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Unbundling cultural ecosystem services in urban river restoration: contingent valuation evidence

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ABSTRACT

Urban river restoration requires service-specific economic valuation. This study estimated willingness to pay, aggregate WTP, and associated determinants across four cultural ecosystem services: recreation, environmental education, aesthetics, and ecotourism in Indonesia. Contingent valuation involved 100 households randomly sampled from 2,135 eligible households and 30 tourists recruited on-site, following a 30-respondent pilot survey. Highest accepted bids were analyzed using Tobit regression with robust standard errors and average marginal effects. Residents' mean WTP ranged from IDR 24,610 to 67,700 per household per month, compared with IDR 17,000 to 52,500 per tourist visit. Environmental attitudes were positively associated with residents' recreational WTP (marginal effect: IDR 5,598) but negatively associated with tourists' educational WTP (marginal effect: IDR −8,270). Midpoint-based aggregation for aesthetics yielded an indicative annual WTP of IDR 1.518 billion when extrapolated to 5,996 households. Findings revealed service- and stakeholder-specific preferences, supporting differentiated restoration planning while acknowledging the limitations of sampling and extrapolation.

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Introduction

Urban rivers are increasingly affected by urbanization, land-use changes, wastewater discharge, and inadequate waste management, threatening ecological integrity and the provision of ecosystem services (Paul & Meyer, 2001; Walsh et al., 2005). Beyond their hydrological and ecological functions, urban rivers provide cultural ecosystem services (CES), including recreation, environmental education, aesthetic appreciation, and ecotourism, which contribute to human well-being and urban quality of life. Recent evidence highlights both the diversity of ecosystem services associated with urban rivers and their vulnerability to environmental degradation (Sousa et al., 2025). Understanding these non-material benefits is therefore essential for developing restoration strategies that respond to ecological pressures while addressing the social and cultural needs of urban communities. Cultural ecosystem services arise from interactions between ecological conditions, landscape characteristics, accessibility, and human experiences (Daniel et al., 2012; Fish et al., 2016). River pollution, sedimentation, and visible waste may reduce recreational opportunities, diminish aesthetic quality, and constrain educational and tourism-related activities. However, these effects may differ across cultural service domains and population groups. Li et al. (2025) demonstrated that perceptions of CES in urban waterfront environments vary across service categories and are associated with natural and built landscape attributes. Such

findings underscore the importance of examining cultural benefits individually rather than treating them as a homogeneous component of ecosystem services.

Economic valuation provides a framework for assessing public preferences for environmental benefits that are not directly traded in markets. The Contingent Valuation Method (CVM) elicits willingness to pay (WTP) for specified environmental improvements through hypothetical scenarios (Carson, 2000; Carson & Hanemann, 2005). When valuation scenarios and payment arrangements are clearly defined, CVM can provide policy-relevant estimates of stated monetary preferences (Johnston et al., 2017). Recent empirical research has applied stated-preference approaches to urban river restoration Lee et al. (2021) found that attitudes and place attachment were associated with WTP for river revitalization in Hong Kong, while Ma et al. (2025) identified positive associations between preferences for ecological and recreational restoration benefits and WTP. Using a discrete choice experiment, Shore et al. (2025) further demonstrated that monetary preferences differ across riparian restoration attributes. Together, these studies highlight the relevance of public perceptions and preference heterogeneity in environmental valuation. For each cultural ecosystem service, respondents' willingness to pay (WTP) was recorded as the highest accepted bid, with zero assigned to respondents who declined payment. This measure was used consistently for descriptive statistics and as the dependent variable in the service-specific Tobit regression models. Local residents' WTP was expressed in IDR per household per month, whereas tourists' WTP was expressed in IDR per visit.

The assessment of CES also requires attention to socioeconomic, spatial, and environmental attitudinal factors. Research in Jakarta has shown that access to urban cultural ecosystem services varies across socioeconomic groups and residential locations (Rahman et al., 2025), suggesting that the distribution of ecosystem benefits warrants consideration in urban environmental planning. Environmental attitudes may also shape stated monetary preferences. The New Ecological Paradigm (NEP) provides an established framework for assessing ecological worldviews (Dunlap et al., 2000), while recent river valuation studies have linked environmental attitudes and perceptions to WTP for restoration (Lee et al., 2021; Ma et al., 2025). Incorporating NEP alongside socioeconomic and spatial characteristics therefore enables an examination of whether ecological worldviews are associated with WTP across distinct cultural service domains. Despite growing interest in river restoration valuation, the economic assessment of individual cultural ecosystem services remains an area requiring further empirical investigation. Sousa et al. (2025) identified relatively limited attention to economic valuation and stakeholder perspectives in urban river ecosystem service research. Similarly, Comalada et al., 2026) reported that monetary valuation constitutes a relatively small proportion of CES assessments in inland aquatic ecosystems, with greater emphasis on recreation and ecotourism than on other cultural benefits. Although previous studies have examined restoration preferences and multiple environmental attributes, further evidence is needed on how stated monetary preferences differ across recreation, environmental education, aesthetics, and ecotourism within a common urban river setting. Addressing these domains separately may provide more informative evidence for restoration planning than relying exclusively on broader valuations of river improvement programs.

The lower Arau River corridor in Padang City, West Sumatra, Indonesia, provides a relevant setting for examining these issues because of its environmental degradation and historically significant cultural and recreational activities. Five river-adjacent urban neighborhoods Batang Arau, Seberang Palinggam, Pasa Gadang, Berok Nipah, and Kampung Pondok were purposively selected based on their proximity to the river and concentration of river-related activities. These neighborhoods comprised 21,763 residents in 5,996 households. A quantitative, site-specific contingent valuation design involved 130 respondents: 100 household representatives and 30 tourists. The household sample target was determined using Slovin's formula, with a nominal 10% margin of error and an assumed household size of 4 persons. Following purposive selection of neighborhood units, 2,135 households formed the operational sampling frame, from which households were randomly selected using proportional allocation. Tourists were recruited through non-probability on-site intercept sampling. Further sampling and valuation procedures are described in the Method section. Against this background, this study contributes a disaggregated economic assessment of four cultural ecosystem services in the lower Arau River corridor. Separate contingent valuation scenarios are employed to elicit WTP for improvements in recreation, environmental education, aesthetic quality, and ecotourism. The study further examines associations between WTP and environmental attitudes, socioeconomic characteristics, and spatial factors using Tobit regression with robust standard errors and average marginal effects. Specifically, it aims to (1) estimate individual WTP for each cultural service improvement, (2) assess aggregate household WTP for the proposed improvements within the defined beneficiary population, and (3) identify factors associated with WTP across the four service domains. By distinguishing monetary preferences for individual cultural benefits, the study seeks to inform restoration priorities and context-sensitive financing strategies for urban river conservation.

