Understand Blue: The Importance of the Perceiving Water Value and its Mediating Effect on Park Satisfaction

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Master thesis for the degree of
Master of Sciences (Geospatial Data Sciences)
in the University of Michigan - Ann Arbor

April 2024

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Abstract

Urban blue and green spaces (UBGS) are important places for connecting humans and nature in urban settings. People's satisfaction with parks, as valuable UBGS, has received great attention. How green features such as vegetation will impact environmental satisfaction has been widely discussed and studied, but the attention given to green features far exceeds that given to water bodies. Considering that the boundaries between blue spaces and green spaces can be blurry, with blue spaces sometimes still subsumed under green space, the importance of water bodies on individuals' UBGS experience has been overlooked. The potential oversight of the importance of water bodies compromises the ability to understand individuals' interaction with the environment. To improve the understanding of the perceptions of water bodies and how such perceptions are important to environmental satisfaction, we conducted a survey-based empirical study in the Huron River watershed. We used partial least squares structural equation modeling (PLS-SEM) to conduct the analysis. First, we defined the perceptions of water bodies as perceived water value and quality and investigated what factors will impact them. Second, we analyzed what factors will impact park satisfaction. Our results suggested that compared to other variables, perceived water value is the most important factor that impacts park satisfaction. Furthermore, the results highlight the significant and robust mediating effect of water bodies in mediating the perceptions of vegetation and park satisfaction, providing a new perspective to understand and explain how and why water bodies are important in environmental satisfaction. Our results encourage rethinking water as a mediator in planning, landscaping, and environmental governance, as water bodies may serve as the bridge linking the perceptions of different landscape elements with broader environmental satisfaction.

Contents

1 Introduction

The linkage between human well-being and the natural environment has been extensively studied and discussed across various fields[1][2][3]. Both blue spaces and green spaces are important components of the natural environment. Blue space is generally understood to encompass both freshwater and marine settings[4][5][6]. Green space is usually considered as vegetation, including parks, forests, green roofs, and community gardens[7][8]. The well-being brought by blue space, green space, and their related features has been continuously confirmed in previous studies[9][10][11].

Considering that more than half of the world's population now lives in urban areas and urban living is usually associated with reduced contact with nature[12][2][13], the limited supply of urban blue-green space(UBGS) in urban settings receives significant attention. Among UBGS, parks are considered valuable spaces in urban environments as they provide health benefits and contribute to the social well-being of communities and individuals[14]. Therefore, park users' satisfaction has received attention. Satisfaction of place reflects the utilitarian value of the place to meet basic needs such as social needs, services, and physical characteristics[15][16]. Understanding park users' satisfaction is fundamental to improving urban livable and societal well-being and serves as an important factor for the policymaking, planning, and management of parks[17][18][19].

Previous studies have attempted to investigate factors associated with park users' satisfaction. Among the factors impacting park satisfaction, the green features have received considerable attention[17]. For example, vegetation such as trees and plants are considered to provide perceivable ecological service value and aesthetic value[20][21]. Researchers focused on green features like landscapes and trees because they primarily serve as a scenic backdrop for outdoor activities, reflecting a narrow scope of nature appreciation and a preference for visually dominant plants[22]. However, many urban parks are waterfront parks, which are typically designed and built around water bodies. Water bodies have been considered one of the most attractive visual elements of the landscape, and specific combinations of water bodies and different landscape elements bring different aesthetic preferences[23][24][9]. For these waterfront parks, water is an important visual element. However, the importance of water in these parks has not yet been emphasized. In fact, blue spaces have generally received much less attention from researchers than terrestrial green spaces[25][26] and blue space is sometimes still subsumed under green space, especially riparian areas[27]. The potential oversight of the water compromised the ability to understand users' interaction with the environment. It prompted a call for more exploration of the specific role and importance of water bodies within different environmental settings including these urban waterfront parks[26].

Although some previous studies have confirmed park users' preference for water bodies[28][29] or the potential restorativeness of water bodies[9][30][31], these discussions were still limited on how the importance of the waterbody itself without further exploring the underlying causes of such benefit bring by water. As a result, human perceptions of water bodies and how such perceptions are important to broader environmental satisfaction were still unclear. Therefore, the following questions have been raised and sought answers:

·1 What factors might impact individuals' perceptions of water bodies?

·2 How are different factors, including the perceptions of water bodies, important to individuals' environmental satisfaction?

·3 If the perceptions of water bodies are important to environmental satisfaction, how to explain and understand it?

To answer these questions, we conducted in-person survey from July 2023 to August 2023 in eight riparian waterfronts parks in the Huron River watershed to gather opinions from park users. We categorize the perception of water bodies into two parts, perceived water value (PWV) and perceived water quality (PWQ). Then we investigate how river contamination conccern(RCC), place attachment(PA), and perceived vegetation value (PVV) influences these two dimension of perception of water bodies. We found that PWV is positively correlated with PA and PVV, and negatively correlated with RCC. Building on this, we explored which factors, including perceptions of water bodies, influence overall park satisfaction (PS). We found that compared to other variables, the PWV is the most important factor influencing PS. Furthermore, the PWV is a significant and robust mediator between the PVV and PS.

These results shows the importance of water bodies to environmental satisfaction by emphasize the perception of water bodies have direct and indirect effect on park satisfcation. We also discussed the subtle differences in perception paths based on gender. Our results also highlight the mediating effect of water bodies in connecting vegetation and park satisfaction, The results implied water bodies may serve as the bridge linking broader perception of different landscape elements with broader environmental satisfaction, providing a new perspective to understand how and why the water bodies are importance for perception.

2 Methodology

2.1 Study Area

The study area was eight riparian waterfront parks in the Huron River watershed(Figure 1). The watershed is a HUC-8 watershed, it spans a land area of more than 2330.99 km^2. The watershed includes seven Michigan counties (Oakland, Livingston, Ingham, Jackson, Washtenaw, Wayne, Monroe) and 68 municipal governments, serving six hundred and fifty thousand residents[32]. Many waterfront parks were built along the banks of the Huron River, supporting residents with a place to interact with nature. According to Britton et al.[27], riparian areas are the most common type of blue space often subsumed under "green space." These waterfront park settings provided a space to investigate and compare individuals' perceptions of water bodies and green feature and their impact on park satisfaction.

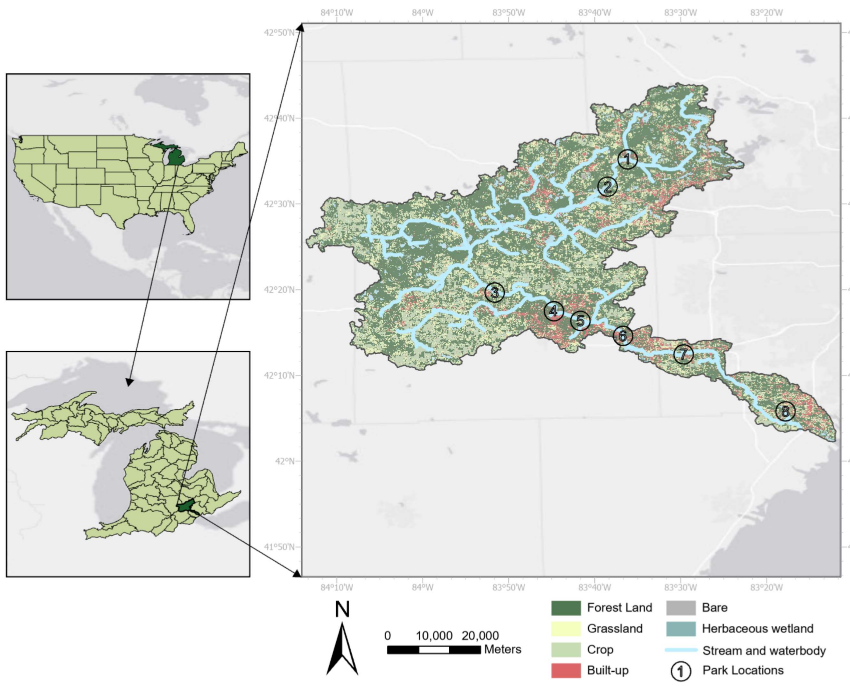

Figure 1: Study Area, from upstream to downstream are: (1)Central Park, (2)Kensington Park, (3)Dexter Park, (4)Argo Park, (5)Gallup Park, (6)Riverside Park, (7)Horizon Park, and (8)Huroc Park.

