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Not Too Small to Benefit Society: Economic Valuation of Urban Lake Ecosystems Services

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ABSTRACT

Although the importance of urban lake ecosystem services is widely recognised, the integration of associated values and benefits into decision-making is still under-developed. Therefore, this study has assessed the use and non-use values of two urban lakes viz., Ukkadam Big Lake (UBL) and Sulur Lake (SL) in Coimbatore, Tamil Nadu. Primary data were collected from 208 respondents, comprising fishermen, local residents, and visitors, during 2021–22. The estimated total economic value (TEV) was Rs. 107.96 lakhs and Rs. 77.15 lakhs, for UBL and SL, respectively, of which, three-fourth of the value was accounted by use values and the remaining one-fourth by non-use value services. Among use values, the provisional services were estimated at current market prices ranging from 8 to 11 per cent of TEV. The value of recreational services was assessed by the travel cost method and the estimated value was Rs. 75.85 lakhs and Rs. 49.92 lakhs for UBL and SL. The non-use values were assessed using the contingent valuation method, and the mean willingness to pay was found to be Rs. 979.63 and Rs. 801.23, respectively, for UBL and SL per annum. Logit regression estimates indicated that age, education, and income significantly influenced the willingness to pay for the lake's services. It is concluded that all stakeholders, including the government, should consider the conservation of the lakes by making the necessary efforts to charge entrance fees, desilt the lake, install more sewage plants, and allocate a sufficient budget under the smart city plan.

Keywords: ecosystem services, use and non-use values, recreational services, conservation

JEL: Q26, Q57, Z32

I

INTRODUCTION

According to the estimates of the United Nations (2015), more than 60 per cent of the global population will be concentrated in urban areas by 2030 and they determine the urban ecology. Urban ecology is highly fragmented and heterogeneous landscapes, which include both man-made and natural elements such as buildings, roadways, lakes and ponds, parks, and so on. Urban lakes are described as artificial ecosystems, usually small in size and shallow in depth, with flood-control roles and recreational purposes (Birch and McCaskie, 1999). Urban lakes are one of the landscape features that significantly contribute to increasing the quality of life in urban centers by offering amenities, recreational and educational activities, and also help to mitigate the urban climate (Martínez-Arroyo and Jáuregui 2000). Further, urban lakes provide psychological, emotional, and physical human well-being (Mantler and Logan, 2015,) and support for groundwater recharge, sediment

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retention, water purification, flood control, and microclimate regulation (Sterner *et al*., 2020), wildlife habituations, water supply for municipal and industrial uses and fisheries (Schallenberg *et al*., 2013). In addition, it also provides timber and non-timber products, medicinal plants, drinking water for humans and livestock, and pasture for livestock and the livelihood of human beings (Sterner et al. 2020).

Though there is an increasing demand for urban lakes due to offering various ecosystem services, it is being damaged by anthropogenic activities (Inostroza, 2014), climate change (Schmid *et al*., 2014; Sarwary *et al*., 2021; Saravanakumar *et al*., 2022), industrialisation, improper infrastructure plan and development, encroachment, and mixing of domestic sewage. In terms of institutional constraints, stakeholders and managers involved in urban lakes have often faced numerous problems such as a lack of funding for maintenance and monitoring, and difficulty in controlling multiple drivers of water degradation (Birch and McCaskie, 1999). The pressure on ecosystems is rising globally unless human attitudes and actions change. It is noted that globally about 60 per cent of all ecosystem services are being degraded and over-exploited because of human activities and natural disasters. Therefore, maintaining ecosystem services to sustain growing urban needs is one of the greatest challenges to the sustainable development of cities (Grunewald and Bastian, 2017). Hence, there is a need to protect the sustainability of the urban lake ecosystem.

A better understanding of the services and payments to ecosystem services offered by urban lakes will serve as an incentive to conserve the natural capital. Therefore, the valuation of different ecosystem services has become increasingly important in recent times, as society is indiscriminately using these goods as public goods. Valuing of the lake’s services is a challenge and many times the services are undervalued because people cannot realise the wide range of products derived from lakes. One reason that these services may not have economic value as a large part of these ecosystem services falls under common goods and public goods. Because of the challenge associated with valuing and measuring ecosystem services, they have often been ignored.

Despite their environmental and economic importance and high level of public interface, scanty attention is paid to exploring the urban lake ecosystem service and sustainability (Vreugdenhil *et al.*, 2003); existing studies have mainly been focused on its hydrological and ecological aspects, and less emphasis is placed upon the lake’s economic aspects (Getnet and Taw, 2021). Valuation of ecosystem services encourages the utilitarian view of lake ecosystem services in terms of value which helps to validate the huge conservation efforts as well as in designing policies (Deal *et al.*, 2012).

In the city of Coimbatore, 18 lakes and wetlands were constructed during the eighth century on both sides of the river Noyyal for purposes of irrigation and flood control. However, the quality of these lakes has deteriorated due to recent urbanisation, industrial and infrastructure development, a substantial increase in population, and the discharge of domestic and industrial sewage into the urban lakes. The city has undergone several stages of development, evolving from an agricultural centre to an industrial hub and ultimately establishing itself as an information technology powerhouse. Coimbatore city is one of the Indian cities chosen for the Smart City Mission. The Coimbatore city Municipal Corporation has initiated numerous projects as part of this mission, with a particular emphasis on the water resources restoration project, which includes the rehabilitation of nine lakes. Therefore, it is crucial to assess the lakes' value and formulate appropriate policies to safeguard them, preserving their valuable functions. As a result, the present study was undertaken to evaluate the economic value of various ecosystem services provided by two urban lakes within Coimbatore city. Therefore, the specific objectives of the study are to: (i) estimate the value of the direct or provisional services of the urban lake ecosystem, (ii) assess the economic valuation of recreational services, (iii) evaluate the willingness to pay (WTP) for non-use services of the lake and (iv) analyse the factors affecting WTP and (v) suggest appropriate policies to conserve and maintaining the existing urban lake ecosystems.