Method

Estimate willingness to pay (WTP) for improvements in four cultural ecosystem services (CES): recreation, environmental education, aesthetics, and ecotourism. The study was conducted along the lower Arau River in Padang City, West Sumatra, Indonesia. The study area was purposively selected because of its environmental degradation, cultural significance, and ongoing recreational and economic activities.

This study involved 130 respondents, comprising 100 local household representatives and 30 tourists. The study area encompassed five urban villages with a total population of 5,996 households, as verified through local administrative records. Of these, 2,135 households met the study's geographical eligibility criteria based on their location and proximity to the river and constituted the operational household sampling frame. The household sample size was determined using Slovin's formula with a nominal 10% margin of error and rounded to 100 respondents. Proportionate stratified random sampling was then applied, with households allocated across Batang Arau (58), Pasa Gadang (19), Seberang Palinggam (12), Berok Nipah (10), and Kampung Pondok (1). Eligible households were randomly selected within each village. The 30 tourist respondents were recruited through non-probability on-site intercept sampling at riverside recreation and tourism sites, targeting visitors who had experienced the area's cultural ecosystem services. The tourist sample (n = 30) was exploratory and was not determined through an a priori statistical power analysis. Consequently, findings for tourists should be interpreted cautiously and should not be generalized to the entire tourist population.

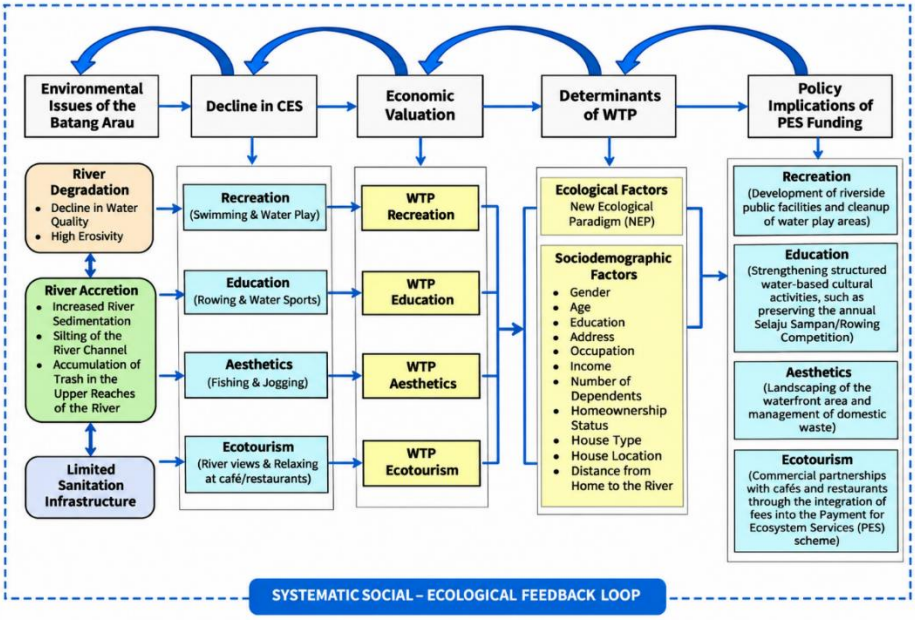


Figure 1. Conceptual Framework of the Study.

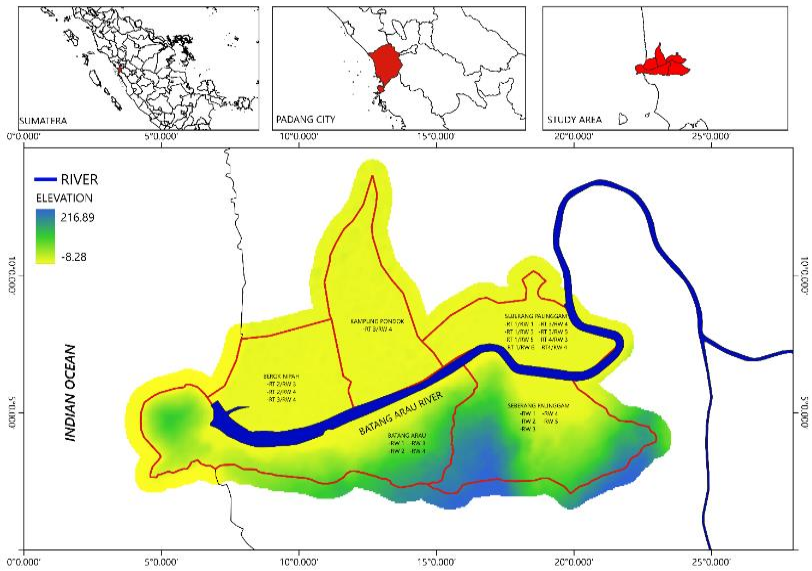


Figure 2. The Study Area's Map.

Four separate hypothetical improvement scenarios were developed to elicit service-specific WTP. Bid levels were established before pilot testing using field assessments of local prices and activity-related costs, including waterpark admission fees, floating-cube maintenance costs associated with rowing activities, recreational fishing expenditures, and food and beverage prices at riverside establishments. A pilot survey involving 30 respondents examined bid responses, scenario comprehension, reasons for zero WTP, and interview difficulties. Additional explanations were provided when respondents had difficulty distinguishing among the four CES scenarios. Before the main survey interviews, respondents were informed of the research background and purpose. The WTP questions employed sequential dichotomous-choice responses to predetermined bid amounts, and the highest accepted bid was recorded as the operational WTP measure. Residents were presented with a hypothetical monthly household contribution, whereas tourists were presented with a hypothetical payment per visit.