2.2 Constructs and Hypothesis Development

The development of constructs and hypotheses either directly came from previous studies or designed based on was related theories. Constructs used in the study include perceived water value, perceived water quality, perceived vegetation value, river contamination concern, and park satisfaction(Table 1).

2.2.1 Constructs Development

Perceived value and perceived quality are two dimensions of perceiving urban ecosystem services[39]. First, in the user environmental perceptions context, perceived values are "consistent knowledge and belief about the worth and importance of an object"[39]. Marketing literature often focuses on the utilitarian dimensions of perceived value, However, perceived value is a multidimensional construct that includes emotional value, social value, and hedonic[40]. Previous studies often emphasize the utilitarian dimensions of perceived water values and perceived vegetation value[41][42][43], rarely considering other dimensions of perceived value. Considering that both blue spaces and green spaces provide potential recreational, aesthetic, and ecological value, and they are related to environmental satisfaction and perceptions[34][9][26], the perceived water value and perceived vegetation value focus on these aspects had been constructed. The perceived water value and perceived vegetation value focus on these aspects has been used in the study.

Table 1: Hypothesis in PLS-SEM

Constructs	Survey Questions	Reference
perceived water value(PWV)	The water body in this park provides a good environment for recreation.	[26]
	The water body in this park provides a good aesthetic value.	[9]
	The water body in this park provides a good ecological value	[26]
perceived water quality(PWQ)	How would you think the general water quality is on average at this waterfront park?	[33]
perceived vegetation value(PVV)	The vegetation in this park provides a good environment for recreation.	[34]
	The vegetation in this park provides a good aesthetic value.	[34]
	The vegetation provides a good ecological value.	[34]
river contamination concern(RCC)	The Huron River faces threats from various sources of contamination.	[35]
	Contact with Huron River waterbody is unsafe.	[36]
	It's still not safe to eat fish from the most part of Huron River	[37]
place attachment(PA)	I am very attached to Huron River.	[38]
	Huron River is a special place for me and my family.	[38]
	No other place can compare to Huron River.	[38]
park satisfaction(PS)	Visiting this park is enjoyable	[38]
	Visiting this park is a positive experience	[38]
	Visting this park is fun	[38]

Perceived quality in the water bodies context refers to perceived water quality. The meaning of perceived water quality may vary under different contexts. Some previous studies have used it to refer to the perceptions of specific services such as drinking water[44][45]. In this study, perceived water quality referred to users' general rating of environmental water quality to the riparian water bodies (i.e., the river).

Environmental concerns have been treated as an evaluation of, or an attitude towards facts, one's own behavior, or others' behavior with environmental consequences[46]. We used river contamination concerns to manifest individuals' specific environmental concerns about the watershed and its riparian environment.

Place attachment describes a bonding between individuals and their meaningful environments. Place attachment is usually related to environmental perceptions and attitudes[47].

Place attachment describes a bonding between individuals and their meaningful environments. Place attachment is related to environmental perceptions and attitudes In the study, place attachment referred to individuals' attachment to the Huron river watershed and the river itself.

Satisfaction is a perceived condition. One evaluates perceptions formed from an outcome against previously held expectations[48][49]. In this study, park satisfaction referred to an individual's assessment of their contentment with a park visiting experience

2.2.2 Hypothesis Development

The primary argument of Social Cognitive Theory (SCT) is that people's behavioral intention is a function of cognitive personal and environmental factors[50]. In the SCT context, personal factors (e.g., environmental concerns) will impact outcome expectations (e.g., environmental perceptions and environmental satisfaction) and behavior patterns[51]. Therefore, we proposed hypotheses H1a, H2a, and H3a(Table 2) by assuming that river contamination concerns, a representation of environmental concerns, will impact environmental perceptions and satisfaction.

Place attachment has been defined as a three-dimensional, person–process–place organizing framework. The psychological dimension of place attachment includes the affective, cognitive, and behavioral components of attachment[47]. Therefore, we proposed hypotheses H1b, H2b, and H3b(Table 2) by assuming that place attachment will impact human psychological activities, including environmental perceptions and satisfaction.

The Landscape Perception Theory (LPT) suggests that landscape perception is an interaction process between a scene's objective features and a person's subjective preferences, triggering the person's psychological activity or behavior[52]. Therefore, we proposed hypotheses H3c, H3d, and H3e(Table 2) by assuming that objective feature perceptions affect individuals' psychological activity (satisfaction).

Perceived value and perceived quality are two dimensions of perceiving urban ecosystem service, and they contribute to citizens' perceptions[39]. We proposed hypotheses H1c and H1d(Table 2) by assuming that the perceived value of landscape elements is related to their perceived quality. In addition, the combination of different landscape elements affects the overall aesthetic evaluation and environmental perceptions[9]. We proposed hypothesis H2c(Table 2) by assuming that the perceived value of a specific landscape element has connections with the perceived value of other landscape elements.

Each hypothesis corresponded to a specific path in later Partial Least Squares Structural Equation Modeling (PLS-SEM) (Figure 2) . Additionally, we tested the mediating effect of perceived water value or perceived water quality on park satisfaction. However we do not hypothesize specific mediating effects in advance, so these hypotheses aren't reflected here.

Table 2: Hypothesis in PLS-SEM

Hypothesis	Corresponding Speific Path	Evidences
H1a	river contamination concern(RCC) -> perceived water quality(PWQ)	[51] [53] [33]
H1b	place attachment(PA) -> perceived water quality(PWQ)	[47] [53] [33]
H1c	perceived vegetation value(PVV) -> perceived water quality(PWQ)	[39] [53] [54]
H1d	perceived water value(PWV) -> perceived water quality(PWQ)	[39] [49]
H2a	river contamination concern(RCC) -> perceived water value(PWV)	[51] [53] [33]
H2b	place attachment(PA) -> perceived water value(PWV)	[47] [53]
H2c	perceived vegetation value(PVV) -> perceived water value(PWV)	[39] [54] [24]
H3a	river contamination concern(RCC) -> park satisfaction(PS)	[51] [55]
H3b	place attachment(PA) -> park satisfaction(PS)	[47] [14]
H3c	perceived vegetation value(PVV) -> park satisfaction(PS)	[52] [20] [21]
H3d	perceived water value(PWV) -> park satisfaction(PS)	[52] [40] [29]
H3e	perceived water quality(PWQ) -> park satisfaction(PS)	[52] [41] [42]

