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Monetizing the Multi-Dimensional Value of a Large Urban Park Through the Context-Adapted Social-Return-on-Investment Framework

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Supplementary Table 1: Estimation of adjusted property-related economic value in the SROI

Item	Value	Data source/calculation	Explanation
Preliminary estimated property premium	RMB 7,670,714,904	Buffer-based comparison	Calculated based on the price difference between the treatment group within the 500-meter buffer and the control group within the 500–2,000-meter buffer
Retained share after deadweight adjustment	15%	Conservative modeling assumption informed by 2024 Pudong New Area villa transaction filing data and the Centaline Property Report	Only 15% of the preliminary buffer-based premium is retained before attribution as an intentionally conservative scenario assumption, reflecting substantial background market and non-park influences that cannot be causally isolated with the available data; the 15% retention rate should not be interpreted as a directly estimated causal park effect
Deadweight factor	85%	100% – 15% = 85%	Correspondingly, 85% is treated as deadweight in the SROI model, which is a conservative accounting

Item	Value	Data source/calculation	Explanation
			assumption rather than an empirically identified causal estimate of background appreciation
Attribution factor	69%	Questionnaire survey	Represents the proportion of respondents indicating that surrounding property value increases may also be attributable to non-park factors, such as housing policy, new housing supply, metro accessibility, school district effects, housing quality, and surrounding amenities
Adjustment after non-park attribution	31%	$100\% - 69\% = 31\%$	Represents the remaining proportion potentially associated with park proximity after deducting non-park attribution
Final property-related economic value included in SROI	RMB 356,688,243.04	$\text{RMB } 7,670,714,904 \times 15\% \times 31\%$	The adjusted property-related economic value included in the SROI calculation

NOTE

Previous studies indicate that park-related property capitalization is generally strongest at relatively short distances from urban green space (source: Refs. [27–34]).

Supplementary Table 2: Key questionnaire items used in the CVM/SROI analysis

Question No.	Survey question/content	Response format	Role in CVM/SROI calculation
Q11	What changes has the park brought to your life? Please select the relevant changes and evaluate their degree of impact.	5-point Likert scale: 1 = no impact, 5 = very strong impact	Used as a value-contextualization question before the WTP question to help respondents identify concrete park-related benefits and reduce hypothetical bias
Q15	If you did not participate in park activities, what do you think you would lose?	Multiple response, with an open-ended “Other” option	Used to help respondents consider the counterfactual scenario and clarify the perceived value of park-related activities
Q20	If the benefits provided by the park could be expressed in monetary terms, how much would you be willing to pay per visit/use for each benefit? Unit: RMB per visit/use. Payment vehicle: An earmarked park-maintenance contribution (special tax or voluntary donation). Benefit dimensions: physical health; mental	WTP amount in RMB per visit/use for each benefit dimension	Core WTP question used to estimate per-visit monetary values for the social outcomes valued using the contingent valuation method (CVM)

Question No.	Survey question/content	Response format	Role in CVM/SROI calculation
	health; social interaction; life satisfaction; family relationships; environmental awareness; nature-related knowledge; and new skills.		
Q22	If you are not willing to pay, what is the main reason? Options included: A. The park should be fully funded by the government B. Personal financial pressure C. Doubt about the park's benefits D. Inconvenient payment method E. Other reasons	Multiple choice/open-ended response for "Other reasons"	Used to distinguish true zero WTP from protest zero responses; Option B was coded as true zero WTP, while Options A, C, and D were coded as protest zero responses; Option E was reviewed case by case

NOTES

1. Q11 and Q15 preceded Q20 to reduce hypothetical bias and support attribution assessment.
2. Q22 was used to distinguish true-zero from protest-zero WTP responses.
3. Environmental-awareness responses were retained for descriptive analysis but were not monetized separately from the science/environmental education outcome.

Supplementary Table 3: Recognition rate, extrapolated benefit-related person-visits, and confidence intervals for social-value indicators

Social-value indicator	Recognition count (<i>N</i> = 105)	Recognition rate	Extrapolated benefit-related person-visits	95% CI (person-visits)
Sports value	54	51.43%	138,773	112,971–164,563
Mental health improvement	56	53.33%	143,899	118,160–169,658
Social network expansion	30	28.57%	77,090	53,777–100,408
Life satisfaction improvement	51	48.57%	131,055	105,263–156,854
Family harmony	47	44.76%	120,775	95,117–146,444
Science/environmental education	38	36.19%	97,651	72,848–122,453

NOTE

95% confidence intervals were calculated using the normal approximation method for proportions, based on the valid questionnaire responses for each indicator, and subsequently extrapolated to the 2024 annual park-use total (269,828 person-visits) reported by the park management authority. The relatively wide confidence intervals reflect the limited survey sample and should be interpreted as an indication of the uncertainty inherent in proportional extrapolation from an on-site intercept sample.

