishing, and recreation). Unfortunately, many rivers and lakes have suffered from anthropogenic eutrophication to the extent that some of them currently represent a considerable risk for the health of surrounding populations (Tundisi and Scheuenstuhl, 2014). Brazil is an example of how economic and urban development has taken a toll on the quantity and quality of water bodies (Costa, 2003; Pedrosa et al., 2004; Rezende et al., 2006). Hence, improvements of water quality would help mitigate health risks and restore services lost due to lakes eutrophication (Keeler et al., 2012).

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Restoring lakes is costly and developing nations may lack the resources required for lakes restoration as they face other pressing needs that compete for budget priority (e.g. poverty alleviation programs, education, health care, drinking water, and sanitation, among others). The lack of information on the economic value of water quality improvements has been an impediment for making budget allocations to lake restoration projects (Keeler et al., 2015). Economic valuation of lake restoration projects has the potential to contribute to the determination of priorities by demonstrating the relative importance of lakes to surrounding populations. For instance, using the contingent valuation method, Wang et al. (2013) demonstrated that households are willing to pay approximately 3% of their monthly income for five years in order to restore the water quality of Lake Puzhehei in China. Similarly, Van Houtven et al. (2014) reported significant willingness to pay for water quality improvements in the United States (an annual average of $60 per household in the state of Virginia).

We implemented a discrete choice experiment (DCE) to investigate the benefits of restoring the water quality of five urban lakes in Campos dos Goytacazes, Brazil. This study focuses on two attributes of the proposed environmental project: 1) the delay in reaching the targeted level of water quality and 2) the institution that would manage the lakes restoration project. Recent studies have implemented DCEs to investigate time preferences for water quality improvements given that environmental projects tend to deliver expected outcomes with some delay (Kahn et al., 2017; Meyer, 2013; Viscusi et al., 2008). Those studies consistently show that households are somewhat impatient in observing environmental improvements. Most of those studies (e.g. Meyer, 2013; Viscusi et al., 2008), however, have investigated time preferences using optimistic levels of delay in observing targeted water quality improvements (e.g. five years or less). Other studies have proposed delays that will likely outlive the average respondent. For example, Kahn et al. (2017) considered up to 60 years of delay in restoring the water quality of the Paraíba do Sul river in Brazil. We consulted local scientists to determine more realistic restoration times for the lakes in question (10 to 20 years).

Additionally, our experimental design includes two potential project managers: 1) the municipal government and 2) an interinstitutional non-governmental committee. It has been shown that households' willingness to pay for improved water services may vary depending on the service management approach. For example, using the contingent valuation method, Vásquez and Franceschi (2013) estimated the willingness to pay for improved water services in León, Nicaragua. Their findings indicated that households were willing to pay a premium if the improved service was managed by the current national water company rather than decentralizing it at the municipal level. A majority of respondents considered the national company to be more accountable as well as technically and financially capable compared to the municipal government. In a related contingent valuation study conducted in a small town of Guatemala, Vásquez (2014) found that households with municipal services were willing to pay for water service improvements while households with community-managed services were not. Similarly, based on a hedonic pricing study implemented at the national level in urban Guatemala, Vásquez (2013) found that households valued having access to water services only if those services are provided by municipal governments rather than by private utilities and community-managed systems. Given that municipal, private, and community-managed systems were comparable in terms of service reliability, Vásquez (2013, 2014) argued that value differentials are due to institutional characteristics of water utilities. As a result of weak regulation, private utilities have the highest tariffs while providing similar services. In the case of community-managed systems, water users are required to undertake managerial duties which counteract the benefits of having access to water.

The analysis of household preferences regarding the management of environmental projects is particularly important in Brazil given a widespread perception of corruption at all government levels.[1] Households may adjust their preferences to project their rejection of the municipal government as a potential manager of the proposed lakes restoration project. Under these circumstances, alternative management approaches may be required to earn public support. This study analyzes household preferences for an interinstitutional, non-governmental committee as an alternative to the municipal government for managing the lake restoration project.

We analyze choice responses using a mixed logit model to account for potential heterogeneity among respondents. It is customary to estimate choice models in preference space and then transform the estimated coefficients to monetary values. However, that approach may result in unconventional, heavily skewed distributions for willingness-to-pay estimates (Scarpa et al., 2008). Alternatively, one can estimate the mixed logit model in willingness-to-pay space, which allows for making distributional assumptions directly on the monetary values and provides willingness-to-pay estimates that are presumably more precise (Train and Weeks, 2005; Hole and Kolstad, 2012). For those reasons, an increasing number of recent studies have estimated choice models in willingness to pay space (e.g. Balogh et al., 2016; Durán-Medraño et al., 2017; Kahn et al., 2017; Martínez-Jauregui et al., 2016). We follow this approach to investigate local preferences for different attributes of a lakes restoration project. Estimation results indicate that respondents' willingness to pay for lakes restoration decreases with restoration time in a non-linear fashion. Our findings also suggest that there is minimal support for the local government to undertake the proposed project, mainly because it is perceived as corrupt and incapable of containing project costs.

The rest of this paper is organized in the following sections. Section 2 provides a general overview of the study site and the water quality of its lakes. Section 3 presents the survey methodology and the DCE design. Section 4 introduces the analytical framework and econometric methodologies used to analyze respondents' choices. Section 5 shows the survey and estimation results. Section 6 concludes the paper with a discussion of our findings and their policy implications.