Environmental attitudes were measured using the New Ecological Paradigm (NEP) scale, alongside respondents' socioeconomic and spatial characteristics. The NEP instrument comprised 15 items, with negatively worded statements reverse-coded before calculating the mean score. Internal consistency of the NEP scale was assessed using Cronbach's alpha. Because the four WTP questions represented distinct CES improvement scenarios rather than interchangeable indicators of a single latent construct, internal consistency coefficients were not calculated across the WTP responses. The pilot testing procedures provided preliminary evidence regarding bid elicitation and questionnaire comprehension but did not establish formal construct validity for the WTP instrument. Descriptive statistics were used to summarize WTP responses for each CES and respondent group. The average individual WTP, Consumer Surplus (CK), and Total Aggregate WTP (TWTP) are calculated using the following equations:

$$\Sigma WTP = \sum_{i=1}^{n} Wi.\ Pfi \quad \ldots\ldots\ldots\ldots\ldots (1)$$

$$CK = \Sigma(WTPi\text{-}P) \quad \ldots\ldots\ldots\ldots\ldots (2)$$

$$TWTP = \sum_{i=1}^{n} WTP.\left(\frac{ni}{N}\right)P \quad \ldots\ldots\ldots\ldots\ldots (3)$$

Where WTP_i is the i-th WTP value, Pf_i is the relative frequency, P_mean is the sample average WTP, n_i/N is the proportion of paying respondents in the sample, and P_pop is the total population of beneficiary households. Latent Tobit regression modeling with robust standard errors and Average Marginal Effects (AME) was employed to examine the environmental attitudes and socioeconomic factors that affect WTP. In order to prevent estimation bias in Ordinary Least Squares (OLS), the Tobit model was selected to handle left-censored WTP = 0 data from respondents unwilling to pay. The determinants of WTP were examined using separate left-censored Tobit regression models for residents and tourists across the four CES categories. The Tobit model was specified as:

$$WTP_i^* = \alpha + \beta_1 NEP_i + \sum_{n=2}^{12} \beta_n X_n + \varepsilon \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Where (WTP_i^*) represents latent willingness to pay, and (X_i) denotes environmental attitudes and selected socioeconomic and spatial characteristics. Models were estimated using maximum likelihood with robust standard errors. Average marginal effects (AMEs) were calculated to assess changes in expected observed WTP, accounting for censoring at zero, while multicollinearity was assessed using variance inflation factors (VIFs) from auxiliary ordinary least squares regressions. Zero-WTP responses were examined to distinguish genuine zero valuations from protest responses, particularly those reflecting distrust in fund management or the perceived responsibility of government financing. Sensitivity analyses were conducted by re-estimating the Tobit models after excluding identified protest responses and comparing coefficient estimates, statistical significance, and AMEs with the full-sample results.

Aggregate willingness to pay (TWTP) was estimated separately for the aesthetic improvement scenario among local households. Unlike the descriptive and Tobit analyses, this calculation used bid-class midpoints weighted by the observed frequencies, including zero-WTP responses. Each midpoint was multiplied by the estimated number of households in the corresponding WTP category, and the resulting monthly aggregate was annualized over 12 months. This midpoint-based procedure was used to approximate WTP within the bid intervals and was not treated as equivalent to the highest accepted bid. All analyses were performed using Stata. Given the relatively small tourist sample, non-probability recruitment procedure, and predetermined bid categories, the estimated associations were interpreted as exploratory rather than causal or population-representative findings. Figures 1 and 2 illustrate the methodological framework and geographical setting, respectively. Figure 1 summarizes the research stages, from study design and data collection to WTP estimation and sensitivity analysis, while Figure 2 presents the study location along the lower Arau River in Padang City, Indonesia.

Results and Discussions

The study involved 100 local residents and 30 tourists, each of whom evaluated four environmental cultural service (CES) scenarios, resulting in 520 WTP observations from 130 individuals (Table 1). First, the analysis notes that payments by local residents were recorded per household per month, while those by tourists were recorded per visit; therefore, the monetary values for the two groups were not directly compared. Next, it reports that the average NEP score was 3.891 (SD = 0.586), with no significant differences between groups according to the Welch test ($p = 0.997$), and high internal reliability ($\alpha = 0.916$). However, reliability alone does not guarantee cross-context construct validity (Dorward et al., 2024).

Table 1. Characteristics of the Study Respondents

Characteristics	Residents n (%)	Tourists n (%)	Total n (%)
Gender			
Male	70 (70,00%)	20 (66,67%)	90 (69,23%)
Female	30 (30,00%)	10 (33,33%)	40 (30,77%)
Age			
<18 years old	0 (0,00%)	0 (0,00%)	0 (0,00%)
18–55 years old	67 (67,00%)	19 (63,33%)	86 (66,15%)
>55 years old	33 (33,00%)	11 (36,67%)	44 (33,85%)
Education			
Primary education	23 (23,00%)	10 (33,33%)	33 (25,38%)
Secondary education	57 (57,00%)	13 (43,33%)	70 (53,85%)
Higher Education	20 (20,00%)	7 (23,33%)	27 (20,77%)
Address			
Arau area	100 (100,00%)	10 (33,33%)	110 (84,62%)
Outside the Arau area	0 (0,00%)	20 (66,67%)	20 (15,38%)
Occupation			
Civil servant	5 (5,00%)	0 (0,00%)	5 (3,85%)
Private-sector employee	12 (12,00%)	3 (10,00%)	15 (11,54%)
Laborer	3 (3,00%)	0 (0,00%)	3 (2,31%)
Housewife	28 (28,00%)	0 (0,00%)	28 (21,54%)
Merchant	15 (15,00%)	10 (33,33%)	25 (19,23%)
Other	1 (1,00%)	0 (0,00%)	1 (0,77%)
Civil servant	24 (24,00%)	1 (3,33%)	25 (19,23%)
Private-sector employee	1 (1,00%)	0 (0,00%)	1 (0,77%)
Laborer	11 (11,00%)	16 (53,33%)	27 (20,77%)
Income (IDR/month)			
<IDR2.500.000	19 (19,00%)	13 (43,33%)	32 (24,62%)
IDR2.500.000–IDR5.000.000	71 (71,00%)	16 (53,33%)	87 (66,92%)
>IDR5.000.000	10 (10,00%)	1 (3,33%)	11 (8,46%)
Number of Dependents			
<2 People	7 (7,00%)	5 (16,67%)	12 (9,23%)
2–4 People	79 (79,00%)	22 (73,33%)	101 (77,69%)
>4 People	14 (14,00%)	3 (10,00%)	17 (13,08%)
Housing Status			
Owned	93 (93,00%)	21 (70,00%)	114 (87,69%)
Rented/Leased	7 (7,00%)	7 (23,33%)	14 (10,77%)
Communal	0 (0,00%)	2 (6,67%)	2 (1,54%)
Type of Housing			
Permanent	83 (83,00%)	14 (46,67%)	97 (74,62%)
Semi-Permanent	17 (17,00%)	12 (40,00%)	29 (22,31%)
Non-Permanent	0 (0,00%)	4 (13,33%)	4 (3,08%)
Location of Home			
Facing the River	70 (70,00%)	15 (50,00%)	85 (65,38%)
Backing the River	30 (30,00%)	15 (50,00%)	45 (34,62%)
Distance from Home to River			