Supplementary Table 4: Descriptive statistics of user demographics

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	56	53.33
	Female	49	46.67
Age	≤ 20	2	1.90
	21–30	12	11.43
	31–40	66	62.86
	41–50	19	18.10
	51–60	6	5.71
	≥ 61	0	0.00
Place of residence	Near the park (within 1 km)	9	8.57
	Zhangjiang	16	15.24
	Jinqiao	38	36.19
	Main urban area	32	30.48
	Outside the main urban area	10	9.52
Educational attainment	High school, vocational school, or below	4	3.81
	Associate or bachelor's degree	45	42.86
	Postgraduate degree or above	56	53.33
Monthly income (RMB)	< 5,000	4	3.81
	5,000–10,000	22	20.95
	10,001–30,000	51	48.57
	> 30,000	28	26.67
Respondent role	Government department	1	0.95
	Park construction/operation entity	6	5.71
	Nearby resident	35	33.33
	Local corporate employee	22	20.95
	Tourist	31	29.52
	Volunteer	0	0.00
	Others (students, freelancers)	10	9.52

NOTE

Percentages are calculated from the frequencies and rounded independently to two decimal places; therefore, the displayed percentages for respondent role sum to 99.98% rather than 100.00%.

Supplementary Table 5: Quantitative methods for ecological value assessment

Indicator	Formula	Parameter explanation
Water conservation	$W = S \times P \times t$ $V_W = W \times F_W$	W : water conservation volume; S : green space area; P : average precipitation; t : conservation coefficient; V_W : value; F_W : unit reservoir construction cost
Carbon sequestration	$V_C = S \times T_C \times Q_C$	V_C : value; S : area; T_C : carbon tax rate; Q_C : annual carbon absorption per unit area
Oxygen release	$V_O = S \times C_O \times B$	V_O : value; S : area; C_O : industrial oxygen price; B : annual oxygen release per unit area
Air purification	$V_A = S \times (Q_S \times F_S + Q_N \times F_N)$	V_A : value; S : area; Q_S : annual SO ₂ absorption; F_S : SO ₂ treatment cost; Q_N : annual NO _x absorption; F_N : NO _x treatment cost
Dust retention	$V_D = S \times Q_D \times F_D$	V_D : value; S : area; Q_D : annual dust retention; F_D : dust treatment cost
Noise reduction	$V_N = S \times B \times C \times 0.15$	V_N : value; S : area; B : mature forest timber volume; C : average afforestation cost
Cooling	$V_T = S \times D \times M \times G \times F_T \times 24$	V_T : value; S : area; D : number of cooling days; M : number of air-conditioning units; G : rated power per air-conditioning unit; F_T : electricity price
Biodiversity	$H' = -\sum p_i \log p_i$ $V_{sd} = S \times Q_{sd}$	H' : Shannon–Wiener index; V_{sd} : value; S : area; Q_{sd} : biodiversity conservation value per unit area

Supplementary Table 6: Recommended prices and parameters for ecological value assessment

Parameter	Unit	Base price/value	Source and basis
Unit reservoir construction cost	RMB/m ³	6.15	2024 Shanghai reservoir construction cost data
Average urban precipitation	mm	1,280.6	2023 Shanghai average precipitation
Water conservation coefficient (t)	—	44%	Annual evapotranspiration of forest land in China accounts for 30%–80% of annual precipitation, with an average of approximately 56%; based on this, it is taken as 44%
Carbon tax rate	USD/t	150	Based on the classic Swedish carbon tax price (equivalent to approx. 1,200 RMB/t)
Annual carbon sequestration per unit area	kg/(hm ² ·a)	900	Ref. [57]
Industrial oxygen price	RMB/t	1,000	Market survey
Annual oxygen release per unit area	kg/(hm ² ·a)	600	Ref. [57]
Annual SO ₂ absorption per unit area	kg/(hm ² ·a)	88.65	Ref. [58]
SO ₂ treatment cost	RMB/kg	6.65	2018 Shanghai Air Pollutant Usage Tax Standard