2. The city of Campos Dos Goytacazes and its lakes

Located approximately 275 km northeast the city of Rio de Janeiro, Campos dos Goytacazes (hereafter refer to as Campos) is the largest municipality of the Rio de Janeiro state with an area of 4026 km^2. According to the last demographic census, Campos had a population of 463,731 inhabitants as of 2010; most of which (90.3%) lived in the urban center. The average household had approximately three members with monthly income of R$ 2251. The average monthly income was R$ 2372 in urban areas and R$ 1105 in rural areas.[2]

The city of Campos has several lakes including Cima (14.8 km^2), Campelo (10.2 km^2), Das Pedras (1.48 km^2), Taquaraçu (0.51 km^2) and Vigário (0.25 km^2), all of which are relatively shallow (<2 m). The more extensive lakes, Cima and Campelo, are located outside the city surrounded by pasture and sugar cane (see Fig. 1). Lakes Das Pedras, Taquaraçu and Vigário are located within or closer to the city, exposed to sewage and garbage disposal. Recent analyses revealed the presence of fecal coliforms in those lakes (above 2400 CFU/100 mL), making it unsafe for humans to have direct contact with their waters. Also, Jesus et al. (2012) found that Mercury levels in carnivorous fishes from Lake Campelo are above Brazilian legal standards for human consumption (500 $ng \cdot g^{-1}$ in wet weight). Based on those results, local scientists have classified the five lakes as Type IV which, according to Brazilian

[1] According to the public opinion polls of Transparency International, a vast majority of Brazilians believe that both political parties (81%) and the legislature (72%) are very corrupt. In contrast, many Brazilians (65%) perceived non-governmental organizations as honest (see http://www.transparency.org/gcb2013/country/?country=brazil, last accessed on December 21, 2017).

[2] The census information was retrieved from https://cidades.ibge.gov.br, last accessed on November 14, 2017.

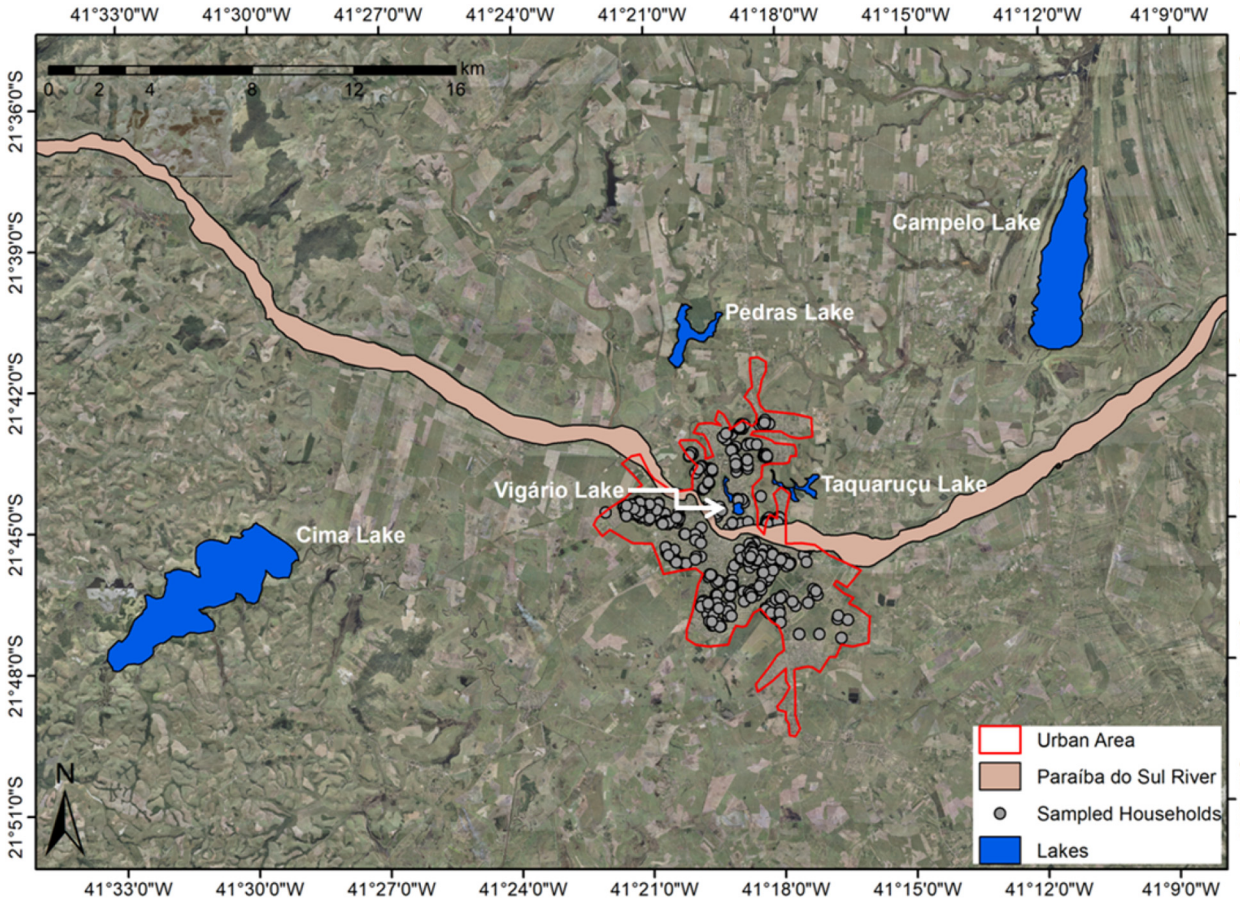

Fig. 1. Location of lakes in the city of Campos dos Goytacazes.

environmental regulations, implies that those lakes are useful only for transportation and landscape view. Human contact with that water is strongly discouraged.