Characteristics	Residents n (%)	Tourists n (%)	Total n (%)
< 1 km	100 (100,00%)	18 (60,00%)	118 (90,77%)
1- 3 km	0 (0,00%)	3 (10,00%)	3 (2,31%)
> 3 km	0 (0,00%)	9 (30,00%)	9 (6,92%)
Total	100 (100,00%)	30 (100,00%)	130 (100,00%)

Source: Processed Primary Research Data (N = 130).

Of the 520 observations, 381 (73.27%) showed a positive WTP and 139 (26.73%) had a value of zero. These figures represent the proportion of scenario observations, not the proportion of unique individuals. The four services evaluated reflect physical interaction, learning, visual experiences, and visits centered on the local environment and culture in the Arau corridor. This classification aligns with findings regarding recreation, social interaction, and urban river landscape experiences (Grzyb, 2024; Ramirez Aranda et al., 2024; Lin et al., 2024; Sousa et al., 2025). The results of the Yangtze River restoration also showed positive willingness to pay, although the scenarios and populations differed (Sari et al., 2023; Zhang et al., 2023).

Table 2. Observed WTP values by respondent group and CES type

Group	CES	N	Mean (IDR)	SD (IDR)	Median (IDR)	Zero bids
Residents (IDR/household/month)	Recreation	100	36,470	36,506	44,000	29 (29.0%)
Residents (IDR/household/month)	Environmental education	100	45,580	44,534	20,000	29 (29.0%)
Residents (IDR/household/month)	Aesthetics	100	24,610	15,628	27,000	24 (24.0%)
Residents (IDR/household/month)	Ecotourism	100	67,700	51,598	100,000	36 (36.0%)
Tourists (IDR/visit)	Recreation	30	17,000	12,052	18,000	6 (20.0%)
Tourists (IDR/visit)	Environmental education	30	23,900	29,634	20,000	10 (33.3%)
Tourists (IDR/visit)	Aesthetics	30	31,900	10,787	32,000	2 (6.7%)
Tourists (IDR/visit)	Ecotourism	30	52,500	29,529	60,000	6 (20.0%)

Note: WTP was measured as the highest bid accepted by each respondent. Descriptive statistics included zero-WTP responses. Residents' WTP was expressed in IDR per household per month, whereas tourists' WTP was expressed in IDR per visit. SD = standard deviation.

The highest accepted bid values for local residents (Table 2) averaged Rp67,700 for ecotourism, Rp45,580 for environmental education, Rp36,470 for recreation, and Rp24,610 for aesthetic experiences per household per month. For tourists, the averages were Rp52,500, Rp23,900, Rp17,000, and Rp31,900 per visit, respectively. These variations are consistent with the literature indicating that WTP is influenced by service attributes, location, and preferences (Ma et al., 2025; Kim & Kim, 2025), but the rankings cannot be separated from the scenario design and the level of offers. A zero response does not necessarily indicate the absence of benefits; budget constraints, priorities, and objections to the institution or payment mechanism are also relevant (Cunha-e-Sá et al., 2025). These descriptive estimates reflected the highest accepted bids and therefore differed from the midpoint-based estimate subsequently used for the aggregate valuation of aesthetic improvements. Therefore, valid zero responses are distinguished from protest responses and tested through sensitivity analysis (Table 3).

Table 3. Zero WTP responses and protest classifications for sensitivity analysis

Group	CES	N	Zero bids	Protest flags	Sensitivity N
Residents	Recreation	100	29	15	85
Residents	Environmental education	100	29	9	91
Residents	Aesthetics	100	24	8	92
Residents	Ecotourism	100	36	11	89
Tourists	Recreation	30	6	0	30
Tourists	Environmental education	30	10	2	28
Tourists	Aesthetics	30	2	0	30
Tourists	Ecotourism	30	6	5	25

To identify the determinants of WTP, eight left-censored Tobit models were estimated across four services and two groups, using robust standard errors and average marginal effects (AME) (**Table 4**). NEP attitudes, socioeconomic characteristics, and spatial characteristics were treated as predictors, in line with Ma et al. (2025), Iqbal & Hossain (2023), and Villaruel (2024) . However, WTP values were derived from discrete bids; the Tobit model based on the highest accepted bid is an empirical approach rather than a precise identification of continuous WTP. An interval-censored model could be considered in future research (Zapata & Carpio, 2024). The interpretation of the AME must follow the predictive function used and should not be equated simply with the change in average WTP across all respondents.

Table 4. Combined Tobit Regression Coefficients and Average Marginal Effects across Four Cultural Ecosystem Service