II

METHODOLOGY

2.1 Study Area

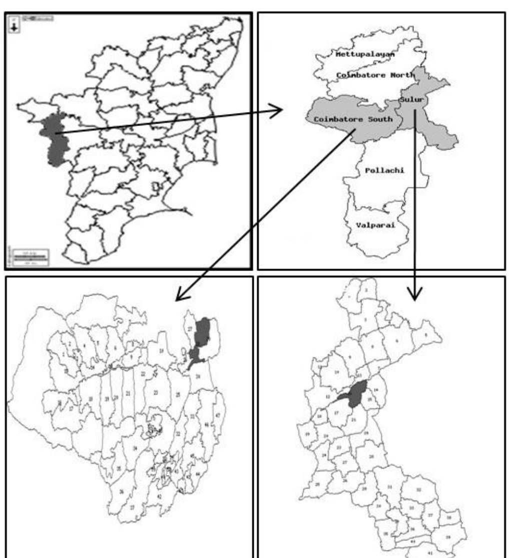

Fig 1. Site location of Ukkadam and Sulur Lakes

The city of Coimbatore was built around the Noyyal River basin and is made up of a network of lakes and canals that served as the major source of surface water. This study specifically focuses on two urban lakes in Coimbatore, Tamil Nadu, situated in the heart of the city: Ukkadam Big Lake (UBL) and Sulur Lake (SL). Both lakes are located along the banks of the Noyyal River. UBL is also popularly known as Periyakulam, which is the largest lake in Coimbatore. It is spread over an area of 129 ha with an average depth of 5.82 meters, covering 136 ha of cultivable area. In 2010, the lake was taken over by Coimbatore Corporation on a 90-year lease from the Public Works Department (PWD) of the Government of Tamil Nadu. SL spreads over an area of 33.24 ha and the depth of the lake is 2.59 meters, covering 212 ha of cultivable area. The site location of UBL and SL is presented in Figure 1.

2.2 Sampling and Data

After having a focus group discussion with different stakeholders like local residents, beneficiaries of the lake, officials of PWD, and the Agriculture Department, we identified different stakeholders and collected data from 30 fishermen; 30 local residents, and 50 visitors randomly in each lake with a sample size of 220 respondents (110 from each lake) to assess the value of different services. Both primary as well as secondary sources of data were collected during 2021-22, which focused mostly on using quantitative and qualitative primary data on age, education level, family size, family income, and willingness to pay money for the lake services.

2.3 Total Economic Value

The ecosystem services obtained from the lake are described under the Total Economic Value (TEV) framework, which is based on the utilitarian value of ecosystems and their components viz., ecological, socio-cultural, and economic values. TEV is typically disaggregated into two categories: (i) use values and (ii) non-use values (Wattage and Mardle, 2007). Use values are equivalent to the sum of the (a) direct use or provisioning services (output that can be consumed directly) *i.e.* fishing, grazing, collecting lotuses, boating, parks, walking trails, irrigation water, etc. (b) indirect use or regulatory services (the benefit that people derive indirectly from services such as recharging groundwater, regulating micro-climate, watershed protection, carbon sequestration and habitat for birds); and (c) recreation / cultural services (ecotourism, bird watching, and scenic views). The direct use values of fishing[1], lotus collection[2], grazing[3], washing[4], and other[5] activities) were derived from the lake that can be valued by multiplying the quantity produced of the particular services by its current market price. In the case of grazing, the households residing in the peripheral areas own livestock that is grazed on the common lands in tank-fed areas. The amount of fodder that would be required to be fed to the cattle if they were not grazed was calculated using the average daily requirement of fodder for animals. The local market price for fodder was used as a proxy to estimate the economic value of grazing. The indirect use values were not assessed in this study since they fall outside the scope of this study.

To evaluate the economic benefits of recreational services, we employ the travel cost method (TCM). TCM relies on the revealed preference or related/allied market approach, wherein the visitation rate to the lake for activities like park visits or boating serves as an indirect measure of the value that people attribute to the lake ecosystem. Further, it is challenging to quantify non-use values, such as existence values (the value placed on knowing that a resource exists even though no one may ever use it) and bequest values (the value placed on leaving the resource to future generations). In such situations, CVM is a stated preference method to place an amount or value on goods and services that are typically not exchanged in the market place (Ajzen and Driver, 1992).