Local scientists at Universidade Estadual do Norte Fluminense Darcy Ribeiro (UENF) believe that restoring those lakes up to a legislation-based Type II level (i.e. a level where the lakes can be used for swimming, irrigation, recreation, and fishing) may take between 10 and 20 years. Those scientists also realize that lakes Cima and Campelo may require different restoration efforts compared to lakes Das Pedras, Taquaraçu and Vigário due to differentials in extension and exposition to pollutants. We used this information to set realistic times for lakes restoration in the DCE.

3. Survey and discrete choice experiment design

A household survey was carefully designed to elicit local preferences for improving the water quality of five lakes in the city of Campos: Cima, Campelo, Das Pedras, Taquaraçu and Vigário. Several interviews with local experts at UENF were conducted to learn about the lakes' physical characteristics and the feasibility of improving the lakes' water quality. The survey design included one-on-one semi-structured conversations and focus groups with local residents implemented through different iterations in order to incorporate feedback. The questionnaire was pretested through a pilot survey administered by trained local interviewers to a random sample of 27 households. The final survey instrument was administered through in-person interviews to a random sample of 401 households in 2014. To select those households, random points were generated in a digital map using a geographical information system, and the nearest household was included in our sample.

Local preferences regarding a lakes restoration project were elicited through a generic (unlabeled) DCE. Table 1 shows the attributes included in the DCE and their corresponding levels. Each choice task had seven attributes to investigate different components of the lakes restoration project (i.e. water quality, recreation, and governance). The proposed project aimed to improve the water quality of those lakes from Type IV to Type II, according to Brazilian environmental

Table 1
Attributes and levels of the discrete choice experiment.

Attributes	Levels	Indicators
Time of restoration of small lakes: Das Pedras, Taquaruçu e Vigário	No restoration	(Base of comparison)
	10 years	SMALL10 [0/1]
	15 years	SMALL15 [0/1]
	20 years	SMALL20 [0/1]
Time of restoration of big lakes: Campelo e Cima	No restoration	(Base of comparison)
	10 years	BIG10 [0/1]
	15 years	BIG15 [0/1]
	20 years	BIG20 [0/1]
Recreation areas	No	(Base of comparison)
	Yes	RECREATION [0/1]
Fishing restrictions	No	(Base of comparison)
	Yes	FISH [0/1]
Frequency of water testing	No water testing	TEST [number of tests in a year]
	Once per year	
	Twice per year	
	Every month	
Project manager	Municipal government	(Base of comparison)
	Non-governmental committee	COMMITTEE [0/1]
Monthly fee for the next 10 years (for a total of 120 payments)	R$ 5	FEE [monthly payment in R$]
	R$ 10	
	R$ 15	
	R$ 20	
	R$ 25	

standards. Type II water quality implies that the water is safe for swimming, irrigation, recreation, and fishing, but unsafe to drink unless it is adequately treated. The quality of water was not varied across respondents because local experts noted that Type III water bodies would still imply considerable health risks for the population. Those experts also believe that restoring the lakes so their water can be classified as Type I (i.e. safe for consumption after simplified treatment) is simply not feasible. Therefore, the study focuses on eliciting preferences for restoration time.

The lakes were divided in two groups because their extension, depth, and location can affect the effectiveness of restoration efforts. The first group includes the lakes Das Pedras, Taquaraçu and Vigário because they are relatively smaller and their location makes them relatively vulnerable to urban pollution (see Fig. 1). The second group includes the bigger lakes that are located outside the city, Cima and Campelo. Restoration time is treated as a separate attribute for each group of lakes varying from 10 to 20 years based on consultations with local scientists (see Table 1). Farizo et al. (2014) used similar restoration time estimates (8 vs 20 years) in their valuation study of water improvements in England and Wales according to the European Community's Water Framework Directive. We treat the restoration time attribute as a discrete one to investigate nonlinearities in time preferences.

Preferences for recreational infrastructure such as walking and biking trials, playgrounds, outdoor gyms, and picnic tables are also investigated as a project attribute in the DCE. This is a binary attribute that would be provided or not, according to the experimental design. The fourth attribute of the proposed project, also a dichotomous one, is related to fishing. When provided, this attribute consists of restrictions to prevent the depletion of fish populations in the lakes. The fifth attribute refers to the periodicity of water testing in order to monitor the project progress and to assure that the water is safe to undertake the activities corresponding to Type II water. As shown in Table 1, this attribute vary from no water testing to testing the water every month.