Group of Respondents	Variable	β (Robust SE; p)	AME (95% CI)
RESIDENTS	1. Recreational		
	NEP	8.009,642 (3.894,79; p = 0,043)	5.597,953 (279,00 to 10.916,91)
	Gender (Female)	-4.718,371 (7.190,72; p = 0,514)	-3.297,678 (-13.111,25 to 6.515,898)
	Age (>55 years)	-20.633,520 (5.808,89; p = 0,001)	-14.420,800 (-22.212,65 to -6.628,952)
	Education (Secondary Education)	34.152,000 (6.077,22; p < 0,001)	23.868,890 (16.021,05 to 31.716,73)
	Education (Higher education)	54.353,270 (6.213,82; p < 0,001)	37.987,590 (30.287,54 to 45.687,65)
	Employment (Private Sector Workers)	-25.230,090 (9.714,91; p = 0,011)	-17.633,350 (-30.840,52 to -4.426,19)
	Employment (Fishermen)	-45.558,840 (13.220,73; p = 0,001)	-31.841,160 (-49.984,32 to -13.697,99)
	Employment (Labourers)	-33.967,640 (9.451,52; p = 0,001)	-23.740,040 (-36.547,26 to -10.932,83)
	Employment (Housewives)	592,635 (16.846,88; p = 0,972)	414,1939 (-22.658,82 to 23.487,21)
	Employment (Farmer)	-106.102,400 (13.248,01; p < 0,001)	-74.155,140 (-93.044,10 to -55.266,17)
	Employment (Merchants)	-17.611,400 (8.376,71; p = 0,039)	-12.308,630 (-23.840,15 to -777,1236)
	Employment (Entrepreneurs)	-4.937,637 (13.618,83; p = 0,718)	-3.450,923 (-22.042,20 to 15.140,35)
	Employment (Other)	-40.481,760 (10.582,57; p < 0,001)	-28.292,770 (-42.539,12 to -14.046,42)
	Income (IDR 2,500,000 - 5,000,000)	156.033,200 (16.920,93; p < 0,001)	109.051,900 (86.993,75 to 131.110,00)
	Income (> IDR 5,000,000)	213.038,800 (21.777,13; p < 0,001)	148.893,200 (121.590,80 to 176.195,60)
	Number of Dependents (2–4 people)	-12.892,150 (9.038,76; p = 0,158)	-9.010,346 (-21.331,84 to 3.311,145)
	Number of Dependents (>4 people)	-8.008,971 (11.942,07; p = 0,504)	-5.597,484 (-21.904,56 to 10.709,59)
	Housing Status (Rent/Lease)	9.151,978 (5.790,35; p = 0,118)	6.396,334 (-1.457,494 to 14.250,16)
	House Type (Semi-Permanent)	10.341,610 (6.404,55; p = 0,110)	7.227,772 (-1.492,134 to 15.947,68)
	House Location (Facing Away from the River)	-2.324,261 (5.517,84; p = 0,675)	-1.624,430 (-9.190,565 to 5.941,705)
	Log pseudolikelihood: -800.319 | Pseudo R^2: 0.1035 | N: 100		
	2. Educational		
	NEP	4.069,484 (4.316,62; p = 0,349)	2.968,496 (-3.203,45 to 9.140,44)
	Gender (Female)	-8.259,204 (5.930,40; p = 0,168)	-5.910,506 (-14.062,77 to 2.241,76)
	Age (>55 years)	-24.446,710 (5.159,08; p < 0,001)	-17.837,830 (-24.906,91 to -10.768,75)
	Education (Secondary Education)	28.447,400 (7.144,74; p < 0,001)	20.256,400 (10.971,17 to 29.541,62)
	Education (Higher education)	52.946,290 (8.151,91; p < 0,001)	39.633,190 (28.398,98 to 50.867,39)
	Employment (Private Sector Workers)	-28.547,240 (9.558,67; p = 0,004)	-22.624,100 (-37.503,84 to -7.744,37)
	Employment (Fishermen)	-61.526,410 (16.012,44; p < 0,001)	-45.616,640 (-66.489,87 to -24.743,40)
	Employment (Labourers)	-45.389,220 (8.285,31; p < 0,001)	-35.053,010 (-47.696,67 to -22.409,35)
	Employment (Housewives)	-6.691,507 (18.900,80; p = 0,724)	-5.386,216 (-35.122,84 to 24.350,41)
	Employment (Farmer)	-123.531,500 (13.594,07; p < 0,001)	-67.026,280 (-78.467,84 to -55.584,72)

Group of Respondents	Variable	β (Robust SE; p)	AME (95% CI)
	Employment (Merchants)	-29.506,370 (7.297,16; p < 0,001)	-23.358,710 (-34.806,30 to -11.911,13)
	Employment (Entrepreneurs)	-60.946,580 (10.100,19; p < 0,001)	-45.267,220 (-58.738,03 to -31.796,42)
	Employment (Other)	-33.734,680 (9.082,20; p < 0,001)	-26.564,300 (-40.541,16 to -12.587,45)
	Income (IDR 2,500,000 - 5,000,000)	166.158,000 (20.537,84; p < 0,001)	47.346,290 (39.845,41 to 54.847,18)
	Income (> IDR 5,000,000)	254.533,800 (23.340,47; p < 0,001)	133.694,300 (115.086,70 to 152.302,00)
	Number of Dependents (2–4 people)	-28.151,41 (14.795,17; p = 0,061)	-21.403,350 (-44.250,73 to 1.444,04)
	Number of Dependents (>4 people)	-17.213,530 (15.605,97; p = 0,273)	-13.314,550 (-37.322,46 to 10.693,37)
	Housing Status (Rent/Lease)	-4.761,314 (7.404,28; p = 0,522)	-3.438,931 (-13.834,56 to 6.956,70)
	House Type (Semi-Permanent)	16.586,050 (7.983,79; p = 0,041)	12.407,390 (438,21 to 24.376,56)
	House Location (Facing Away from the River)	-9.180,904 (4.790,67; p = 0,059)	-6.657,804 (-13.405,69 to 90,08)
	Log pseudolikelihood: -801.417 | Pseudo R^2: 0.1166 | N: 100		
	3. Aesthetic		
	NEP	-774,089 (1.078,67; p = 0,475)	-625,604 (-2.387,48 to 1.136,27)
	Gender (Female)	-624,491 (1.290,97; p = 0,630)	-504,559 (-2.547,57 to 1.538,45)
	Age (>55 years)	-6.044,382 (1.636,98; p < 0,001)	-4.890,347 (-7.479,07 to -2.301,62)
	Education (Secondary Education)	9.805,623 (2.616,58; p < 0,001)	7.936,131 (3.803,89 to 12.068,37)
	Education (Higher education)	17.874,630 (3.069,08; p < 0,001)	14.472,080 (9.617,26 to 19.326,90)
	Employment (Private Sector Workers)	-1.712,946 (3.176,63; p = 0,591)	-1.386,728 (-6.426,11 to 3.652,65)
	Employment (Fishermen)	-7.802,850 (6.317,92; p = 0,220)	-6.299,886 (-16.251,31 to 3.651,54)
	Employment (Labourers)	-4.529,118 (2.937,28; p = 0,127)	-3.663,950 (-8.321,33 to 993,43)
	Employment (Housewives)	3.686,271 (4.633,13; p = 0,429)	2.985,470 (-4.369,11 to 10.340,05)
	Employment (Farmer)	7.701,916 (3.876,45; p = 0,050)	6.238,189 (86,34 to 12.390,04)
	Employment (Merchants)	29,884 (2.281,71; p = 0,990)	24,198 (-3.596,96 to 3.645,35)
	Employment (Entrepreneurs)	-10.298,560 (2.740,01; p < 0,001)	-8.290,574 (-12.548,17 to -4.032,97)
	Employment (Other)	-1.349,449 (3.071,39; p = 0,662)	-1.092,516 (-5.965,64 to 3.780,60)
	Income (IDR 2,500,000 - 5,000,000)	66.110,050 (6.058,77; p < 0,001)	28.692,880 (26.846,62 to 30.539,15)
	Income (> IDR 5,000,000)	84.397,950 (6.777,56; p < 0,001)	46.976,370 (43.270,31 to 50.682,43)
	Number of Dependents (2–4 people)	-8.346,508 (2.682,38; p = 0,003)	-6.758,054 (-11.014,60 to -2.501,51)
	Number of Dependents (>4 people)	-9.945,834 (2.958,33; p = 0,001)	-8.050,704 (-12.739,82 to -3.361,59)
	Housing Status (Rent/Lease)	-924,388 (2.099,32; p = 0,661)	-746,755 (-4.069,75 to 2.576,24)
	House Type (Semi-Permanent)	5.128,929 (2.706,60; p = 0,062)	4.148,427 (-136,12 to 8.432,97)
	House Location (Facing Away from the River)	-1.715,427 (1.629,61; p = 0,296)	-1.385,556 (-3.962,54 to 1.191,42)
	Log pseudolikelihood: -769.731 | Pseudo R^2: 0.1322 | N: 100		
	4. Ecotourism		
	NEP	-3.350,143 (8.883,30; p = 0,707)	-2.461,586 (-15.262,81 to 10.339,64)
	Gender (Female)	-14.178,770 (12.113,28; p = 0,245)	-10.317,660 (-27.399,42 to 6.764,10)
	Age (>55 years)	-38.708,720 (13.306,81; p = 0,005)	-28.160,710 (-46.378,99 to -9.942,43)