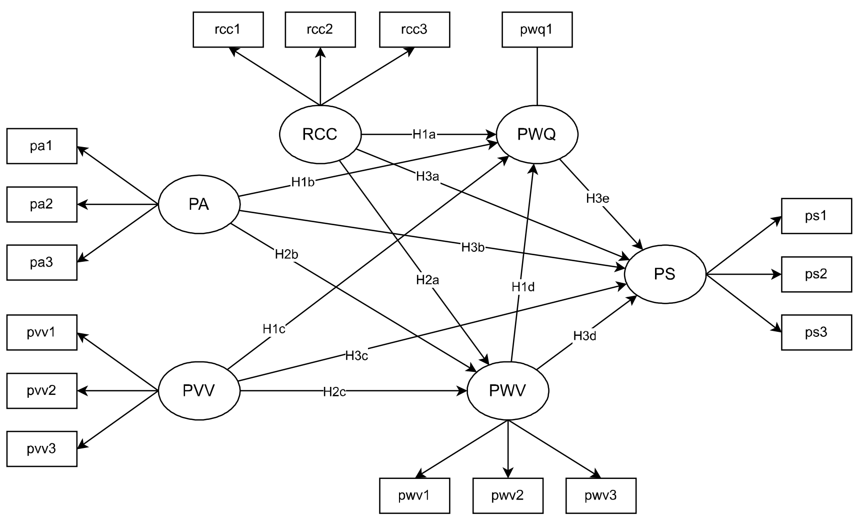

Figure 2: PLS-SEM Path with Hypothesis

2.3 Survey Data Collection

2.3.1 Survey Design

The survey includes two parts. The first part is composed of five-point Likert-type scale questions that are made up of constructs of river contamination concerns, place attachment, perceived vegetation value, perceived water value, perceived water quality, and park satisfaction. The second part asks respondents about their age, gender, race, and education level to understand the profile of the respondents. After designing the first draft of the survey, a pre-test was sent to 94 park users in Gallup Park to collect feedback regarding the clarity. Meanwhile, experts working in several universities in the US checked the content validity and got feedback. Before the full-scale survey, we modified and deleted problematic items according to feedback from both pre-test respondents and experts. The survey used in the study is available in (Appendix A)

2.3.2 Survey Data Collection Procedure

In-person surveys were conducted from July 2023 to August 2023 in eight riparian waterfront parks in the Huron River watershed. At sites with many people, every 2nd or 3rd person encountered while walking throughout the site was invited to participate[33]. Four members of the team conducted surveys. Groups of 2-3 team members were present at each site visit. All team members were trained prior to the fieldwork. All survey participants were read the consent form in English and given the opportunity to provide verbal consent. Surveys took about 5-10 min to complete. Respondents who complete the survey can receive a $10 cash incentive. Surveys were conducted under the requirements of the University of Michigan Human Research Protection Program (HRPP) and approved by the University of Michigan Institutional Review Boards (IRBs).

Six hundred park visitors participated in the survey. Among them, ninety-six pre-test surveys were discarded due to a mid-way modification of the survey structure. Among the five hundred-six full-scale survey responses, thirty-one responses were discarded because they did not answer the required questions. Four hundred fifty-five responses are valid. The validation rate is 93.87%. Respondents came from different parks: Central Park(n=35), Kensington Park(n=92), Dexter Park(n=114), Argo Park(n=84), Gallup Park(n=48), Riverside Park(n=61), Horizon Park(n=18), and Huroc Park(n=23).

2.4 Analysis

2.4.1 Descriptive Statistic

Descriptive statistic was used to depict the profile of survey respondents. Descriptive statistics were conducted in IBM's Statistical Package for the Social Sciences (Spark satisfactionS) Version 29.0.2.0.

2.4.2 Partial Least Squares Structural Equation Modeling (PLS-SEM)

The primary advantage of SEM is its ability to measure complex model relationships while accounting for measurement errors inherent in the indicators[56].. There are two types of SEM methods – Covariance-Based SEM (CB-SEM) and Partial Least Squares SEM (PLS-SEM). First, CB-SEM's objective of reproducing the theoretical covariance matrix without focusing on explained variance, PLS-SEM is a causal modeling approach aimed at maximizing the explained variance of the dependent latent constructs[57][58]. Second, CB-SEM assumes multivariate normality and is sensitive to sample size, while PLS-SEM relaxes the demands regarding the data and specification of relationships[56][57]. Therefore, CB-SEM is typically used for validating and testing existing theories, while PLS-SEM is more suitable for developing theories and making predictions[57]. We chose PLS-SEM for analysis as it better suits the expectations of this study.

In PLS-SEM, path models are diagrams used to visually display the hypotheses and variable relationships that are examined when PLS-SEM is applied. Constructs or latent variables (LVs) (i.e., variables that are not directly measurable) represent a linear combination of the responses for indicators of each construct's measurement model[58]. It is represented in path models as circles. The indicators or observation variables (i.e., variables that are directly measured by containing the raw data) are represented in path models as rectangles. Relationships between constructs, as well as between constructs and their assigned indicators, are depicted as arrows[56].

A PLS-SEM path model consists of two elements. First, there is a structural model that links together different constructs (circles). Second, there are the measurement models of the constructs that display the relationships between the constructs (circles) and their indicator variables (rectangles)[56]. The PLS-SEM used in the studies is shown in (Figure 2). In the path model, each path is associated with a specific hypothesis (Table 2). The evaluation and validation procedure of the PLS-SEM followed by [59][57]'s suggestions. For validation of the measurement model, since we used reflective measurement models, we tested the constructs' internal consistency reliability, indicator reliability, convergent validity, and discriminant validity. For validation of the structure model, at first, we assessed the proximate fix indices of the model. Second, we assessed the multicollinearity among latent variables through the variance inflation factor (VIF). Third, we evaluated the coefficient of determination (R^2)and the blindfolding-based cross-validated redundancy measure (Q^2) for the endogenous latent variables. Fourth, we assessed the significance and relevance of the path coefficients. To test mediating effects, we evaluated whether perceived water quality and perceived water value have potential indirect effects between different constructs and park satisfaction. To explore whether these relationships vary between groups, we divided the data by male and female and performed a multigroup analysis (MGA). Finally, to check the robustness of our result, we tested the nonlinear effects, endogeneity, and unobserved heterogeneity of the model. The Partial Least Squares Structural Equation Modeling (PLS-SEM) and related tests were conducted in SmartPLS 4.0[60].

3 Result

3.1 Descriptive Statistics

The descriptive statistics depicted a profile of the respondents(Table 3). The respondents in our study were relatively young. There are 45.1% of the respondents were between 18 to 29 years old, 21.1% were between 30 to 39 years old, and 17% were between 40 to 49 years old. Both the 50-59 age group and those aged 60 and above make up 9% of the population. Among them, the proportion of females (54.3%) was higher than that of males (43.6%). For race, the majority of respondents were white (58%), followed by black (13%) and Asian (12%). In terms of education level, most respondents claimed they have high school degrees (33%), followed by graduate degrees (27%) and associate degrees (21%).