Following prior studies that demonstrated that willingness-to-pay estimates can vary depending on the proposed management approach (e.g. Vásquez, 2013, 2014; Vásquez and Franceschi, 2013) the DCE also included an institutional attribute that could vary the project management between the municipal government and a non-governmental committee that would include representatives from the private water utility, the local university UENF, the water basin committee, and environmental NGOs in the area. In Brazil, there is a widespread perception that a considerable amount of government revenues goes directly into the pocket of politicians rather than being allocated to public services and social programs. The perceived corruption may affect the willingness to pay for environmental programs if they are administered by local governments. For this reason, in addition to including the local government as a potential manager of the proposed project, respondents were given the option of a non-governmental committee.

There are some alternatives that could be used as payment vehicle for the proposed project such as increased taxes, voluntary contributions, and increases in service charges (e.g. water and sewage payments). In the context of this study, respondents would not believe that taxes raised for a specific purpose will actually be used for that objective. This concept repeatedly surfaced on focus groups, presumably because of perceived levels of corruption in governmental agencies. Voluntary contributions could be more credible than taxes as a means of payment to fund environmental programs. However, focus group participants demonstrated some concerns regarding the effectiveness of voluntary contributions to fund the project due to free-riding attitudes among local citizens. Compared to voluntary contributions, an increase in water bills would be feasible and would reach a more extensive base of contributors given that >90% of inhabitants are connected to the water system. In addition, the private water utility is perceived to be subject to more checks and balances than tax collection agencies. Consequently, an increase in monthly water bills varying from R$ 5 to R$ 25 was used as payment vehicle in the DCE. Respondents were informed that the payment would be collected for the next 10 years (for a total of 120 monthly payments) according to the minimum time in which local water experts expect to observe the proposed change in the water quality of lakes. The fact that the length of the payment period is fixed to 10 years may minimize strategic responses favoring a shorter period of restoration time just because this would imply to make fewer payments.

A D-optimal orthogonal design (assuming zero priors) was applied to select 16 choice tasks using the statistical software JMP. Each task had two options that varied in attribute levels and the status quo alternative as a third option. The choice tasks were randomly grouped in four sets to avoid respondent fatigue. Respondents were randomly assigned one of those groups so each of them was asked to perform four choices. To introduce the proposed project, interviewers showed a map to the respondent to clearly identify the lakes included in this study (Cima, Campelo, Das Pedras, Taquaraçu and Vigário). Respondents were also provided with information about the current quality of lakes' waters. Specifically, they were told that scientists at the local university UENF had classified lakes' water as Type IV implying that water was safe for transportation and landscape view only, and that other activities such as swimming, skiing, diving, irrigating, fishing, and drinking would represent a significant health risk. Then, interviewers carefully explained to the respondent each of the attributes. Respondents were informed that the project would entail monthly payments that would reduce their disposable income for other needs in order to confront them with their budget constraint. Finally, respondents were provided with an example of the choice tasks (see Appendix A) so they could become familiar with the process of choosing among the three alternatives in each task. This example was not included in the analysis.

Follow up questions were included to further analyze respondents' perceptions regarding potential project managers. Respondents were asked to choose between the municipal government and the non-governmental committee to administrate the lakes restoration project.[3] In addition, respondents were asked to choose between the municipal government and the non-governmental committee based on seven specific characteristics: responsiveness, corruption, project cost containment, efficiency, potential to receive governmental support, financial capacity, and likelihood of hiring capable personnel. Subsequently, respondents were given the opportunity to form an institutional committee of 10 members. They could choose representatives from the municipal government, (private) water utility, local university UENF, water committee, and other environmental NGOs. Along with the DCE, these questions allow us to understand local preferences for lakes restoration and for environmental management approaches.

4. Analytical framework and econometric modeling

The Random Utility Model (RUM) provides a theoretical framework to analyze the results of DCEs. The RUM assumes that individuals will choose the alternative that gives them the highest expected utility. If the individual n is observed choosing alternative i over alternative j at time t (or choice task t), it is implied that the utility derived from the chosen alternative is greater than that of the forgone alternative (i.e. $V_{nit} > V_{njt}$). The monotonic relationship between the conditional indirect utility that the individual n derives from alternative i at time t (i.e. V_{nit}) and the probability of choosing alternative i can be represented using a multinomial logistic specification:

$$\Pr(i) = \exp(V_{nit}) / \sum_{j=1}^{J} \exp(V_{njt}) \quad (1)$$

[3] Respondents were given the opportunity to vote for both institutions in case they considered them equally capable to administrate the project, or for none of them if they believed both institutions were unqualified to undertake the proposed project. These options, however, were not read to the respondents. Surveyors were instructed to mark those responses only if the respondents declared so.

In the context of this study, the alternative *i* represents a change in environmental quality due to the restoration of lakes Cima, Campelo, Das Pedras, Taquaraçu and Vigário.

The RUM assumes that the utility derived from an alternative depends on observed and unobserved attributes of the alternative and individual. While observed attributes are depicted by explanatory variables, unobserved ones are represented as random variables. Hence, the utility level *V* that individual *n* derives from alternative *i* at time *t* (or choice task *t*) can be represented using a linear form:

$$V_{nit} = \lambda M_{it} + \delta X_{it} + e_{nit} \quad (2)$$

where M_{it} stands for the project fee, X_{it} represents the vector of attributes associated to the proposed lakes restoration project other than the fee, λ and δ are parameters to be estimated, and *e* is the idiosyncratic error term. Estimated δ coefficients depict the marginal utility derived when moving from one attribute level to another.