2.4 Travel Cost Model (TCM)

The recreational benefits can be assessed using the individual travel cost method. Using the principle of consumer utility maximization and inferring a revealed demand curve, TCM estimates the economic value of recreational services of the lake. The first supposition is that an individual must decide whether to consume non-market environmental products by choosing to pay the market price of travel in order to visit a recreational site. The consumer will therefore have a utility function (U) that contains a market good vector (X) and a non-market environmental goods vector (Q) (Freeman, 1993). Travel cost is the amount of expenditure incurred by an individual for a trip to a tourist spot that reflects his desire to spend for the area (Ortacesme *et al.,* 2002). The main purpose of TCM is to provide a value measurement for recreational sites by developing a demand 'curve' based on consumers' maximum use (Marothia, 2001, Bedate *et al.,* 2004). The empirical model[6] of the individual travel cost method (ITCM) was used in this study, is given in equation (1):

$$\ln V = \beta_0 + \beta_1 TC + \beta_2 AGE + \beta_3 EDU + \beta_4 INC + \beta_5 DIST + \beta_6 FS + \beta_7 MS + u_t \quad \ldots. (1)$$

Where V is the number of visits made by the individual to the lake; TC is the travel cost *i.e.* the sum of travel cost from a place of residence, expenses of parking, boating, and eating; and the opportunity cost of making the visit (Rs per head per trip); AGE is the age of the respondent in years; INC is the annual household income (Rs per year): DIST is the distance travelled (km per trip); FS is the family size (Numbers); MS refers marital status (0 - Unmarried, 1- Married) and u_t is the error term.

The individual consumer surplus could be derived with the following formula (Torres-Ortega *et al*., 2018). Consumer surplus= $-1/\beta_1$. Which is multiplied by the number of individuals visiting the lake annually helps to estimate the consumer surplus for the lake ecosystem.

2.5 Contingent Valuation Method (CVM)

The CVM method has been applied to estimate both use values and non-use values of environmental goods (Cummings *et al*., 1986; Mitchell and Carson, 1989). CVM is frequently used methodologies in the valuing of ecosystem services by asking people directly about their willingness to pay (WTP) for preserving environmental assets and services (Marothia, 2001, Ekka and Pandit, 2012). WTP is the maximum amount consumers are prepared to pay for a good or service, i.e., WTP is the amount of money that a person is willing to pay to enjoy non-use services (McConnell, 1985). It measures whether an individual is willing to forego their income in order to obtain more goods and services, and is typically used for non-market goods (Samdin, 2008).

In this study, the respondents were asked to express their WTP to a value derived from the lake among values for non-use (existence and bequest). Further, the CVM method estimates the WTP of non-market services using structured surveys and the bidding game technique. The questionnaire asks respondents to indicate their WTP in a hypothetical (contingent) market for the lake's non-use values (Suresh Kumar and Indira Devi, 2022). When using the bidding game method (Figure 2), the respondent is questioned about accepting to pay a specific amount of money. If they reject the offered sum, the question is then repeated with a reduced amount, by a certain percentage (let's say 10 per cent). It is done again and again until the respondent answers "yes". The maximum WTP for attaining the environmental benefit is this accepted amount. If the person accepts the initial amount offered, the process continues until they respond "no". The penultimate amount is taken as the maximum willingness to pay for the benefit obtained. The initial proposed amount in this study was set at Rs.800. This amount is the maximum WTP for obtaining the non-use values. If the individual accepts the initially proposed amount, the procedure continues until the individual answer “no”.

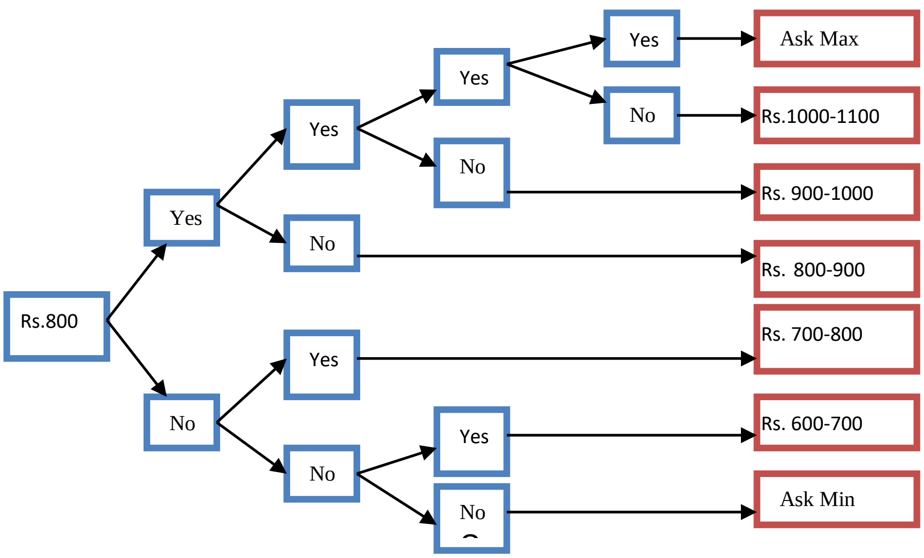

Figure.2 Bid for WTP on Lake Ecosystem

2.6 Estimation of WTP

We use simple OLS linear regression to estimate the mean WTP for the non-use values of lake services.

$$WTP = \beta_0 + \beta_1 AGE + \beta_2 EDN + \beta_3 FS + \beta_4\, INCOME + \beta_5\, PR + \beta_6\, DIST + \varepsilon \qquad \text{…. (2)}$$

Where WTP is the willingness to pay (in Rupees); AGE is the age of the respondent in years; EDN is the number of years of education (in years); FS is the Family size (in Numbers); $INCOME$ is the annual household Income (Rupees per year); PR is the period of residence (in years); $DIST$ is the distance from the lake (kilometres); ε is error term; β_0 to β_6 parameters to be estimated.

The estimated value of lake ecosystem services was achieved based on the mean amount that the respondents were willing to pay for the use of specific services of the lake. The WTP value was calculated using the formula (Lipinska *et al.*, 2019):

$$\text{WTP} = \breve{k} * \text{n} \qquad \text{…. (3)}$$

Where WTP is the value of the lake ecosystem services obtained based on a mean WTP value; $\breve{k}$ –average amount which the respondent was willing to pay for ecosystem services; n –number of people who expressed willingness to pay for a particular service of the lake.