Table 3: Survey Respondents Profile

Variable	Respond	N	%
Age	18-29	214	45%
	30-39	100	21%
	40-49	79	17%
	50-59	41	9%
	60+	41	9%
Gender	Male	207	44%
	Female	258	54%
	Genderqueer	10	2%
Race	White	276	58%
	Black	62	13%
	Asian	58	12%
	Hispanic	45	9%
	Other	34	7%
Education Level	Bachelor	53	11%
	Associate	98	21%
	Some College	36	8%
	High School	158	33%
	Graduate	130	27%

3.2 Partial Least Squares - Structural Equation Modeling(PLS-SEM)

3.2.1 Validation of Measurement Model

Internal consistency among the components in each construct was checked using Cronbach's Alpha (CA) and Composite Reliability (CR). Cronbach's alpha is the lower bound, and the composite reliability is the upper bound for internal consistency reliability. The suggested threshold values are 0.7 for both indicators[59]. As shown in (Table 4), the CA value for all constructs ranged from 0.843 to 0.930, and the CR value for all constructs ranged from 0.847 to 0.930. These estimations suggested a reliable internal consistency among these constructs. The convergent validity of the measurement model was examined based on factor loadings and average variance extracted (AVE). As shown in (Table 4), factor loading values of all components were higher than 0.7, presenting satisfactory reliability levels[61][59]. Suggested AVE value of constructs is higher than 0.5[59]. As shown in (Table 4), AVE ranges from 0.716 to 0.843. These estimations suggested validity in the convergence of the measurement model.

Discriminant validity was checked to what extent a construct within its components differs from others. The fornell-Larcker criterion is a popular option for checking the discriminant validity. Recently, fornell-Larcker criterion has been shown not to perform well[62]. As a replacement, Henseler et al. [62] proposed the heterotrait-monotrait (HTMT) ratio of the correlations[59]. The HTMT is defined as the mean value of the item correlations across constructs relative to the (geometric) mean of the average correlations for the items measuring the same construct. Discriminant validity problems are present when HTMT values are high. The suggested HTMT for conceptually different constructs is HTMT lower than 0.85[59]. As shown in (Table 5), all constructs in the model met the requirement, suggesting discriminant validity among the constructs satisfied requirements.

In summary, the measurement models met requirements regarding internal consistency reliability, convergent validity, and discriminant validity. Empirically validated the suitability of the measurement model in this study[61].

Table 4: Test for Internal Consistency Reliability, Indicator Reliability, abd Convergent Validity

	Items	Loadings	Cronbach's Alpha (CA)	Composite Reliability (CR)	Average Variance Extracted (AVE)
RCC	RCC1	0.819	0.883	0.885	0.716
	RCC2	0.844			
	RCC3	0.875			
PA	PA1	0.897	0.843	0.847	0.763
	PA2	0.91			
	PA3	0.81			
PVV	PVV1	0.915	0.907	0.908	0.843
	PVV2	0.936			
	PVV3	0.902			
PWV	PWV1	0.903	0.884	0.885	0.812
	PWV2	0.905			
	PWV3	0.895			
PS	PS1	0.926	0.930	0.930	0.877
	PS2	0.953			
	PS3	0.931			

Table 5: Test for Discriminant Validity

	RCC	PA	PVV	PWV	PS	PWQ
RCC						
PA	0.154					
PVV	0.087	0.395				
PWV	0.102	0.440	0.770			
PS	0.068	0.392	0.548	0.653		
PWQ	0.263	0.205	0.227	0.428	0.219	

3.2.2 Evaluation for Structural Model

We adopted proximate fit indices, including the standardized root mean square residual (SRMR) and the Normed Fit Index (NFI) to assess the PLS-SEM model fit. In our PLS-SEM, SRMR was equal to 0.056 (lower than the threshold of 0.08[63]) and NFI equal to 0.849 (higher than the threshold of 0.8[64]). These values indicated that the structural model fit satisfied the requirement[61]. But should be pointed out that any thresholds advocated in the PLS-SEM literature should be considered very tentative[59].

Before assessing the structural relationships, collinearity must be examined to make sure it does not bias the regression results[59]. In the PLS-SEM, the latent variable scores of the predictor constructs in a partial regression were used to calculate the Variance Inflation Factor (VIF) values. The VIF values among constructs in the model were all below 3(Table 6), which indicated satisfactory reliability and suggested no serious collinearity issue[59]. As collinearity was not an issue, we examined the predictive capability by the coefficient

Table 6: Collinearity Statistics

	VIF
RCC - PWQ	1.036
PA - PWQ	1.210
PVV - PWQ	1.954
PWV - PWQ	2.039
RCC - PWV	1.013
PA - PWV	1.149
PVV - PWV	1.136
RCC - PS	1.094
PA - PS	1.220
PVV - PS	1.967
PWV - PS	2.269
PWQ - PS	1.276

of determination(R^2) and cross-validated redundancy measure (Q^2). The R^2 measures the variance explained in each of the endogenous constructs and is therefore a measure of the model's explanatory power[65]. Acceptable R^2 values are based on the context. As a guideline, R^2 values of 0.75, 0.50, and 0.25 can be considered substantial, moderate, and weak[59]. The Q^2 based on the blindfolding procedure that removes single points in the data matrix, inputs the removed points with the mean and estimates the model parameters[66]. As such, the Q^2 is not a measure of out-of-sample prediction but combines aspects of out-of-sample prediction and in-sample explanatory power[59]. As a guideline, Q^2 values should be larger than zero for a specific endogenous construct to indicate the predictive accuracy of the structural model for that construct. Usually, Q^2 higher than 0, 0.25, and 0.50 depict small, medium, and large predictive relevance of the PLS-path model[59].

In our model, R^2 was 0.506, 0.377, and 0.210 for perceived water value, park satisfaction, and perceived water quality(Table 7). These results indicated a moderate to weak level of predictive accuracy. Considering the potential antecedents of environmental perceptions and satisfaction, this construct's R^2 values were satisfactory. In our model, Q^2 are 0.500, 0.278, and 0.113 for perceived water value, park satisfaction, and perceived water quality(Table 7). These results showed the sufficient predictive capability of the proposed model in this study.

Table 7: Coefficient of Determination and Cross-validated Redundancy Measure for Structural Model

Endogenous Latent Constructs	R^2	Q^2
PWV	0.506	0.500
PS	0.377	0.278
PWQ	0.210	0.113

3.2.3 Direct Path Relationships for Structural Model

PLS-SEM is a nonparametric method and therefore bootstrapping is used to determine statistical significance[59]. To assess the direct relationship among constructs, the path coefficients(β) and their significance were tested using a bootstrapping procedure with a resample of 5000[59]. The path relationship was deemed to be significant at 0.05 significance levels when the t-value was higher than 1.96[61]. (Table 8) showed the direct path relationship among constructs. Each path relationship corresponded to a hypothesis that was raised in (Table 3).