It is standard practice to estimate choice models in preference space (as specified in Eq. (2)), and then transform the estimated coefficients to monetary values. This can be achieved by multiplying those coefficients by the negative reciprocal of the coefficient corresponding to the project fee (i.e. $-\delta / \lambda$). However, this approach may result in unconventional, heavily skewed distributions for willingness-to-pay estimates particularly when values of the denominator are close to zero, which is possible under most typical distributions (Scarpa et al., 2008). Train and Weeks (2005) showed that Eq. (2) can be rescaled using the negative reciprocal of λ without affecting the behavioral assumptions behind the RUM (also see Cameron, 1988 and Hole and Kolstad, 2012). By rescaling Eq. (2), choice models can be estimated in willingness-to-pay space as follows

$$\upsilon_{nit} = -M_{it} + \beta X_{it} + \varepsilon_{nit} \quad (3)$$

where β depicts the marginal willingness to pay for the attributes included in vector *X*. This approach allows for making distributional assumptions directly on the monetary values of each level of associated attributes. Balogh et al. (2016), Durán-Medraño et al. (2017), Hole and Kolstad (2012), Jacobsen et al. (2011), Kahn et al. (2017), Martínez-Jauregui et al. (2016) and Scarpa et al. (2008) provide recent examples of choice models estimated in willingness-to-pay space.

Eq. (3) indicates that the willingness to pay for alternative *i* is associated with the attributes of the proposed lakes restoration project. However, the association between willingness to pay and attributes can vary across individuals due to their heterogeneity. McFadden and Train (2000) propose using the mixed logit model (also known as random parameters logit model), which assumes that heterogeneity across respondents is due to differentials in preferences for each attribute (i.e. taste heterogeneity). This approach adds random coefficients (η_n) to the marginal willingness to pay for a given attribute, which is depicted by an estimable β coefficient, in order to account for taste heterogeneity among respondents. After introducing random components for taste heterogeneity, the indirect utility can be represented as follows:

$$\upsilon_{nit} = -M_{it} + (\beta + \eta_n) X_{it} + \varepsilon_{nit} \quad (4)$$

The random coefficients η_n are assumed to follow a normal distribution.[4] We estimated the mixed logit model in willingness-to-pay space in order to analyze choice responses on the proposed lakes restoration project while accounting for potential taste heterogeneity across respondents. Although this approach does not always fits the data better than choice models in preference space, it yields willingness-to-pay estimates that are presumably more precise (Hole and Kolstad, 2012; Train and Weeks, 2005).[5]

Table 1 presents the experimental indicators included in vector *X*. Respondents are expected to derive utility from environmental improvements (i.e. lakes restoration), which would be depicted by positive coefficients of SMALL10, SMALL15, SMALL20, BIG10, BIG15 and BIG20. Based on recent evidence suggesting that individuals lose benefits due to delays in environmental improvements (e.g. Meyer, 2013), it can be hypothesized that $\beta_{SMALL10} > \beta_{SMALL15} > \beta_{SMALL20}$ because individuals may prefer to observe improvements of the water quality of lakes Das Pedras, Taquaraçu and Vigário sooner rather than later. Similar expectations can be held for the bigger lakes, Cima and Campelo (i.e. $\beta_{BIG10} > \beta_{BIG15} > \beta_{BIG20}$). Individuals are also expected to derive utility from recreation facilities (i.e. $\beta_{RECREATION} > 0$), and from periodic water testing as this would provide information about water quality that can be used to reduce exposure to water pollutants (i.e. $\beta_{TEST} > 0$). The utility effects of the other two attributes, FISH and COMMITTEE, could be ambiguous. Fishing restrictions could have a negative effect on individuals' utility if they have strong preferences for immediate fish consumption. In contrast, individuals could find those restrictions appealing if they have nonuse preferences or if they are concerned about the sustainability of fish populations. The COMMITTEE coefficient could also go in both directions depending on individual perceptions regarding how capable, dependable, and accountable the institutions included in the non-governmental committee are in comparison to the municipal government. Hence, those effects remain to be empirically estimated.

5. Survey and estimation results

Table 2 presents the mixed logit model estimated to investigate individual preferences for lakes restoration projects. Because the model is estimated in willingness-to-pay space, estimated coefficients can be interpreted as the marginal value of corresponding attribute levels relative to the attribute level used as base of comparison (known as part-worth or willingness to pay). With the exception of the variable TEST, all estimated coefficients are statistically significant with expected signs. Corresponding standard deviation estimates are also statistically significant, which suggests that respondents have heterogeneous preferences for each attribute. Estimated coefficients on indicators representing the time required for the lakes to reach a classification of Type II indicate that respondents' willingness to pay for lakes restoration decays over time in a non-linear fashion, and that the decay is observed at different times for small and big lakes. For restoring small lakes (Das Pedras, Taquaruçu e Vigário), respondents are willing to pay approximately R$ 14 (US$ 5.27) per month if those improvements occur in 15 years or sooner.[6] The willingness to pay for improving those lakes decreases substantially for a restoration time of 20 years.