Parameter	Unit	Base price/value	Source and basis
Annual NO _x absorption per unit area	kg/(hm ² ·a)	380	Ref. [58]
NO _x treatment cost	RMB/kg	7.6	2018 Shanghai Air Pollutant Usage Tax Standard
Annual dust retention per unit area (coniferous/broadleaf)	t/(hm ² ·a)	33.2/10.11	Ref. [59]
Dust treatment cost	RMB/t	170	Market survey
Average afforestation cost in China	RMB/hm ²	28,812.08	Ref. [60]
Noise reduction value coefficient	—	0.15	Ref. [60]
Cooling parameters (cooling days/number of air-conditioning units/rated power per unit)	d/unit/kW	60/189/0.86	Ref. [60]
Urban electricity price	RMB/(kW·h)	0.617	Average residential electricity price in Shanghai
Biodiversity conservation value per unit area	RMB/(hm ² ·a)	3,000	GB/T 38582–2020: Specifications for Assessment of Forest Ecosystem Services

Supplementary Table 7: Person-visit-based quantification of social outcomes

Outcome	Benefit-related person-visits	Proxy	Unit value (RMB/time)	Calculation	Annual value (RMB)
Sports value	138,773	Gym membership fees	66.00	138,773 × 66.00	9,159,018.00
Mental health improvement	143,899	N/A (WTP)	57.58	143,899 × 57.58	8,285,704.42
Science/environmental education	97,651	Nature education fees	332.00	97,651 × 332.00	32,420,132.00
Social network expansion	77,090	N/A (WTP)	36.63	77,090 × 36.63	2,823,806.70
Family harmony	120,775	N/A (WTP)	50.26	120,775 × 50.26	6,070,151.50
Life satisfaction improvement	131,055	N/A (WTP)	52.32	131,055 × 52.32	6,856,797.60
Total social value					65,615,610.22

NOTES

1. Annual social values are calculated as benefit-related person-visits × per-visit unit value.
2. Visit frequency is not applied again in the monetary aggregation.

Supplementary Table 8: Full adjustment details of monetized outcome values by category

Category	Estimated value (RMB)	Deadweight	Attribution	Displacement	Drop-off	Monetized value (RMB)	Proportion (%)
I. Ecological value							
Water retention	2,149,200.00	0%	0%	0%	0%	2,149,200.00	0.54%
Carbon sequestration	3,475,800.00	0%	0%	0%	0%	3,475,800.00	0.88%
Oxygen release	8,094,100.00	0%	0%	0%	0%	8,094,100.00	2.04%
Air purification	128,600.00	0%	0%	0%	0%	128,600.00	0.03%
Dust retention	107,000.00	0%	0%	0%	0%	107,000.00	0.03%
Noise reduction	228,300.00	0%	0%	0%	0%	228,300.00	0.06%
Temperature reduction	8,947,600.00	0%	0%	0%	0%	8,947,600.00	2.25%
Biodiversity conservation	185,900.00	0%	0%	0%	0%	185,900.00	0.05%
Subtotal						23,316,500.00	5.87%
II. Economic value							
Direct economic value	8,386,000.00	0%	0%	0%	0%	8,386,000.00	2.11%
Property-related economic value	7,670,714,904.00	85%	69%	0%	0%	356,688,243.04	89.81%
Subtotal						365,074,243.04	91.92%
III. Social value							
Physical exercise/sports value	9,159,018.00	50%	46%	0%	0%	2,472,934.86	0.62%
Mental health improvement	8,285,704.42	63%	54%	0%	0%	1,410,226.89	0.36%
Science/environmental education	32,420,132.00	70%	91%	0%	25%	875,343.56	0.22%
Social network expansion	2,823,806.70	50%	82%	0%	0%	254,142.60	0.06%
Family harmony	6,070,151.50	65%	60%	0%	0%	849,821.21	0.21%
Life satisfaction improvement	6,856,797.60	50%	15.2%	0%	0%	2,907,282.18	0.73%
Subtotal						8,769,751.31	2.21%
Total						397,160,494.35	100.00%

NOTES

1. Deadweight: proportion of the outcome that would have occurred in the absence of the park intervention; sources and assumptions are reported in Supplementary Table 9.
2. Attribution: proportion of the outcome attributable to factors other than the park; questionnaire-based attribution sources are reported in Supplementary Table 10.
3. Displacement: proportion of the outcome that displaces equivalent benefits elsewhere.
4. Drop-off: annual rate of decline in the sustained impact of the outcome.