Table 8: Results of Direct Effects among Constructs

Paths (Hypothesis)	β (path coefficient)	SE	t.values (one-tailed)	P values	Result	Robustness Checks
H1a: RCC - PWQ	-0.215	0.042	5.077	0.000	Supported	Robust
H1b: PA - PWQ	0.086	0.046	1.871	0.061	Not Supported	Robust
H1c: PVV - PWQ	-0.099	0.054	1.849	0.065	Not Supported	Robust
H1d: PWV - PWQ	0.424	0.055	7.676	0.000	Suported	Robust
H2a: RCC - PWV	-0.106	0.043	2.477	0.013	Suported	Sensitive
H2b: PA - PWV	0.173	0.041	4.183	0.000	Suported	Sensitive
H2c: PVV - PWV	0.634	0.037	17.103	0.000	Suported	Robust
H3a: RCC - PS	0.006	0.041	0.140	0.889	Not Supported	Robust
H3b: PA - PS	0.127	0.043	2.941	0.003	Suported	Robust
H3c: PVV - PS	0.157	0.062	2.550	0.011	Suported	Robust
H3d: PWV - PS	0.447	0.061	7.288	0.000	Suported	Robust
H3e: PWQ - PS	-0.026	0.042	0.606	0.544	Not Supported	Robust

Among them, hypotheses H1b, H1c, H3a, and H3e have been rejected because they were not significant at the significant level of 5%. All other paths have been accepted at a significant level of 5%. We found that for factors that impacted perceived water quality, perceived water quality was positively impacted by perceived water value (β=0.424) and negatively impacted by river contamination concerns(β=-0.215). For factors that impacted perceived water value, perceived water value was positively impacted by place attachment(β=0.173) and perceived water value(β=0.634) and negatively impacted by river contamination concerns(β=-0.106). For factors that impacted park satisfaction, park satisfaction was positively impacted by place attachment(β=0.127), perceived water value(β=0.447), and perceived water value(β=0.157), for which the impact of perceived water value on park satisfaction was greater than others. The robustness of these results has also been reported in (Table 8). The procedure for the robustness check will be introduced in later sections.

The evidence we've obtained regarding the perceptions of water bodies aligned with the findings of previous studies. First, the perceptions of water bodies were negatively impacted by environmental concerns[67]. Our findings regarding the negative impact of river contamination concerns on perceived water quality and perceived water value supported such conclusions. Second, the perceptions of water bodies were impacted by other conditions of aquatic environments, such as vegetation and naturalness[54]. Such inference was also reflected in our conclusion that perceived water value has a positive impact on perceived water value. Additionally, a close connection between the perceived value and quality of water bodies indicated the consistency in individuals' environmental perceptions in the context of water.

Our conclusion that place attachment, perceived water value, and perceived water value had positive impacts on park satisfaction also aligned with previous studies[47][21][40]. Although previous studies have suggested a correlation between environmental concerns(e.g., river contamination concerns) and park satisfaction[55], our results do not support such a conclusion. Perhaps it was because our definition of environmental concerns was limited to the river context. Although previous studies have suggested that water quality had a hedonic value[41][42], our results do not support the significant impact of perceived water quality on park satisfaction.

In summary, the direct path relationships showed factors that might impact individuals' perceptions of water bodies and park satisfaction. The perceived water quality was negatively impacted by river contamination concerns and positively impacted by perceived water value. The perceived water value was negatively impacted by river contamination concerns and positively impacted by place attachment, perceived vegetation value, and perceived water quality. The park satisfaction was positively impacted by place attachment, perceived vegetation value, and perceived water value. The perceived value of water was the most significant factor impacting park satisfaction. Illustrated the importance of the perception of water bodies on environmental satisfaction. The paths plot (Figure 3) showed the significance and relevance of each path. We also test whether such relationships may vary across females and males. The results of an additional Multigroup Analysis(MGA)(Appendix B) illustrated that psychological factors seem to play a more important role in females' environmental perceptions.

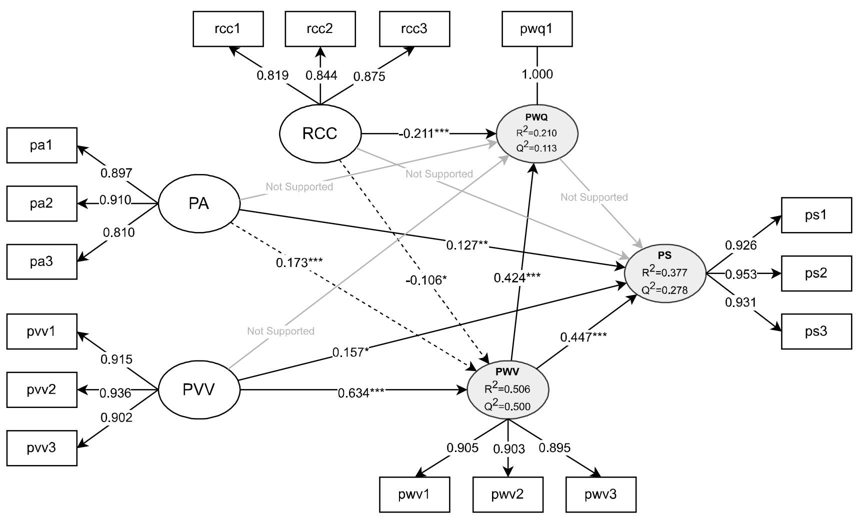

Figure 3: PLS-SEM Path with Significance and Relevance of the Path Coefficients

3.2.4 Mediating Effect (Indirect Path Relationship) for Structural Model

The direct effect of perceived water value on park satisfaction was greater than other direct effects, supporting previous studies' conclusions about the importance of water bodies on environmental satisfaction[9]. Although past discussions had provided potential explanations for water preferences from a human evolutionary perspective[9][52], discussions on such preferences still lacked an explanation driven by a quantitative framework. Previous studies revealed that landscapes with water bodies were generally more popular than those without water bodies[9], and people had different preferences for various landscape compositions and different proportions of water bodies[9][24][52]. These findings implied that the impact of water bodies on environmental perceptions and satisfaction may be related to other landscape elements, not only to the water bodies themselves. To explore whether water bodies impact the perceptions of other landscape elements and whether this impact also affects overall environmental satisfaction, we hypothesized the existence of a mediating effect.

The mediating effect is that the effect of an independent variable on a dependent variable is transmitted through a third variable[68]. In the PLS-SEM context, the significant mediating effect refers to significant existing indirect effects. The mediating effect or indirect effect among constructs was supported when the t-value exceeded the benchmark of 1.96 at a significance level of 0.05, as well as the zero value being excluded from the confidence interval[61][56]. In the context of this study, this referred to that the perceptions of water bodies may simultaneously impact the perceptions of other landscape elements and environmental satisfaction. If the mediating effect existed, it indicated that the perceptions of water bodies not only had a direct effect on park satisfaction but also had an indirect effect on park satisfaction by influencing other landscape elements.

In the PLS-SEM framework, we tested all potential mediating effects on park satisfaction(Table 9) . Among them, the mediating effect of perceived water value was significant in several paths. Specifically, perceived water value acted as a mediator. It provided mediating effects among river contamination concerns to park satisfaction(β=-0.047), place attachment to park satisfaction(β=0.077), and perceived water value to park satisfaction(β=0.283). Although three paths are significant, only the path of perceived water value to perceived water value to park satisfaction passed the later robustness check. Therefore, only this path has generalizable significance, and other mediating effects may still need further exploration.

Although there was a positive direct effect of perceived water value on park satisfaction, the indirect effect brought by the mediator, perceived water value, far exceeds the direct effect of perceived water value on park satisfaction. This emphasizes that those who perceived both vegetation value and water value are likely to have higher park satisfaction compared to those who only perceived vegetation value. A fun fact was that we also conducted additional tests to assess whether perceived water value will serve as a mediator between perceived water value to park satisfaction. However, the result was not significant. The result, once again, emphasized the importance of the water bodies on environmental satisfcations and perceptions. Especially, we introduce a new perspective to understand why scenes with water receive preference. Our results support such an explanation: the perceptions of water bodies act as a mediator, impacting the connection between other landscape elements and environmental satisfaction.