The decay in willingness to pay for restoring the big lakes (Campelo and Cima) is more rapid than for small lakes, although it is not as drastic. Moreover, respondents are willing to pay more for restoring the small lakes than for big lakes when the restoration time is 15 years or less. The willingness to pay estimates reverse when the restoration time is 20 years.[7] Respondents are willing to pay about R$ 8 (US$ 3) per month when the restoration time is 10 years. Beyond that time (15

[4] Although other distributions have been proposed (e.g. the triangular distribution), the normal distribution is most commonly used to depict taste heterogeneity in choice models (Fiebig et al., 2010).

[5] With an Akaike and Bayesian information criteria of 2955 and 3090 respectively, the choice model in utility space fits our data better than the model in willingness-to-pay space. However, the model in preference space produces statistically insignificant willingness-to-pay estimates for all the attributes with the exception of the restoration of small and big lakes in 10 and 15 years. Hence, we estimated the mixed logit model in willingness-to-pay space.

[6] The exchange rate used here corresponds to December 31, 2014 (US$ 0.376276 per R$ 1).

[7] WTP differentials between small and big lakes are statistically significant at 1% level for restoration periods of 10 and 15 years and at 5% level when the restoration time is 20 years (10 years: $z = -6.98$; 15 years: $z = -12.08$; 20 years: $z = 2.44$).

Table 2
Mixed logit model.

	Part-worth estimates (R$)		St. dev. of random effects (η)	
	Coefficient	Clustered S.E.	Coefficient	Clustered S.E.
SMALL10	14.01	0.68***	26.03	0.95***
SMALL15	14.61	0.50***	−1.77	0.41***
SMALL20	2.36	0.55***	−17.01	0.66***
BIG10	8.33	0.35***	1.41	0.41***
BIG15	4.12	0.55***	−12.04	0.56***
BIG20	4.45	0.58***	−16.43	0.61***
RECREATION	5.79	0.41***	−17.63	0.53***
FISH	−1.58	0.43***	−8.70	0.46***
TEST	−0.51	0.05	−3.19	0.10***
COMMITTEE	1.65	0.37***	−10.58	0.42***

Notes: Choice tasks = 1601; log-likelihood = −1078.08; degrees of freedom = 20; Akaike information criterion (AIC) = 3636.17; and Bayesian information criterion (BIC) = 3765.71.
*** Significance at 1% level.

Table 3
Present values for project attributes over different time intervals.

	One year		10 years	
	R$	S.E.	R$	S.E.
SMALL10	148.16	7.24***	635.44	31.06***
SMALL15	154.57	5.30***	662.93	22.74***
SMALL20	24.95	5.83***	106.99	24.98***
BIG10	88.07	3.70***	377.71	15.88***
BIG15	43.54	5.85***	186.73	25.12***
BIG20	47.06	6.11***	201.84	26.21***
RECREATION	61.28	4.29***	262.80	18.41***
FISH	−16.73	4.54***	−71.74	19.45***
TEST	−0.54	0.54	−2.31	2.33
COMMITTEE	17.47	3.91***	74.92	16.77***

*** Significance at 1% level.

+ years), the willingness to pay for restoring big lakes decays by half (i.e. R$ 4 or US$ 1.50 per month).

The project fee was introduced in the DCE as monthly payments over 10 years. Those 120 payments are converted to present values for each project attribute, as well as to an annual value (see Table 3). A monthly interest rate of 2% was used to discount the 120 monthly payments required in the proposed lakes restoration project. That discount rate is what individuals usually pay for loans at major banks in Brazil. The present value of the 120 monthly payments required to restore the small lakes is approximately R$ 635 (US$ 239) as long as the project does not take 20 years or more to improve the water quality. When the restoration time is 20 years, the present value of corresponding monthly payments would be R$ 107 (US$ 40). The present value of the 120 monthly payments required to restore the big lakes is between R$ 187 (US$ 70) and R$ 378 (US$ 142), depending on the restoration time.

Table 2 also shows willingness-to-pay estimates for other project attributes. Respondents are willing to pay for recreational infrastructure to be implemented around the lakes (i.e. walking and biking trials, playgrounds, outdoor gyms, and picnic tables), as indicated by the positive and statistically significant coefficient of RECREATION. Results also indicate that respondents reject fishing restrictions. The negative coefficient of FISH suggests that respondents believe that they are entitled to a monetary compensation if fishing restrictions are imposed. Currently, those restrictions do not exist, which may have led to a widespread opinion that Campos' inhabitants have the right to fish in the lakes with no restrictions. The estimated coefficient on TEST is statistically insignificant suggesting that respondents are indifferent about the frequency of water testing.

Findings also indicate that respondents have stronger preferences for a non-governmental committee to manage the lakes restoration project than for the municipal government. Households would pay a premium of R$ 1.65 (US$ 0.62) per month if the non-governmental committee manages the lakes restoration project. This is not surprising given the widespread public perception that government officials are corrupt and inefficient. The non-governmental committee would have minimal political incentives and it may be a governance approach with more checks and balances than the municipal government. Those characteristics may be appealing to the respondents.

Follow up questions were included to explore in more detail why respondents would be willing to pay a premium when an interinstitutional, non-governmental committee is proposed to manage the lakes restoration project rather than the municipal government. Respondents were asked to choose between the municipal government and the non-governmental committee in terms of governance characteristics such as responsiveness, corruption, cost containment, efficiency, governmental support, financial capacity, and personnel capabilities. Fig. 2 shows the respondents' choices. Consistent with findings from the DCE, a majority of the respondents would choose the non-governmental committee over the municipal government to administrate the lakes restoration project.