Group of Respondents	Variable	β (Robust SE; p)	AME (95% CI)
	Education (Secondary Education)	92.736,700 (19.115,55; p < 0,001)	60.347,740 (42.047,03 to 78.648,46)
	Education (Higher education)	114.698,300 (19.633,24; p < 0,001)	79.609,720 (60.195,93 to 99.023,52)
	Employment (Private Sector Workers)	-15.753,060 (13.275,51; p = 0,239)	-13.181,140 (-35.057,08 to 8.694,80)
	Employment (Fishermen)	-36.563,230 (21.234,33; p = 0,089)	-29.460,820 (-61.929,68 to 3.008,05)
	Employment (Labourers)	-35.255,750 (14.830,03; p = 0,020)	-28.480,390 (-51.844,74 to -5.116,05)
	Employment (Housewives)	-104.618,300 (38.495,08; p = 0,008)	-69.205,950 (-104.628,10 to -33.783,81)
	Employment (Farmer)	-124.642,500 (27.843,28; p < 0,001)	-75.447,040 (-96.845,73 to -54.048,35)
	Employment (Merchants)	8.164,900 (11.345,67; p = 0,474)	7.088,115 (-12.294,54 to 26.470,76)
	Employment (Entrepreneurs)	-33.333,410 (18.190,91; p = 0,071)	-27.027,930 (-54.914,60 to 858,73)
	Employment (Other)	-9.373,363 (14.665,07; p = 0,525)	-7.925,140 (-32.095,25 to 16.244,97)
	Income (IDR 2,500,000 - 5,000,000)	13.513,860 (31.821,16; p = 0,672)	9.745,947 (-34.691,30 to 54.183,20)
	Income (> IDR 5,000,000)	58.005,830 (34.541,72; p = 0,097)	45.467,710 (-7.179,45 to 98.114,86)
	Number of Dependents (2–4 people)	-13.303,750 (16.547,73; p = 0,424)	-9.947,297 (-34.654,56 to 14.759,97)
	Number of Dependents (>4 people)	-2.269,928 (20.054,03; p = 0,910)	-1.731,075 (-31.734,93 to 28.272,78)
	Housing Status (Rent/Lease)	19.667,470 (12.029,37; p = 0,106)	14.920,030 (-3.352,91 to 33.192,98)
	House Type (Semi-Permanent)	26.030,540 (13.921,16; p = 0,065)	19.557,970 (-1.514,84 to 40.630,79)
	House Location (Facing Away from the River)	9.977,793 (10.283,34; p = 0,335)	7.375,571 (-7.731,96 to 22.483,10)
	Log pseudolikelihood: -775.177 | Pseudo R^2: 0.0826 | N: 100		
	1. Recreational		
	NEP	14.934,670 (11.763,26; p = 0,220)	10.461,330 (−5.136,467 to 26.059,12)
	Gender (Female)	−25.967,900 (14.789,43; p = 0,095)	−16.746,340 (−32.537,44 to −955,2448)
	Age (>55 years)	−7.329,459 (11.838,17; p = 0,543)	−5.076,551 (−20.961,58 to 10.808,48)
	Education (Secondary Education)	−9.859,330 (11.033,72; p = 0,383)	−6.583,933 (−20.416,98 to 7.249,109)
	Education (Higher education)	7.227,900 (8.126,251; p = 0,385)	5.454,077 (−6.574,308 to 17.482,46)
	Income (IDR 2,500,000 - 5,000,000)	−27.200,120 (17.971,10; p = 0,147)	−20.044,610 (−43.610,52 to 3.521,30)
TOURISTS	Income (> IDR 5,000,000)	−163.679,700 (42.841,16; p = 0,001)	−35.596,090 (−57.209,04 to −13.983,14)
	Number of Dependents (2–4 people)	−13.121,520 (18.531,51; p = 0,488)	−10.109,870 (−39.123,34 to 18.903,59)
	Number of Dependents (>4 people)	−39.468,830 (28.895,67; p = 0,188)	−24.582,470 (−58.536,53 to 9.371,59)
	Distance from House to River (1–3 km)	36.290,600 (13.993,71; p = 0,018)	28.069,330 (10.597,85 to 45.540,81)
	Distance from Home to River (>3 km)	24.695,510 (14.264,17; p = 0,100)	17.914,200 (−1.524,631 to 37.353,03)
	Log pseudolikelihood: -278,933 | Pseudo R^2: 0,0291 | N: 30 | Wald F: 11,19; p < 0,001		
	2. Educational		
	NEP	-13.582,95 (5.747,86; p = 0,028)	−8.270,028 (−15.077,10 to −1.462,958)
	Gender (Female)	8.198,546 (11.080,68; p = 0,468)	4.998,616 (−8.163,267 to 18.160,50)