By summing up the declared amounts assigned to every service of the lake *viz.*, (i) use services (provisioning and recreational services) and (ii) non-use services, it was possible to define the total economic value (TEV) of lake services.

2.7 Factors Affecting WTP

In order to assess the influence of the socio-economic variables on the dependent variable ‘WTP’ for lake services has two possible values: '1' (willingness to pay) and '0' (not willing to pay). Based on previous research (Chandrasekaran *et al.*, 2009) and knowledge gained during the survey, the model specification and independent variables were determined. We used the logit model to identify the socio-economic factors influencing the willingness to pay of the respondents (Gujarati and Porter, 2009):

$$ln\left(\frac{P(Y=1)}{P(Y=0)}\right) = \beta_0 + \textstyle\sum_i^n \beta_i\; X_i \qquad \text{…. (4)}$$

Where P(Y=1) is the probability of willingness to pay for the non-use services of the lake; P(Y=0) is the probability of not willing to pay. The same independent variables (X_i) mentioned in equation (2) have been used to estimate equation (4).

III

RESULTS AND DISCUSSIONS

During the in-person interview, a high response rate of 94.54 per cent was achieved. Due to the respondents' inadequate responses, 12 samples were rejected. The high response rate could be attributed to stakeholders (fishermen, lotus collectors) and visitors' interest in the lake’s ecosystem services.

3.1 Descriptive Statistics

The socio-economic characteristics are summarised in Table 1, revealing that the average age of the respondents was 44.62 years with an average education of 10 years and the average family size ranged from 3 to 6 members with an average size of 3.98. The mean monthly income was Rs. 119214.28 and the experience of fishermen ranged from 24 to 33 years. The average fishing time was around five hours per day. It's noteworthy to mention that the average distance travelled by stakeholders and city visitors to the lake was about 9 kilometres (km) radius.

TABLE 1: DESCRIPTIVE STATISTICS

Variables (1)	UBL (2)	SL (3)	Overall (4)
Age (years)	41.52	47.71	44.62
Education (years)	10.79	9.99	10.39
Family size (Nos.)	4.08	3.88	3.98
Distance (Km)	9.94	8.73	9.33
Income (Rs/year)	237848	223294	230571
Number of visits	3.23	2.01	2.62
Travel costs	213.82	189.69	201.76
Marital status	0.46	0.48	0.47
Observations (N)	104	104	208

Source: Field Survey, 2021-22.

3.2 Estimation of Travel Cost Model (ITCM)

We take the number of visits per year to the lake as the dependent variable and the average visit per year to the lake was 2.62 (Table 1). It is observed that different age group of people visits the lake, among them, bachelors had a higher visit than married people along with family members. The family size varies from three to six members. The mean annual income was Rs. 230571. The travel cost (which includes the cost of travel from residence to the lake, boating ticket cost, food, etc.) ranged from Rs. 189.69 to Rs. 213.82 with an average of 201.76 per visit.

The estimated results of the individual travel cost model are presented in Table. 2. The R square value was 0.69, which indicates the goodness of fit of the model. The coefficient of education was positive and significant indicating that as the year of education increases by one year then the number of visits would increase by 15.5 percent. Educated people know about the importance of the lake ecosystems, hence tend to visit the lake and realize the amenity services. The effect of income was positive; however, it was not statistically significant. People with higher incomes did not make as many visits. The travel cost and distance were statistically significant and had a negative influence on the number of visits. The travel cost includes pocket-out costs such as parking, boating, and dining in the vicinity of the lakes, as well as the opportunity cost of making the trip, which represents the income that could have been earned otherwise. The coefficient for travel cost suggests that for every one-rupee increase, *ceteris paribus*, the number of visits would be expected to decrease by 0.43 per cent. The negative sign of the travel cost coefficient aligns with the neoclassical theory of demand. These findings are similar to the findings of Marothia, 2001 who studied the valuation of the Lake Vivekanand, Raipur.

TABLE 2. ESTIMATED RESULTS OF THE SEMI-LOG MODEL OF INDIVIDUAL TRAVEL COST METHOD

Variables (1)	Coefficients (2)	SE (3)
Intercept	1.2727	0.7352
Travel cost	-0.0043***	0.0014
Age	-0.0019	0.0034
Education	0.0155**	0.0052
Income	0.0328	0.0214
Distance	-0.0131**	0.0052
Family size	-0.0003	0.0013
Marital status	-0.0607	0.1175
R square	0.69	
F Statistics	32.19***	
N[7]	100	

Source: Authors' estimates based on field survey.
***, **, *- Significant at 1, 5, and 10 per cent level, respectively.

The expenditure incurred was used to derive the demand function. The travel cost was treated as the surrogate price or proxy value for the recreational benefits of the lake. Using the estimates, the average consumer surplus per visit has been calculated (Torres-Ortega *et al.*, 2018) as Rs. 221.24. The total annual consumer surplus obtained from the lake visitors could be calculated by multiplying the individual consumer surplus by the number of visitors to the respective lakes was Rs. 75.85 lakhs and Rs. 49.92 lakhs respectively for UBL and SL (the average number of visitors in the UBL and SL were 34286 and 22563 per year).