Table 9: Results of Specific Indirect Effects on PS among Constructs

Specific Indirect Effect	β (path coefficient)	SE	t.values (one-tailed)	P values	Mediating Effect	Robustness Checks
RCC - PWV - PS	-0.047	0.020	2.311	0.021	YES	Sensitive
PVV - PWQ - PS	0.003	0.005	0.521	0.602	NO	Robust
PA - PWV - PS	0.077	0.022	3.474	0.001	YES	Sensitive
PWV - PWQ - PS	-0.011	0.018	0.596	0.551	NO	Robust
PVV - PWV - PS	0.283	0.043	6.554	0.000	YES	Robust
PA - PWV - PWQ - PS	-0.002	0.003	0.584	0.559	NO	Robust
RCC - PWV - PWQ - PS	0.001	0.002	0.545	0.586	NO	Robust
PVV - PVW - PWQ - PS	-0.007	0.012	0.593	0.553	NO	Robust
RCC - PWQ - PS	0.005	0.010	0.575	0.565	NO	Robust
PA - PWQ - PS	-0.002	0.004	0.531	0.596	NO	Robust

The total effect refers to the sum of the direct and indirect effects(Table 10). Perceived water value and perceived water value had the greatest total effect on park satisfaction, followed by place attachment. The total effects of perceived water quality and river contamination concerns on park satisfaction are insignificant.

Table 10: Results of Total Effects on PS among Constructs

Total Effects on PS	β (path coefficient)	SE	t.values (one-tailed)	P values
RCC - PS	-0.035	0.045	0.768	0.443
PA - PS	0.200	0.043	4.692	0.000
PVV - PS	0.436	0.047	9.225	0.000
PWV - PS	0.436	0.059	7.372	0.000
PWQ - PS	-0.026	0.042	0.606	0.544

3.2.5 Robustness Check for PLS-SEM

For the last decade, PLS-SEM has become popular as a method of choice for investigating intricate relationships between observed and latent constructs in social science research. However, when applying PLS-SEM, researchers need to perform necessary robustness checks or the reliability of their results will be questioned[69]. Regrettably, most applications of PLS-SEM in environmental science neglected robustness checks. This challenges the reliability of the results. To check the robustness of our results, we test the nonlinearity, endogeneity, and unobserved heterogeneity in our PLS-SEM.

In PLS-SEM, it is necessary to verify whether there are nonlinear effects between variables. If a relationship is "erroneously assumed to be linear then not only will the true relationship be underestimated, but the effects of this relationship might register as weak or insignificant"[70]. Our analysis of nonlinear effects followed [71]'s rules of thumb. First, we used the two-stage approach to create the nonlinear term. The following equation showed a model with a quadratic effect:

$$Y_1 = p_1 Y_2 + p_2 Y_2^2 + e_1, \tag{1}$$

where p_1 and p_2 are the path coefficients of the linear and quadratic relationships between Y_1 and Y_2. Y_2^2 introduced a quadratic effect referred to as an interaction term describing the interplay of the predictor construct with itself.

[72]'s two-stage approach is more appropriate for operationalizing the interaction term[71]. In the first stage of their approach, the model was estimated with Y_1, but without the interaction term Y_2^2. The PLS-SEM results included the Y_1 construct scores, which allow for computed Y_2^2. The second stage added the interaction term as the single-item construct Y_2^2 to the model, for which we computed the final results[71]. Second, we assessed the quadratic effect's statistical significance through bootstrapping with 5000 subsamples based on the percentile approach and using no sign changes(α=0.05). The quadratic effect was significant in both paths of river contamination concerns to perceived water value and place attachment to perceived water value and the quadratic effect was insignificant in other paths(Table 11).

Although both existing quadratic effects coefficients were small for these two paths[71], the conclusion from these two paths might still need to be considered sensitive.

Table 11: Nonlinearity Result

Potential Nonliearity	Coefficient	P-Value
QE (RCC) - PWQ	-0.039	0.271
QE (PA) - PWQ	-0.011	0.774
QE (PVV) - PWQ	-0.022	0.537
QE (PWV) - PWQ	-0.003	0.936
QE (RCC) - PWV	-0.092	0.008
QE (PA) - PWV	0.072	0.031
QE (PVV) - PWV	-0.026	0.352
QE (RCC) - PS	0.014	0.678
QE (PA) - PS	-0.015	0.688
QE (PVV) - PS	-0.021	0.661
QE (PWV) - PS	-0.004	0.921
QE (PWQ) - PS	-0.045	0.244

The consideration of endogeneity is a key issue when applying PLS-SEM. In PLS-SEM, the endogeneity occurs when a predictor construct is correlated with the error term of the dependent construct to which it is related. It mostly arises from omitted constructs that correlate with one or more predictor constructs and the dependent construct in a partial regression of the PLS path model[70]. [73] developed a systematic procedure for identifying and treating endogeneity in PLS-SEM. It controls for endogeneity by directly modeling the correlation between the endogenous variable and the error term utilizing a copula. Our assessment of potential endogeneity followed[73], starting with applying the Gaussian copula approach, using the latent variable scores of the original model estimation as input[70]. The results in (Table 12) showed that none of the Gaussian copulas was significant(all p value > 0.05). It suggested that there are no critical endogeneity problems exist in the model.

Table 12: Endogeneity

Potential Endogeneity	Constructs	Coefficient	P values
Gaussian Copula of Endogenous Variable	RCC	0.146	0.346
PWQ	PA	-0.039	0.79
	PVV	-0.078	0.264
	PWV	0.001	0.993
Gaussian Copula of Endogenous Variable	RCC	-0.187	0.175
PWV	PA	0.114	0.245
	PVV	0.027	0.613
Gaussian Copula of Endogenous Variable	RCC	0.094	0.452
PS	PA	-0.033	0.724
	PVV	0.004	0.951
	PWV	-0.08	0.16
	PWQ	-0.198	0.36

Unobserved heterogeneity occurs when subgroups of data exist, each entailing substantially different model estimates[70]. To identify unobserved heterogeneity, we applied the Finite Mixture Partial Least Squares(FIMIX-PLS) approach[74]. Following[70], we initiated the procedure by assuming a one-segment solution, using the default settings for the stop criterion($10^{-10} = 1.0E - 10$), the maximum number of iterations (5000), and the number of repetitions (10). To determine the number of segments used in FIMIX-PLS, we applied the minimum r-squared method[75][76]. In the significance level of 0.05 and assuming that power was set at 0.8, the minimum r-squared method suggested a minimum sample size in each segment was 147. Our total sample size was 475, which allows for extracting a maximum of three segments. We, therefore reran FIMIX-PLS for two to three segments using the same settings as in the initial analysis. According to [74]'s suggestion, we compared several information criteria, including modified AIC with Factor 3 (AIC_3), modified AIC with Factor 4 (AlC_4), and consistent AIC ($CAIC$). In addition, normed entropy statistic (EN) values should be above 0.50 to permit a clear-cut classification of data into the pre-determined number of segments. In our test results (Table 13), EN for all new segments higher than 0.50. Among these criteria, AIC3 suggested 3 segments, AIC4 suggested 3 segments, and CAIC suggested 2 segments. When metrics point to a one-segment solution or produce divergent results, we can conclude that unobserved heterogeneity does not significantly affect the data[70].