Fig. 2 also shows that approximately 48% of the respondents believe that the committee would be more responsive to community needs than the municipal government, which is almost the double of respondents who believe the opposite. A vast majority of respondents perceive the municipal government to be corrupt in using public funds and incapable to contain project costs, relative to a small number of respondents who believe so about the non-governmental committee. The public opinion is more balanced in terms of efficiency (i.e. who would restore the lakes in a shorter period of time), with a slight difference in favor of the non-governmental committee. >60% of respondents believe that, compared to the non-governmental committee, the municipal government would have more access to financial resources and would receive more support from the central government to restore the lakes. On the other hand, many respondents consider that the non-governmental committee would hire more competent personnel than the municipal government.

The DCE, as well as the choice responses shown in Fig. 2, revealed that respondents would prefer a non-governmental committee over the municipal government to administrate the lakes restoration project. However, those questions did not uncover the committee composition that individuals would prefer. Another follow up question allowed respondents to form an inter-institutional committee of 10 members. Respondents could select how many seats they would reserve for representatives of the municipal government, private water utility, local public university (known as UENF), river basin committee, and other non-governmental organizations. Fig. 3 shows individual preferences for the composition of the interinstitutional committee that would administrate the proposed project. The average respondent would give the highest number of seats (almost four out of 10) in the committee to the public university UENF. The difference between seats reserved for UENF and for other institutions is statistically significant at 1% level (UENF vs river basin committee: $t = 12.56$; UENF vs NGOs: $t = 10.82$; UENF vs water utility: $t = 11.37$; UENF vs municipality: $t = 10.73$). The average person would equally distribute the remaining six seats among the other four institutions (i.e. NGOs, municipal government, water utility, and river basin committee), although a t-test indicates that the small difference in seats assigned to NGOs and the river basin committee is statistically significant at 5% level ($t = 2.22$). These findings suggest that individuals would prefer to have a representative lakes restoration committee with balanced influence in the decision making process, at least among institutions other than UENF, the most preferred institution.

6. Conclusions

The restoration of lakes, as well as other hydrological systems, is increasingly becoming a priority in order to recover the multiple services that have been lost over time as a result of anthropogenic

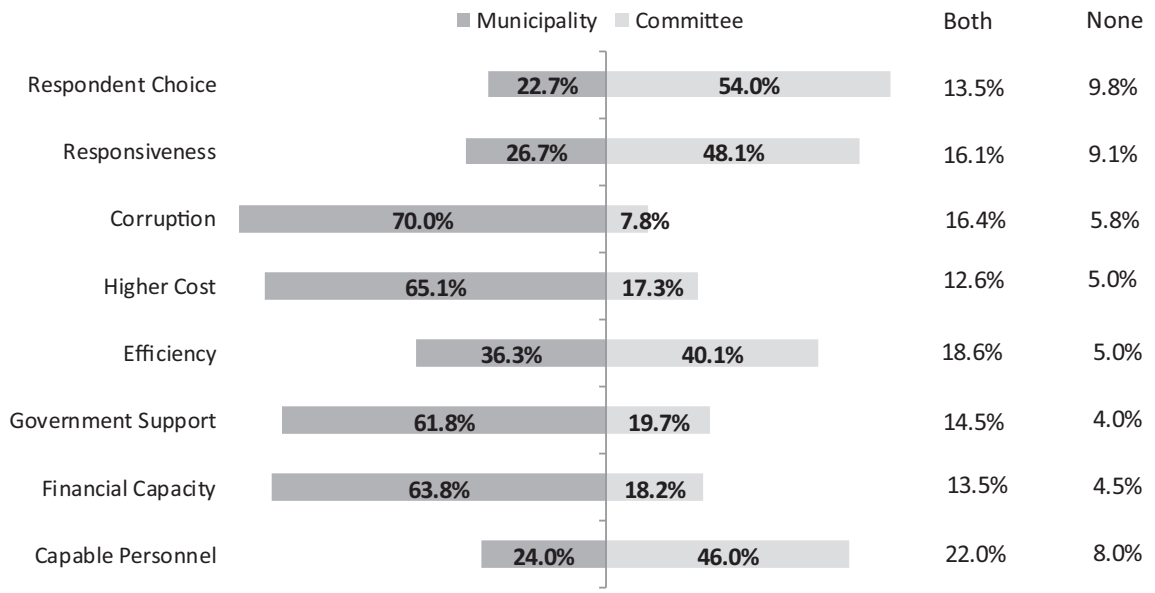

Fig. 2. Perspectives on institutional characteristics of potential project administrators.

eutrophication. This study proposed a project to restore the water quality of five lakes in the city of Campos dos Goytacazes (Brazil) so individuals may have direct contact with lakes' water for swimming, fishing, and irrigating. More specifically, a discrete choice experiment was implemented to elicit values for different attributes of the proposed lakes restoration project, with particular emphasis on delays in achieving the targeted level of water quality and the project manager. Findings indicate that there are strong preferences for lakes restoration, particularly if water quality improvements occur in a timespan of 10 to 15 years. Respondents also show strong preferences for recreational services to be provided by walking and biking trials, playgrounds, and picnic tables. Moreover, respondents rejected fishing restrictions, presumably because they would prefer to be able to fish at any time. Opposition to fishing restrictions may be an obstacle for sustainable management of fish populations.