3.3 Estimation of Willingness to Pay (WTP)

It is important to find the distribution of the initial bid value to overcome the 'initial bid price' under CVM studies. This study has used hexa-modal pricing bids with ranges from Rs. 800 to more than Rs. 1200 to increase diversified respondents' strength in both lake services (Table 3). It is noted that as price increases, the demand

TABLE. 3. DISTRIBUTION OF INITIAL BID

Initial Bid (1)	Frequency (2)
800	44
900	45
1000	36
1100	27
1200	33
>1200	23
Total	208

Source: Field survey, 2021-22

for the lake service declines, initially there was high demand as WTP was Rs. 800, as the WTP moves from Rs. 800 to more than Rs.1200, demand for lake service get decreases i.e., the respondents' number increases in the category of 'No' to payment

(Table. 4). Around 36 per cent of the respondents said to ‘No’ for WTP of Rs. 800, while 65 per cent of respondents says ‘No’ as WTP was more than Rs. 1200. The results were consistent with the law of demand.

TABLE. 4. DISTRIBUTION OF INITIAL BID AND CORRESPONDING ANSWERS

Answer/ Bid (1)	800 (2)	900 (3)	1000 (4)	1100 (5)	1200 (6)	>1200 (7)	Total (8)
Yes	28	23	19	12	10	8	139
	(63.44)	(51.11)	(52.78)	(50.00)	(27.78)	(34.78)	(66.83)
No	16	22	17	12	26	15	69
	(36.36)	(48.89)	(47.22)	(50.00)	(72.22)	(65.22)	(33.17)
Total	44	45	36	24	36	23	208
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Source: Authors’ calculation based on field survey, 2021-22.
Figures in parentheses indicate the percentage to the column total.

The amount of willingness to pay for non-use services, such as existence and bequest values was collected from respondents. Nearly 33.17 per cent of respondents said they would prefer not to pay for non-use services, and the remaining 66.83 per cent were willing to pay for the same.

We used simple linear regression analysis to estimate the amount of WTP for the non-use service of the lake (Table 5). To improve the accuracy of estimation, we use control variables such as age, education, family income, family size, and distance to the lake. Age, education, and family income were found to be positively significant in determining the WTP for the lake’s non-use service. A one-unit increase in these factors has resulted in increasing the WTP by Rs. 9.94, Rs. 18.21, and Rs. 0.04, respectively. The estimated WTP for the non-use services of the lake ecosystem ranged between Rs. 673.17 and Rs. 1346.89, with a mean WTP of Rs. 979.63 for UBL and Rs. 801.23 for SL.

TABLE 5. ESTIMATED WILLINGNESS TO PAY FOR LAKE SERVICES

Sr. No. (1)	Variable (2)	Coefficient (3)	P value (4)
1.	Age (years)	9.94**	0.04
2.	Education (years)	18.21***	0.00
3.	Family size (numbers)	-2.32	0.83
4.	Family income (rupees)	0.04**	0.02
5.	Period of residence (years)	-1.63	0.78
6.	Distance (km)	-2.1	0.24
7.	Intercept	-54.193	0.29
	No of observations	208	
	R square	0.63	
	F Statistic	25.39***	

Source: Authors’ estimates based on field survey. ***, **- Significant at 1 and 5 per cent level, respectively.

As a robustness check, we asked respondents an open-ended question, what would they pay for the lake services? The average WTP for the lake's existence, present use, and potential future use were found to be Rs. 931.47 and Rs. 814.96 per year for UBL and SL, respectively. The results indicated that the majority of locals were prepared to pay for the non-use values. As yearly willingness-to-pay figures were used in the calculation, it is reasonable to assume that people would use lake services every year. The reasons for not being willing to pay for ecosystem services, the respondents thought the government or NGO should be in charge of managing the lake, taxes should be used for maintenance, and mismanagement of funds. More people would pay for the services if lakes were managed transparently. Some respondents said they would pay for more for the ecosystem services if their income levels rose but that their existing levels are insufficient at present.

3.4 Total Economic Value (TEV) of Lake Ecosystem Services

TEV is calculated by adding the use value and non-use value that was estimated either directly or indirectly, and the estimates are presented in Table 6. The estimated TEV was Rs. 107.96 lakhs for UBL and Rs. 77.15 lakhs for SL, respectively. In both UBL and SL, the share of use and non-use values to TEV was approximately 80 per cent and 20 per cent, respectively. Among the use values, the major share was contributed by cultural services i.e., recreational services, which ranged from 65 to 70 per cent to the TEV followed by the provisional services (8 to 11 per cent). The main factors contributing to the higher use values in UBL were the lake's accessibility to the city, amenities geared towards families, walking trails, boating opportunities, and the lake's picturesque surroundings. Boating was the primary economic activity that attracted more visitors because of its central location in the city and the availability of boating amenities. Additionally, a private company and the municipal corporation collaborated under the Public-Private Partnership (PPP) mode to provide and manage a variety of boat services, such as those for pedal boats, jet skis, family boats, speed boats, and motorboats.

TABLE 6: TOTAL USE VALUE OF THE LAKE SYSTEMS

(*Rs. / year*)

S.No.	Particulars	Ukkadam Big Lake (UBL)		Sulur Lake (SL)	
		Value (Rs.)	Per cent share	Value (Rs.)	Per cent share
(1)	(2)	(3)	(4)	(5)	(6)
Use values					
I. Direct Use value					
1	Fishing activity	625484	5.79	244377	3.17
2	Lotus collection	-	-	117013	1.52
3	Grazing	176076	1.63	351648	4.56
4	Washing activity	-	-	85077	1.10
5	Other	86400	0.80	67200	0.87
	Sub-total (I)	887960	8.22	865315	11.22
II	Recreational value	7585398	70.26	4991814	64.70
A	Total Use value (I+II)	8473358	78.49	5857129	75.92
Non-Use values					
	Number of households (Nos)	2371		2319	
	Average WTP (Rs. / Year)	979.63		801.23	
B	Total Non-use values	2322703	21.51	1858052	24.08
C	Total Economic Value (A+B)	10796060	100.00	7715181	100.00

Source: Authors' estimates based on field survey.