Table 13: Unobserved Haterogeneity

Information Criteria	1 Segments	2 Segments	3 Segments
AIC_3	3405.294	2583.611	2546.084
AIC_4	3420.294	2614.611	2593.084
$CAIC$	3467.744	2712.674	2741.759
EN	0	0.896	0.824

Overall, there were no significant robustness problems in the model. We did not find endogeneity and unobserved heterogeneity. Although nonlinearity was found in two specific paths, the quadratic effect was weak. In the future, it might be possible to consider investigating them by nonlinear models.

4 Discussion

4.1 Complexity of perception of water bodies beyond the framework

The results of PLS-SEM reveal some processes of perceptions of water bodies. We defined the perceptions of water bodies as a dual concept of perceived values and quality. Although these two forms of perceptions are very similar, there are still subtle differences. Perceived values may emphasize knowledge and beliefs. Values refer to a consistent knowledge and belief about the worth and importance of an object[39]. The perceptions and judgments of the value of water are likely to be impacted by individuals' knowledge and beliefs. Perceived quality may emphasize the visual attributes of water. In the context of water, quality perceptions were more directly expressed as water quality perceptions. Previous studies suggested that visual parameters dominate the perceptions and judgment of water quality, whether for drinking or environmental water[53].

However, the perceived water value of water bodies may also be impacted by visual factors[42], and perceived water quality may also be impacted by knowledge and beliefs[53]. These subtle similarities and differences illustrate the complexity of environmental perceptions. We discussed factors that impacted the perceptions of water bodies. However, when considering the complexity of environmental perceptions, the relationships revealed in our quantitive framework are just the tip of the iceberg. The perceptions of water bodies or the perceptions of the aquatic environment, are also impacted by many other factors such as water quality, environmental characteristics, and demographics[53][77][33]. We hope to point out that considering such a level of complexity within a limited framework may not be meaningful, therefore, we focus only on how individual knowledge and beliefs and general vegetation perceptions related to the perceptions of water bodies.

4.2 Rethink Water - Highlighting the Mediating Effect

Our results emphasize the importance of water bodies in the experience of UBGS. Riparian zones should not be simply subsumed into green space[27]. When studying urban green spaces (UGS), water-related attributes should be identified to avoid potential biases.

Previous literature has emphasized human preferences[9]. From the landscape perspective, water bodies are often viewed as a favorite landscape element and highly related to aesthetic preferences[24][9]. While previous research has discussed how water is important[41][25], our findings provided a new insight to explain why water is important. As previously discussed, the perceived water value may be based on visual aspects or knowledge and beliefs aspects. In our discussions, we will focus on its visual aspects because the perceived vegetation value to perceived water value to park satisfaction is the only significant and robust mediating effect path. Furthermore, insight from visual aspects may provide more practical insights into the landscape field.

From the visual aspect, water bodies can be considered as mediators between landscape elements and broader environmental perceptions. In our study, the perceived water value is a significant and robust mediator between perceived vegetation value and park satisfaction. In other words, individuals who perceive the value of both water bodies and vegetation are more likely to have higher park satisfaction than those who perceive only the value of vegetation. Here, perceived water value was a mediator, strengthening individuals' perceived vegetation value and park satisfaction. This finding was also hinted at in previous research. Natural or built environments with water bodies are generally preferred over those without[24][9]. By varying the proportion of aquatic, green, and built environments in the scenes, preferences also changed[9]. While these studies typically emphasized the importance of water bodies for environmental perceptions and satisfaction, the mediating effect we identified suggests an underlying relationship where water bodies impact not only environmental perceptions and satisfaction but also the perceptions of other landscape elements. Therefore, the importance of water bodies for environmental perceptions and satisfaction stems from their direct and indirect effects on perceptions and satisfaction.

It should be noted that this study and most previous literature primarily focus on the positive aspect of water bodies on perceptions. However, water bodies can have negative impacts during the perception process, and the mediating effects might amplify these negative impacts. For example, water bodies in post-industrial landscapes were often composed of industrial wastewater. These aesthetically unpleasing water bodies reinforce the negative perceptions people have toward post-industrial landscapes[78]. Additionally, varying water attributes can lead to different perceptions of design elements. For example, High and low water levels will likely degrade landscape experiences[79].

In summary, we hope that landscape designers rethink the mediating effects of water. Aesthetically pleasing water bodies may enhance the positive perceptions of other landscape elements and improve environmental satisfaction. Conversely, aesthetically unpleasing water bodies might also reinforce the negative perceptions of other landscape elements and degrade environmental satisfaction. Considering the substantial direct and indirect effects(mediating effects) that water bodies have on aesthetics, as well as the potential restorativeness of blue spaces, we call for more care and attention to the design and maintenance of water bodies.

4.3 Limitation and future study

This study still has many limitations. Firstly, it is a cross-sectional study, and there may be potential biases. Secondly, perceptions are complex, and many factors outside the framework could impact perceptions, but these factors were not considered in our framework. Thirdly, some paths have nonlinear relationships that did not pass robustness checks (our research tools require linear relationships). Understanding and addressing these non-linear relationships in future studies could provide useful insight. Fourthly, we provided male and female subgroup analyses to test if the conclusions of the paths vary between different groups. However, the conclusions might also change across other groups, such as groups with different ages. In the future, the moderating effects of different groups could be considered. Fifthly, we primarily focused on the perceptions of water bodies as a mediator from a landscape perspective. Considering that blue spaces often have potential health benefits (e.g., restorativeness), we encourage exploring whether water is a mediator of health from other disciplinary perspectives.

5 Conclusion

Blue space cannot simply be subsumed into green space. Oversight of the water feature will compromise understanding people's interactions with the environment. In our empirical research, we further revealed the importance of water body perceptions and how these perceptions impact environmental satisfaction.

First, by categorizing the perceptions of water bodies into perceived water quality and perceived water value. We found that perceived water quality is positively impacted by perceived vegetation value and negatively impacted by river contamination concerns. Perceived water value is positively impacted by perceived vegetation value and place attachment and negatively impacted by river contamination concerns. Perceived water quality and perceived water value are positively correlated with each other. These environmental perception mechanisms may be different among different groups. In our study, psychological factors seem to play a more important role in female's environmental perceptions.

Second, we found that place attachment, perceived water value, and perceived vegetation value have significant positive direct effects on park satisfaction. Among them, the direct effect of perceived water value on park satisfaction is greater than others. This highlights the importance of water bodies in environmental satisfaction.

Third, we revealed that perceived water value is a positive mediator between perceived vegetation value and place attachment to park satisfaction. Additionally, perceived water value is a negative mediator from river contamination concerns to park satisfaction. Among these, the mediating effect of perceived water value between perceived vegetation value and park satisfaction is robust. The results implied water bodies may serve as the bridge linking the perceptions of different landscape elements with broader environmental satisfaction. The insight provides a new perspective to understand and explain how and why the water bodies are important for environmental perceptions and satisfaction.

In summary, our results highlight the importance of water in various aspects of human-nature interactions. We encourage rethinking water as a mediator in different settings. Increasing care and attention to water bodies in the various stages of planning, landscape design, and environmental governance can help create more enjoyable natural environments for people.

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A Survey for the study

1. How would you think the **general water quality is on average at** this waterfront park?

Worst possible quality:
May have bad odor, oil, raw sewage, unhealthy for plant and animal life.