The respondents' willingness to pay for water quality improvements varies with the amount of time required before realizing those improvements in a non-linear form. This finding is consistent with prior evidence suggesting that households are impatient in observing environmental improvements (Kahn et al., 2017; Meyer, 2013; Rezende et al., 2015; Viscusi et al., 2008). Findings also indicate that time preferences vary across the lakes. The decay in willingness-to-pay estimates occurs sooner for the big lakes (between 10 and 15 years) than for the small lakes (between 15 and 20 years). This suggests that respondents value lakes restoration using discount rates that vary with the restoration delay and the resource to be improved. Those variations in discount rates can be associated with the uncertainty inherent in future events (Epper et al., 2011). Respondents may be more uncertain about the results of a 15-year project to improve the big lakes than for a project with the same delay in improving the small lakes. As a result of that uncertainty, individuals' willingness to pay decays more rapidly for big lakes than for small lakes. Farizo et al. (2014) also found heterogeneous time preferences for improvements of water bodies at local and national levels in England and Wales.

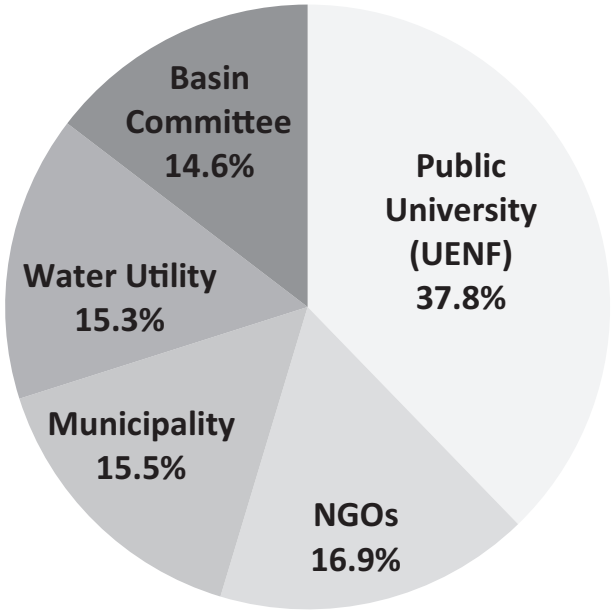

Fig. 3. Preferences for composition of the inter-institutional committee.

This study also provides guidance about the management of environmental programs. Results indicate that there are stronger preferences for a non-governmental committee to manage the lakes restoration project than for the municipal government. Respondents reject the municipal government because they perceive it as corrupt and incapable of containing project costs. In contrast, respondents would support a non-governmental committee because they believe this committee would be more responsive, efficient and capable to restore the lakes than the municipal government. The inclusion of some representatives of the municipal government would still be accepted as long as equally distributed decision power is guaranteed. There would be more checks and balances in a committee with members representing different interests and perspectives regarding improvements of urban lakes.

It is worth noting that preferences for management approaches are context specific. For example, Vásquez (2013) found that Guatemalan households assign higher value to water services provided by municipal governments than to services provided by community committees. Vásquez (2015), who also found evidence in favor of the municipal government over community committees, argues that those preferences are based on the public perception that municipal governments are more capable and efficient to provide reliable services than community-based organizations. Against this backdrop, our results should not be interpreted as evidence that interinstitutional, non-governmental committees are the panacea for environmental

management. Instead, our findings suggest that future studies on environmental management preferences should consider management approaches that are relevant in the local context.

Finally, estimated values can be used to calculate the benefits of different specifications of the lakes restoration project. A project that intends to improve the water quality of the five lakes in 10 years and install recreational infrastructure under the administration of the non-governmental committee would provide annual benefits valued at R$ 315 (US$ 118.50) per household. If those figures are aggregated over the number of households in Campos (estimated at 144,596 connections to the potable water system), the (discounted) annual benefits would be of approximately R$ 45.5 million (about US$ 17.1 million). If the same project is managed by the municipal government, the annual benefits would be less at R$ 43 million (US$ 16.2 million). If the latter scenario is slightly changed to consider that the big lakes (Campelo and Cima) may take 20 years to reach a Type II classification, annual benefits for the entire city are estimated at R$ 39.6 million (US$ 14.9 million) under the administration of the non-governmental committee, and R$ 37.1 million (US$ 14 million) under the administration of the municipal government. These estimates can be compared to annual costs of the proposed project to assess its feasibility and prioritization among other environmental and social programs.

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Appendix A. Example of choice task presented to respondents

Characteristics	Option 1	Option 2	Status quo
Restoration of lakes: **Das Pedras**, **Taquaruçu** and **Vigário**	No restauration	Restauration in 20 years	No restoration
Restoration of lakes: **Campelo** and **Cima**	Restoration in 20 years	Restoration in 20 years	No restoration
Recreation areas in all lakes	No	Yes	No
Fishing restriction in all lakes	No	Yes	No
Water testing in all lakes	Once per year	Every month	No
Project Manager	Municipality	Committee	No one
Monthly payment in the next 10 years	R$ 10	R$ 20	R$ 0
Your Choice:	☐	☐	☐

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