Fishing was a second major important activity and a major source of income for the fishermen households living around UBL. It was noted that the Kovai taluk fishermen cooperative association purchased fingerlings of different fish species, such as Catla, Mrigal, and Roghu, four or five times annually for a total of Rs. 4.68 lakhs and released them in the water spread area of UBL in order to maintain the sufficient fish population to harvest throughout the year. As a result, 17 tonnes of fish were harvested each year, and depending on the species, they were sold for prices ranging from Rs. 45 to Rs. 70. The value of the fishing activity in UBL was estimated to be around Rs. 6.25 lakhs per year (after deducting the cost of fingerlings), which contributed almost 5.79 percent to the TEV. The quantity of fish harvested in SL was 3.879 tonnes per year, with a corresponding value of about Rs. 2.44 lakhs per year (3.17 percent of the TEV). The Seviyar fishing community in SL is granted the traditional right to fish, and fishing rights are typically auctioned. Other economic activities in SL included washing, picking lotus leaves and flowers, and grazing, which together made up 1.10, 1.52, and 4.56 percent of the TEV. There were no lotus gatherings or washing activities in UBL. The catchment area beneath each lake was not irrigated and the sluices were closed as a result of encroachment of the command area due to various city development activities and growing urbanization. In addition, the panchayat rented out retail space near these lakes was categorised as other activities, which accounted for less than one percent of the TEV.

It is important to note that the Tamil Nadu Agricultural University (TNAU) and Tamil Nadu State Land Use Research Board (TNSLURB) together established the Floating Vetiver Wetlands in the UBL for treating the lake water and increasing its quality through plant roots. It controls the concentration of nutrients N and P; as a result, eutrophication of water resources can be inhibited and prevented due to a decrease in the rate of evaporation from lakes (Mahmoudpour *et al.,* 2021). It also serves as a habitat for fish and birds. Despite the shrinking water bodies due to massive encroachment and pollution, the lakes continue to attract many exotic birds and seasonal migrants. These lakes were mostly home to the birds Purple Moorhen, Little Cormorant, Pelicans, Common Coot, and Indian Darter. However, these indirect services were not estimated in this study.

3.5 Factors Affecting The WTP for Lake Services

The logit model was used to determine the factors influencing people's willingness to pay for ecosystem services provided by the lake and the parameter estimates of logit regression are presented in Table 7. The logit coefficients reflect the impact of the magnitude of explanatory variables on the probability of respondents' willingness to pay for the ecosystem services of the lake. A positive coefficient increases the probability of respondents' willingness to pay, while negative values increase the probability of their unwillingness to pay. In order to obtain a more precise explanation, the odds ratio (ratio of probabilities of willingness to non-willingness) of the factors influencing willingness to pay was worked out.

It is clear from Table 7 that family income, age, and education had a substantial impact on the likelihood of being willing to pay for lake services. The coefficient of age was positive and significant at five percent. The odds ratio of 1.1716 with a probability of 0.0824 suggests that for every additional year of age, the likelihood of willing to pay increases by 8.24 percent. Due to their ability to comprehend and personally experience the repercussions of the decline in ecosystem services, more elderly persons expressed a higher willingness to pay for the services. Similarly, education and income would increase the probability of willingness to pay by 28.06 percent and 7.41 percent respectively. As educational level increase people tend to become more aware of the value of ecosystem services, and as income levels increase, they are prepared to pay more for ecosystem services in order to improve both their own and future generations' quality of life.

TABLE 7. PARAMETER ESTIMATES OF LOGISTIC REGRESSION

Sr. No. (1)	Variable (2)	Coefficient (3)	Standard Error (4)	Odds Ratio (5)	Prob. of WTP (6)
1	Age (years)	0.1584**	0.0789	1.1716	0.0824
2	Education (years)	0.4973**	0.2357	1.6422	0.2806
3	Family size (numbers)	0.4854	0.9847	1.6249	0.2747
4	Family income (rupees)	0.1361**	0.00031	1.0006	0.0741
5	Period of residence (years)	-0.03036	0.1425	0.9701	0.02
6	Distance (km)	-1.4035	0.8699	0.2457	0.2741
7	Intercept	-16.0336	6.3309	-	-
	No of observations			208	
	Log likelihood			-18.09	
	Pseudo R^2			0.7335	

Source: Authors' estimates based on field survey. ** Significant at 5 per cent level.

IV

CONCLUSIONS AND POLICY IMPLICATIONS

The lake's numerous economic activities, accessibility to the city, kid-friendly amenities, services along the walking path, boating opportunities, and lovely surroundings attracted various user groups including fishermen, local residents, and visitors. This study estimated the direct use, recreation, and non-use services of the two urban lakes, namely UBL and SL, by collecting data from the respondents. The use values are estimated directly with current market prices of different provisional services, viz., fishing, lotus collection, and grazing. The individual travel cost model was used to estimate the consumer surplus for recreation attributed to lake services. The non-use services (existence and bequest) were determined by WTP using CVM.