Best possible quality:
Clear, safe for all activities, never has closures, healthy for plants and animal life.

◯ *Poor* ◯ *Passable* ◯ *Satisfactory* ◯ *Good* ◯ *Excellent*

2. How would you rate your level of agreement with the following statement, where 1=Strongly Disagree to 5=Strong Agree:

	Strongly Disagree		*Neutral*		*Strongly Agree*
Place Attachment					
I am very attached to Huron River.	*1*	*2*	*3*	*4*	*5*
Huron River is a special place for me and my family.	*1*	*2*	*3*	*4*	*5*
No other place can compare to Huron River.	*1*	*2*	*3*	*4*	*5*
Attitude to this Park					
Visiting this park is enjoyable	*1*	*2*	*3*	*4*	*5*
Visiting this park is a positive experience	*1*	*2*	*3*	*4*	*5*
Visting this park is fun	*1*	*2*	*3*	*4*	*5*
Water Rating					
The water body in this park provides a good environment for ***recreation***.	*1*	*2*	*3*	*4*	*5*
The water body in this park provides a good ***aesthetic*** value.	*1*	*2*	*3*	*4*	*5*
The water body in this park provides a good ***ecological*** value	*1*	*2*	*3*	*4*	*5*
Vegetation Rating					
The vegetation in this park provides a good environment for ***recreation.***	*1*	*2*	*3*	*4*	*5*
The vegetation in this park provides a good **aesthetic** value.	*1*	*2*	*3*	*4*	*5*
The vegetation provides a good **ecological** value.	*1*	*2*	*3*	*4*	*5*
Contamination Understanding					
The Huron River faces threats from various sources of contamination.	*1*	*2*	*3*	*4*	*5*
Contact with Huron River waterbody is unsafe.	*1*	*2*	*3*	*4*	*5*
It's still not safe to eat fish from the most part of Huron River	*1*	*2*	*3*	*4*	*5*

3.What is your **age**?

◯ *18-29* ◯ *30-39* ◯ *40-49* ◯ *50-59* ◯ *60+*

4. What is your **gender**?

◯ *Male* ◯ *Female* ◯ *Genderqueer*

5. What is your **race**?

◯ *White* ◯ *Black or African American* ◯ *American Indian and Alaska Native*
◯ *Asian* ◯ *Hispanic or Latino* ◯ *Native Hawaiian and Other Pacific Islander*
◯ *Other (Indicate it if your like to: ___________________)*

6. What is your highest **educational attainment**?

◯ *Bachelor's degree* ◯ *Associate's degree* ◯ *Some college, no degree*
◯ *High School or equivalent degree* ◯ *Graduate or professional degree*

B Moderating Effect of Gender (Multigroup Analysis) for Structural Model

Gender was one of the interesting demographic factor found to influence environmental perceptions. For example, males tended to perceive that water-related risks were lower than their female counterparts' perceived risks[53]. [80] attribute one possible reasons to greater risk acceptance by males. However, the mechanism behind these differences need further investagtion. To explore the differences brought by gender, we divided the sample into two groups: male and female and invesitgate whether significance and correlation of previous paths will change between two groups.

Multigroup analysis(MGA) was used to understand the significant differeance between two groups. Based on [61] suggestion, we use the three-step procedure to test the measurement invariance of composite models(MICOM), which is a mandatory requirement for executing MGA. Testing for measurement invariance determines "whether or not, under different condition of observing and studying phenomena, measurement models yield measures of the same attribute"[61][63]. The three-step procedure for MICOM are: step1-configural invariance assessment; step2-the establishment of compositional invariance assessment; step3-assessment of equal means and variances[61].

For step1, the configuration of model in two groups should keep as same to conducted MGA. For step2, in [63]'s method, returns permutation-based confidence intervals that allow determining if a composite has a correlations in Group A and Group B that is significantly lower than one. All retruned permutation p-value for constructs in step2 higher than 0.05 illustrated that the composite does not differ much in both groups and compositional invariance (partially invariance) has been established. For step3, in [63]'s method, permutation-based confidence intervals for the mean values and the variances allow assessing if a composite's mean value and its variance differs across groups. All retruned permutation p-value for constructs in step3 higher than 0.05 illustrated that full measurement invariance has been established. Test the measurement invariance results (Table 14) suggested that MGA can be conducted[61].

Table 14: Results of Invariance Measurement Testing Using Permutations

Constructs	Step1 Configural Invariance	Step 2 Compositional Invariance	Partial Measurement Invariance Established	Step3a Equal Mean	Step3b Equal Variances	Full Measurement Variance Established
		Permutaiton P		Permutaiton P	Permutation P	
RCC	YES	0.515	YES	0.372	0.561	YES
PA	YES	0.257	YES	0.794	0.346	YES
PVV	YES	0.892	YES	0.054	0.684	YES
PWV	YES	0.663	YES	0.326	0.473	YES
PS	YES	0.212	YES	0.527	0.842	YES
PWQ	YES	0.104	YES	0.398	0.709	YES

Same to PLS-SEM, the MGA based on bootstrapping method. MGA focuses on comparing whether the significance of the paths changes between different groups. We use a significance level of 0.05 as the threshold to check whether the significance changes. (Table 15) shows the result.

Table 15: MGA result for direct impact: Male vs Female

paths	β (path coefficient-Feamle)	β (path coefficient-Male)	p value (Feamle)	p value (Male)	Invariant
RCC - PWQ	-0.172	-0.267	0.007	0.000	YES
PA - PWQ	0.196	-0.034	0.002	0.614	NO
PVV - PWQ	-0.070	-0.073	0.360	0.348	YES
PWV - PWQ	0.337	0.481	0.000	0.000	YES
RCC - PWV	-0.120	-0.057	0.006	0.494	NO
PA - PVW	0.201	0.113	0.000	0.105	NO
PVV - PWV	0.664	0.607	0.000	0.000	YES
RCC - PS	0.025	-0.010	0.644	0.892	YES
PA - PS	0.133	0.108	0.019	0.118	NO
PVV - PS	0.131	0.181	0.126	0.059	YES
PWV - PS	0.479	0.419	0.000	0.000	YES

First, regading PWQ. Only the relationship between PA to PWQ changed. PA has postive impact on PWQ in famale group(female$\beta_{(PA)\rightarrow(PWQ)}$=0.196,p=0.002), but this but this relationship is not significant in the male group.

Second, regarding PWV. The relationships of RCC to PWV and PA to PWV were changed. PA has positive impact on PWV in female group(female$\beta_{(PA)\to(PWV)}$=0.201,p<0.001) and RCC has negative impact on PWQ in female group(female$\beta_{(RCC)\to(PWV)}$=-0.120,p=0.006) But both relationship is not significant in the male group.

Thrid, regarding PS. The relationships of PA to PS were changed. PA has positive impact on PS in female group(female$\beta_{(PA)\to(PS)}$=0.133,p=0.019), but this relationship is not significant in the male group.

The reasons for this difference still require further attribution, but we note that the changes in relationships are mainly related to psychological factors (PA and RCC) and unrelated to visual features (PWQ and PVV). A guess is that these psychological factors play a more important role in female's environmental perception and satisfcation. This difference might be reasonable because female do indeed show more place attachment and environmental concern than male[81][80]. However, the such guess require further research to confirm.