5. The first-year monetized value equals the estimated value after applying deadweight, attribution, and displacement adjustments. For science/environmental education, an annual drop-off rate of 25% is applied from Year 2 onward. The retained proportion in Year n is calculated as $(1 - D_r)^{n-1}$, where $D_r = 0.25$, consistent with Eq. (1) in the main text.
6. Ecological outcomes were assessed using a unit-value transfer method based on physical quantity measurements; deadweight and attribution adjustments were not applied because these values were treated as directly associated with the park's physical presence under the selected accounting boundary.
7. Percentages are calculated against the first-year total adjusted monetized value of RMB 397,160,494.35.
8. Subtotals and totals are calculated from unrounded values. Accordingly, a subtotal percentage may differ by 0.01 percentage point from the sum of displayed item percentages, and displayed monetary line items may differ by RMB 0.01 from a subtotal because of rounding.

Supplementary Table 9: SROI deadweight sources and assumptions

No.	Deadweight factor description	Data source and basis	Value assumed
1	Property-related value retained after conservative deadweight adjustment (15% retained)	Conservative modeling assumption informed by 2024 Pudong New Area villa transaction filing data and the Centaline Property Report; because the available market data do not causally identify the park-related share, only 15% of the preliminary buffer-based premium is retained before attribution	85% deadweight (15% retained)
2	Participation rate in sports activities in Shanghai in 2024 (48%–52%)	Shanghai Municipal Sports Bureau “2023 National Fitness Development Report,” “Shanghai 15-Minute Community Life Circle Construction Assessment (2024)”	50%
3	Convenience of access to psychological counseling/courses (55%–71%)	2022 National Mental Health Survey Report	63%
4	Participation rate in science popularization activities in Shanghai in 2024 (65%–70%)	Shanghai Municipal Science and Technology Commission “2024 Shanghai Science Popularization Work Annual Report”	70%
5	Background social interaction that may occur without the park	Conservative midpoint model assumption used because a directly comparable citywide benchmark was not available; this parameter should therefore be interpreted as an explicit modeling assumption	50%
6	Background family interaction that may occur without the park	iiMedia Research Report (fathers: 56.7%; mothers: 69.6%; mean benchmark 63.15%); rounded conservatively for model application	65%
7	Chinese residents’ current life satisfaction	Government official website survey data	50%

Supplementary Table 10: SROI attribution sources

SROI outcome	Questionnaire item and option used for attribution	Response criterion	N	Sample size	Park-attributed proportion	SROI attribution factor
Property-related value	Q7 (multiple response): What do you think are the greatest contributions of the park? Option F: Increase in surrounding land value	Selected Option F (increase in surrounding land value)	33	105	31.43%	68.57% $\approx$ 69%
Physical exercise/sports value	Q15 (multiple response): If you did not participate in park activities, what do you think you would lose? Option C: Decline in physical health (e.g., reduced physical activity)	Selected Option C (decline in physical health)	57	105	54.29%	45.71% $\approx$ 46%
Mental health improvement	Q15 (multiple response): If you did not participate in park activities, what do you think you would lose? Option D: Loss of mental health support (e.g., difficulty relieving stress)	Selected Option D (loss of mental health support)	48	105	45.71%	54.29% $\approx$ 54%
Science/environmental education	Q15 (multiple response): If you did not participate in park activities, what do you think you would lose? Option G: Reduced opportunities for cultural experiences and learning (e.g., participation in cultural activities)	Selected Option G (reduced cultural and learning opportunities)	9	105	8.57%	91.43% $\approx$ 91%
Social network expansion	Q15 (multiple response): If you did not participate in park activities, what do you think you would lose? Option B: Reduced social networks (e.g., less contact with friends)	Selected Option B (reduced social networks)	19	105	18.10%	81.90% $\approx$ 82%

SROI outcome	Questionnaire item and option used for attribution	Response criterion	<i>N</i>	Sample size	Park-attributed proportion	SROI attribution factor
Family harmony	Q15 (multiple response): If you did not participate in park activities, what do you think you would lose? Option H: Decline in the quality of family interactions	Selected Option H (decline in family interactions)	42	105	40.00%	60.00%
Life satisfaction improvement	Q11: What changes has the park brought to your life? Item: Improved life satisfaction (1–5 scale)	Rated 4 or 5 (strong or very strong impact)	89	105	84.76%	15.24% $\approx$ 15.2%