The travel cost model indicated that education positively contributed to the visits to the lakes and the travel cost and distance negatively influenced the visits. The estimated total annual consumer surplus was around Rs.75 lakhs and Rs. 50 lakhs respectively in UBL and SL. Regarding non-use services, more than half of the respondents (66.83 percent) were willing to pay for these services provided by the lake. The estimated average WTP for non-use services was Rs. 979.63 and Rs. 801.23 for UBL and SL, respectively. The projected annual TEV of the ecosystem services (both use and non-use values) provided by UBL and SL was Rs. 107.96 lakhs and Rs. 77.15 lakhs, respectively. The probability of WTP for services from the lake was positively and significantly influenced by socioeconomic characteristics such as age, education, and family income of the respondents.

It is time to engage the local stakeholders to conserve the lake using the Payment for Ecosystem Services (PES) approach because the lake ecosystem offers huge benefits and is in a state of degrading. Numerous bird species use the lake as a habitat, therefore promoting birdwatching increases the number of visitors and brings in extra money. Since there is no entrance fee, it will be levied in the future. Even though the lakes offered significant benefits, mixing sewage with lake water is making them unclean and an increase in water hyacinth leads to a decline in biodiversity as well as economic value. The smart city plan would therefore include the construction of more sewage treatment facilities and ensure their continuous operation for clean water in the lake. Further, the lake has to be desilted because of the excessive siltation that has caused the lake's depth to decline, which substantially reduces the fish population. This could involve the participation of local stakeholders in the form of physical and monetary contributions, thus not only increasing the economic gains but also improving indirect and non-use services.

NOTES

1. $V_{Fish} = \sum_{i=1}^{n} QF_i * PF_i$; 1=1,2,3…, n; Where, V_{Fish} is the total value of fish; (V_f) Q_f *is the* quantity of different fish species harvested; P_f *is the* average market price of fish (P_f). (It is assumed that fish are harvested throughout the year).

2. $V_{Lotus} = \sum_{i}^{n} Q_i * P_i * N$; n=1, 2; Where, Q_i is average number of (i) leaves and (ii) flowers were collected per day; P_i Market price of leaf / flower; N is number of days. (The number of days (N) was assumed 180 days per year. The average price of lotus leaf and flower was Rs.1.25 and Rs.10, respectively).

3. $V_{Grazing} = (H_g * Q_f * N_l * D_g) * P_{Fd}$; where, $V_{Grazing}$ the total value of grazing; H_g is Grazing hours in a day (appr. 4 hours/day); Q_f *is* the average Quantity of Fodder grazed (kg/hour); N_l is number of Livestock in the village; D_g *is* the number grazing days (assumed 240 days per year); and P_{Fd} is fodder price.

4. For Washing: $V_{Washing} = (W_n * I_m * N_m)$; $V_{Washing}$ is the value of washing activity; W_n is the number of washermen in the village; I_m is the monthly income through washing; N_m is the number of months activity done (assumed 10 months per year).

5. Other activities include panchayat earns a certain amount of income by providing shop spaces, hotels, tea shop around the lake for rent. This is arrived by number of shop spaces available multiplied by monthly rent per shop.

6. We found semi-log model is the best fit among the different model specifications.

7. The sample size for TCM consists only the number of visitors (N=100)

REFERENCES

Ajzen, I., and B. Driver (1992), "Contingent Value Measurement: On the Nature and Meaning of Willingness to Pay", *Journal of Consumer Psychology*, Vol.1, No. 4, pp.297-316. https://doi.org/10.1016/s1057-7408(08)80057-5

Bedate, A., L. C. Herrero and J. Á. Sanz (2004), "Economic Valuation of the Cultural Heritage: Application to Four Case Studies in Spain", *Journal of Cultural Heritage*, Vol. 5, No.1, pp. 101-111, https://doi.org/10.1016/j.culher.2003.04.002

Birch, S., and McCaskie, J. (1999), "Shallow Urban Lakes: A Challenge for Lake Management", *The Ecological Bases for Lake and Reservoir Management*, pp.365-377. https://doi.org/10.1007/978-94-017-3282-6_31

Chandrasekaran, K., S.K. Devarajulu and P. Kuppannan (2009), "Farmers' Willingness to Pay for Irrigation Water: A Case of Tank Irrigation Systems in South India", *Water*, Vol.1, pp.5-18.

Cummings, R.R., D.S. Brookshire and W.D. Schulze (1986), Valuing environmental goods: An assessment of the "Contingent Valuation Method", Totowa, NJ: Rowman Allanheld.

Deal, R. L., B. Cochran and G. LaRocco (2012), "Bundling of Ecosystem Services to Increase Forestland Value and Enhance Sustainable Forest Management", *Forest Policy and Economics*, Vol. 17, pp. 69-76. https://doi.org/10.1016/j.forpol.2011.12.007

Ekka A, and A. Pandit (2012). "Willingness to Pay for Restoration of Natural Ecosystem: A Study of Sundarban Mangroves by Contingent Valuation Approach." *Indian Journal of Agricultural Economics*, Vol.67, No. 3, July-September, pp1–11, https://doi.org/10.22004/ag.econ.204816. Accessed 4 Sept. 2023.

Freeman A.M. (1993), *The Measurement of Environmental and Resource Values: Theory and Methods*, Washington: Resources for the Future. 516 p.