Group of Respondents	Variable	β (Robust SE; p)	AME (95% CI)
	Age (>55 years)	-3.703,78 (9.074,821; p = 0,688)	−2.226,323 (−12.867,38 to 8.414,734)
	Education (Secondary Education)	111.155,1 (16.598,47; p < 0,001)	25.197,290 (17.790,09 to 32.604,49)
	Education (Higher education)	144.549,4 (19.063,38; p < 0,001)	57.233,630 (40.039,55 to 74.427,72)
	Income (IDR 2,500,000 - 5,000,000)	25.699,64 (12.669,47; p = 0,056)	15.141,670 (2.146,223 to 28.137,12)
	Income (> IDR 5,000,000)	66.608,61 (12.621,48; p < 0,001)	42.340,070 (29.435,94 to 55.244,20)
	Number of Dependents (2–4 people)	5.740,979 (11.706,73; p = 0,629)	3.471,218 (−10.390,70 to 17.333,13)
	Number of Dependents (>4 people)	21.785,95 (12.843,3; p = 0,105)	13.801,400 (−2.375,976 to 29.978,77)
	Distance from House to River (1–3 km)	-19.754,49 (8.157,54; p = 0,025)	−10.388,180 (−18.302,95 to −2.473,415)
	Distance from Home to River (>3 km)	10.042,02 (11.600,9; p = 0,397)	6.206,425 (−8.041,947 to 20.454,80)
	Log pseudolikelihood: -219,972 | Pseudo R²: 0,1155 | N: 30 | F: not available in the output		
	3. Aesthetic		
	NEP	2.275,934 (1.971,76; p = 0,262)	2.274,278 (-1.584,92 to 6.133,48)
	Gender (Female)	2.208,826 (2.673,51; p = 0,418)	2.207,860 (-3.028,05 to 7.443,77)
	Age (>55 years)	-6.977,991 (2.810,22; p = 0,022)	-6.969,828 (-12.442,89 to -1.496,77)
	Education (Secondary Education)	7.010,959 (2.475,30; p = 0,010)	7.009,489 (2.163,25 to 11.855,73)
	Education (Higher education)	17.892,840 (2.768,60; p < 0,001)	17.891,350 (12.473,02 to 23.309,68)
	Income (IDR 2,500,000 - 5,000,000)	6.696,502 (4.470,06; p = 0,150)	6.682,757 (-2.057,97 to 15.423,48)
	Income (> IDR 5,000,000)	11.368,540 (5.384,91; p = 0,048)	11.354,100 (807,21 to 21.900,98)
	Number of Dependents (2–4 people)	-1.080,997 (3.498,00; p = 0,760)	-1.080,831 (-7.935,24 to 5.773,58)
	Number of Dependents (>4 people)	-9.933,634 (6.077,63; p = 0,118)	-9.913,470 (-21.714,04 to 1.887,10)
	Distance from House to River (1–3 km)	454,158 (3.019,10; p = 0,882)	453,860 (-5.459,43 to 6.367,15)
	Distance from Home to River (>3 km)	3.919,877 (2.411,89; p = 0,120)	3.918,658 (-803,56 to 8.640,88)
	Log pseudolikelihood: -284,424 | Pseudo R²: 0,0655 | N: 30 | Wald F: 18,63; p < 0,001		
	4. Ecotourism		
	NEP	2.146,257 (4.336,09; p = 0,626)	1.935,907 (-5.699,45 to 9.571,27)
	Gender (Female)	8.746,032 (6.378,87; p = 0,186)	7.993,289 (-3.438,81 to 19.425,39)
	Age (>55 years)	-173,654 (6.130,99; p = 0,978)	-156,638 (-10.997,48 to 10.684,20)
	Education (Secondary Education)	40.899,200 (7.868,44; p < 0,001)	38.914,410 (25.575,29 to 52.253,52)
	Education (Higher education)	58.083,030 (6.858,97; p < 0,001)	56.090,410 (44.667,80 to 67.513,02)
	Income (IDR 2,500,000 - 5,000,000)	21.628,200 (7.589,84; p = 0,010)	19.762,930 (6.096,82 to 33.429,04)
	Income (> IDR 5,000,000)	48.966,370 (12.299,60; p = 0,001)	46.713,000 (23.046,70 to 70.379,29)
	Number of Dependents (2–4 people)	-2.812,676 (5.940,14; p = 0,641)	-2.657,996 (-13.736,02 to 8.420,03)
	Number of Dependents (>4 people)	-26.260,100 (8.514,63; p = 0,006)	-23.122,570 (-38.203,33 to -8.041,81)
	Distance from House to River (1–3 km)	11.084,460 (8.929,86; p = 0,229)	10.273,560 (-6.190,19 to 26.737,31)
	Distance from Home to River (>3 km)	16.927,900 (7.040,46; p = 0,026)	15.879,520 (2.841,83 to 28.917,20)
	Log pseudolikelihood: -261,434 | Pseudo R²: 0,1073 | N: 30 | Wald F: 70,88; p < 0,001		

Notes: Robust standard errors in parentheses for Tobit (b) and Delta-method 95% CIs for AME. All values are in IDR. Left-censored at zero (ll = 0). Reference categories: Male, Age less than or equal to 55 years, Primary education, Civil servant or

State employee (for Residents), Income less than IDR 2.5 million, Dependents less than 2 people, Self-owned house, Permanent house, Facing river, Distance less than 1 km (for Tourism).

In the recreation sector, NEP is positively associated with the public's WTP (AME of approximately Rp5,598; $p = 0.039$), as are education and high income. Conversely, high income is negatively associated with tourists, while a distance of 1–3 km is positively associated. This pattern aligns with the relationship between ecological attitudes and restoration benefits reported by Lee et al. (2021) and Ma et al. (2025), but also serves as a reminder that income does not always have a positive relationship with WTP (Musa & Nadarajah, 2023). Differences in the benefits of repeat visits and substitute destinations are possible explanations rather than tested mechanisms (Ahtiainen et al., 2022). The spatial findings also do not support the assumption of uniform distance decay (Vollmer et al., 2016).