Getnet, A., and T. B. Taw (2021), Economic Valuation of Attributes of Lake Tana: Random Parameter Model, *Heliyon*, Vol.7, No.11, e08356 https://doi.org/10.1016/j.heliyon.2021.e08356

Grunewald, K., and O. (2017). Special Issue: "Maintaining Ecosystem Services to Support Urban Needs". *Sustainability*, Vol.9, No.9, 1647. https://doi.org/10.3390/su90916477

Gujarati, Damodar N., and Dawn C. Porter (2009), *Basic Econometrics*, Usa, Mcgraw-Hill/Irwin..

Inostroza, L., (2014), Open Spaces and Urban Ecosystem Services. Cooling Effect Towards Urban Planning in South-American Cities, Tema – J. L. Use, Mobil. Environ. SI, 523–534.

Lipinska, H, A. Klopotowska and D. Wlosek (2019), The Contingent Valuation Method in the Study of Ecosystem Services on the Example of the Urban Natural System of Lubartów, IOP Conf. Series: Materials Science and Engineering 603 (2019) 052064 IOP Publishing https://doi.org/10.1088/1757-899X/603/5/052064

Mahmoudpour, M., S. Gholami, M. Ehteshamiand and M. Salari (2021), "Evaluation of Phytoremediation Potential of Vetiver Grass (Chrysopogon zizanioides (L.) Roberty) for Wastewater Treatment", *Advances in Materials Science and Engineering*. DOI:10.1155/2021/3059983

Mantler, A., and A. C. Logan (2015), "Natural Environments and Mental Health", *Advances in Integrative Medicine*, Vol. 2, No.*1*, pp.5-12. https://doi.org/10.1016/j.aimed.2015.03.002

Marothia, Dinesh K. (2001), "Valuation of a Day-Use Recreation Site: Application of Alternative Estimation Techniques." *Indian Journal of Agricultural Economics*, Vol. 56, no. 3, July-September, pp. 313–324. Accessed 4 Sept. 2023.

Martínez-Arroyo, A., E. Jáuregui. (2000), "On the Environmental Role of Urban Lakes in Mexico City", *Urban Ecosystems, Vol.* 4, pp.145–166, https://doi.org/10.1023/A:1011355110475

McConnell, K. E. (1985), Chapter 15 The Economics of Outdoor Recreation. *Handbook of Natural Resource and Energy Economics*, pp.677-722. https://doi.org/10.1016/s1573-4439(85)80022-1

Mitchell, R.C., and R.T. Carson (2013), *Using Surveys To Value Public Goods: The Contingent Valuation Method.* Rff Press.

Ortacesme, Ozkan and Karaguzel (2002), "An Estimation of the Recreational Use Value of Kursunlu Waterfall Nature Park by the Individual Travel Cost", *Turkish Journal Agriculture and Forestry*, Vol. 26, pp.57–62.

Samdin Z. (2008), "Willingness to Pay in Taman Negara: A Contingent Valuation Method", *International Journal of Economics and Management*, Vol. 2, No.1, pp.81-94.

Saravanakumar, V., Lohano, H. D., and Balasubramanian, R. (2022). A district-level analysis for measuring the effects of climate change on production of rice: Evidence from southern India. *Theoretical and Applied Climatology*, *150*(3-4), 941-953. https://doi.org/10.1007/s00704-022-04198-y

Sarwary, M., S. Senthilnathan, Saravanakumar, V., Arivelarasan, T., and Manivasagam, V. (2021)., "Climate Risks, Farmers Perception and Adaptation Strategies to Climate Variability in Afghanistan", *Emirates Journal of Food and Agriculture*, https://doi.org/10.9755/ejfa.2021.v33.i12.2797

Schallenberg M, De Winton M.D., P. Verburg, D.J.Kelly, K.D. Hamill and D.P. Hamilton (2013), "Ecosystem Services of Lakes", in J.R. Dymond (Ed.), *Ecosystem Services in New Zealand – Conditions and Trends*, Manaaki Whenua Press.

Schmid, M., S. Hunziker and A. Wüest (2014) "Lake Surface Temperatures in a Changing Climate: A Global Sensitivity Analysis", *Climatic Change*, *124*(1-2), 301-315. https://doi.org/10.1007/s10584-014-1087-2

Sterner, R. W., Keeler, B., Polasky, S., Poudel, R., Rhude, K., and Rogers, M. (2020). Ecosystem services of earth's largest freshwater lakes. *Ecosystem Services*, *41*, 101046. https://doi.org/10.1016/j.ecoser.2019.101046

Suresh Kumar, D. and P. Indira Devi. (2022). *Ecosystem Valuation: Theory, Analytical methods and applications*. Scientific Publishers (INDIA), Jodhpur.

Torres-Ortega, S., R.Pérez-Álvarez, De Díaz-Simal, P., J.Luis-Ruiz and F. Piña-García (2018). Economic valuation of cultural heritage: Application of travel cost method to the national Museum and research center of Altamira. *Sustainability*, *10*(7), 2550. https://doi.org/10.3390/su10072550

United Nations, Department of Economic and Social Affairs, Population Division (2015). Population 2030: Demographic challenges and opportunities for sustainable development planning (ST/ESA/SER.A/389).

Vreugdenhil D, J. Terborgh A.M. Cleef, M.Sinitsyn G.D. Boere, V.L Archage, H.H.T. Prins (2003), *Comprehensive Protected Areas System Composition and Monitoring*, World Institute.

Wattage, Premachandra, and Simon Mardle (2007). "Total Economic Value of Wetland Conservation in Sri Lanka Identifying Use and Non-Use Values", *Wetlands Ecology and Management*, Vol.16, No.5, pp. 359–369, https://doi.org/10.1007/s11273-007-9073-3