Regarding environmental education, education and income are positively associated with WTP in both groups, consistent with the importance of socioeconomic characteristics in valuation studies (Kang et al., 2024). Variations in residents' occupations also indicate heterogeneity in livelihoods, without proving differences in ecological concern (Cheng et al., 2022). The most notable finding is that NEP is not significant among local residents but is significantly negative among tourists; distances of 1–3 km are also negative for tourists. The perception that funding is the responsibility of the government or managers is an alternative explanation worth testing, not a causal conclusion (Jorgensen & Syme, 2000; Wang et al., 2025). Non-uniform spatial relationships have also been found in the river restoration literature (Jørgensen et al., 2013).

Regarding aesthetics, education and high income were positively associated with WTP in both groups, while age over 55 was negatively associated. In the community, a higher number of dependents was negatively associated, and some occupational categories showed opposite relationships; NEP was not significant in either group. These findings are consistent with the role of socioeconomic resources in the valuation of green spaces (Tian et al., 2020; Chen et al., 2026), but variations in restoration attributes can alter the relationship with income (Vollmer et al., 2016). A negative relationship with age has also been reported in the valuation of waterfront open spaces (Dahal et al., 2018). Explanations regarding household budget allocation remain speculative.

In ecotourism, higher education is positively associated with both groups; high income is significantly positive for tourists but not for local residents. Older age and certain occupations are negatively associated with local residents, while having more than four dependents is negatively associated, and a distance of more than 3 km is positively associated with tourists. NEP is not significant. The literature also shows that the relationships between education, income, and demographics vary by location and visitor group (Nesha Dushani et al., 2023; Lan et al., 2024; Diswandi et al., 2025). The positive relationship between distance and tourists indicates that spatial effects cannot be assumed to be consistently negative (J. Lee, 2016).

Sensitivity analysis after excluding protest responses primarily supports the stability of the relationship direction in tourist education: NEP remains negative and significant when the sample size is reduced from 30 to 28 ($p = 0.028$ in the main model; $p = 0.030$ in the sensitivity analysis), with average VIFs of 2.03 and 1.88, respectively. However, excluding the highest-income category from the sensitivity sample limits the comparability of the coefficients. Across services, education was the most consistently positive, while income, NEP, and distance exhibited directions or significance that depended on the type of service and group. These pattern differences are descriptive across models and do not yet constitute formal evidence of differences in coefficients.

For aggregate valuation, the aesthetic improvement scenario was selected because of its relatively high proportion of positive WTP responses, broadly accessible benefits, and clearly defined monthly household payment unit. Among 100 surveyed residents, 76 expressed positive WTP, while 24 reported zero WTP. The mean WTP based on weighted bid-class midpoints was IDR 21,090 per household per month, compared with the mean highest accepted bid of IDR 24,610 reported in Table 2. Applying the observed midpoint distribution to the 5,996 households in the five study villages yielded an indicative monthly TWTP of IDR 126,468,500, equivalent to IDR 1,517,622,000 annually. Because the household survey was drawn from 2,135 geographically eligible households, extrapolation to all 5,996 households assumed that the observed WTP distribution also applied to households outside the operational sampling frame. Accordingly, this estimate should be interpreted as an indicative study-area scenario rather than a statistically representative population total.

Theoretically, the separation of the four services and two beneficiary groups reveals heterogeneity in preferences that may be hidden within a single aggregate CES value. This contribution complements the literature on CES classification and valuation methods (Márquez et al., 2023; Romanazzi et al., 2023), as well as findings that socioeconomic relationships and WTP vary with river restoration attributes (Vollmer et al., 2016). The policy implication is that restoration planning and financing mechanisms must consider the types of benefits, ability to pay, perceptions of responsibility, and equitable access; WTP estimates alone do not

automatically determine tariffs or investment priorities. Interpretation remains limited by the stated-preference design, discrete offers, a small sample of tourists relative to the number of parameters, the possibility of protest responses, and uncertainty about the representativeness of extrapolations to households. Overall test statistics are not available for the main robust Tobit model on tourist education; therefore, no conclusions should be drawn from unreported statistics. Future research should increase the sample size, test interval-censored specifications and payment mechanisms, and assess the influence of trust, perceptions of responsibility, visit experience, and program characteristics on WTP. The current results are best understood as contextual evidence for the design of more differentiated urban river restoration projects.

Conclusions

This study reveals heterogeneous willingness-to-pay (WTP) patterns across four urban river cultural ecosystem services recreation, environmental education, aesthetics, and ecotourism and between local residents and tourists. The service-specific Tobit models indicate that education was positively associated with WTP across several domains, whereas income, environmental attitudes, and spatial characteristics exhibited less consistent associations across services and stakeholder groups. Notably, environmental attitudes measured using the New Ecological Paradigm (NEP) were positively associated with recreational WTP among residents but negatively associated with environmental education WTP among tourists, suggesting that ecological attitudes do not uniformly correspond to higher payment preferences. These patterns provide context-specific evidence that the relationships between beneficiary characteristics and WTP vary according to the cultural ecosystem service being assessed. By estimating WTP separately for four services and two beneficiary groups, this study complements existing environmental valuation approaches by revealing preference heterogeneity that may be obscured when multiple services are assessed as a single bundle. However, these patterns represent comparisons across separately estimated models rather than formally tested differences in coefficients.

For aggregate valuation, aesthetic improvements among local residents were selected based on their relatively high proportion of positive WTP responses, broadly accessible benefits, and clearly defined monthly household payment unit. Among 100 surveyed residents, 76% expressed positive WTP, primarily motivated by restoring river functions and protecting the environment, whereas 24% reported zero WTP, citing differences in service preferences or perceived government responsibility for river restoration. The estimated mean WTP, calculated using weighted bid-class midpoints, was IDR 21,090 per household per month, yielding an indicative annual total willingness to pay (TWTP) of approximately IDR 1.518 billion when extrapolated to 5,996 households in the study area. This estimate represents the stated economic value of the proposed aesthetic improvement scenario rather than the total economic value of all cultural ecosystem services or actual restoration revenue. The findings support differentiated restoration planning and financing strategies that consider service-specific benefits, beneficiary preferences, and payment capacity. Nevertheless, the estimates should be interpreted cautiously given the stated-preference design, discrete bidding, potential protest responses, and sampling limitations, particularly among tourists. Future research should employ larger and more representative samples, examine alternative payment mechanisms, and formally test differences in WTP determinants across services and stakeholder groups.

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