

RESEARCH ARTICLE

Multi-level analysis of environmental justice perception's influence on public participation in urban planning

Jiaxin Yi¹, Tao Zou^{2*}

¹ *Urban Design and Planning, University of Sydney, Australia*

² *School of Management, Northwestern Polytechnical University, Xi'an 710000, China*

* **Corresponding author:** Tao Zou, waltzszou@163.com

ABSTRACT

This study investigates the multi-level effects of environmental justice perceptions on public participation willingness in urban planning. Employing a hierarchical linear modeling approach, we analyzed data from 816 residents across three major U.S. cities. Results reveal that procedural justice is the strongest predictor of participation willingness, followed by distributive and recognition justice. Significant cross-level interactions were observed, with neighborhood social capital amplifying the effect of procedural justice, and city-level environmental quality moderating the impact of distributive justice. Socioeconomic factors exhibited both direct and indirect effects, with income level positively moderating the relationship between procedural justice and participation. The study contributes to environmental justice theory by demonstrating the differential impacts of justice dimensions and their contextual variations. It also bridges environmental justice and public participation literature through an integrated multi-level framework. Practical implications include the importance of transparent decision-making processes, context-sensitive participation strategies, and initiatives to build community social capital. These findings provide valuable insights for urban planners and policymakers seeking to enhance public engagement in environmental planning and promote more just, sustainable urban environments.

Keywords: Environmental justice; public participation; urban planning; multi-level analysis; procedural justice; distributive justice; recognition justice; social capital; environmental quality; civic engagement

1. Introduction

In recent decades, the concept of environmental justice has gained significant traction in both academic discourse and policy-making circles, particularly in the context of urban planning and development. As cities continue to expand and evolve, the equitable distribution of environmental benefits and burdens has become a critical concern for planners, policymakers, and citizens alike ^[1]. The perception of environmental justice, or the lack thereof, has emerged as a crucial factor influencing public participation in urban planning processes, shaping the way communities engage with and respond to proposed urban developments and environmental policies. Environmental justice, as defined by Schlosberg ^[2], encompasses the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. This

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multifaceted concept not only addresses the distribution of environmental risks and benefits but also emphasizes the importance of recognition, participation, and procedural fairness in decision-making processes ^[3]. As urban areas grapple with challenges such as climate change, air pollution, and green space allocation, the lens of environmental justice becomes increasingly relevant in shaping sustainable and equitable urban futures. Public participation in urban planning has long been recognized as a cornerstone of democratic governance and sustainable urban development. Arnstein's seminal work on the ladder of citizen participation ^[4] laid the groundwork for understanding the varying degrees of public involvement in decision-making processes. However, the relationship between environmental justice perceptions and the willingness of citizens to engage in urban planning processes remains underexplored, particularly from a multi-level perspective that considers individual, community, and institutional factors. Recent studies have highlighted the complex interplay between environmental justice perceptions and public participation. For instance, Maantay and Maroko ^[5] demonstrated how GIS-based analyses can reveal spatial inequities in environmental burdens, potentially motivating community action. Similarly, Pearsall and Pierce ^[6] explored how perceptions of environmental injustice can mobilize grassroots movements and influence urban policy-making. These findings suggest that individuals and communities who perceive environmental injustices may be more likely to engage in urban planning processes, albeit with varying degrees of efficacy and impact. However, the relationship between environmental justice perceptions and public participation is not straightforward. Factors such as socio-economic status, education level, access to information, and trust in institutions can significantly modulate this relationship ^[7]. Moreover, the multi-level nature of urban governance, involving interactions between individual citizens, community organizations, and various levels of government, adds layers of complexity to understanding and promoting effective public participation ^[8].

This study aims to address these complexities by employing a multi-level analysis to examine how perceptions of environmental justice influence public participation in urban planning. By integrating insights from environmental psychology, urban sociology, and planning theory, we seek to develop a comprehensive understanding of the mechanisms through which environmental justice perceptions shape civic engagement in urban development processes. This research not only contributes to the theoretical discourse on environmental justice and public participation but also offers practical insights for policymakers and planners seeking to foster more inclusive and equitable urban planning practices.

As cities worldwide strive to become more sustainable, resilient, and equitable, understanding the dynamics of environmental justice perceptions and public participation becomes increasingly crucial. This study, therefore, aims to shed light on these important relationships, potentially informing strategies to enhance public engagement in urban planning and promote more just and sustainable urban environments for all citizens.

2. Review of the literature

2.1 Urban Planning: Definition and Levels

Urban planning is a multifaceted discipline that shapes the physical, social, and economic fabric of cities. As defined by the American Planning Association, it is "a dynamic profession that works to improve the welfare of people and their communities by creating more convenient, equitable, healthful, efficient, and attractive places for present and future generations" ^[42]. This comprehensive approach to urban development has evolved significantly over time, reflecting changing societal needs and environmental concerns ^[43]. The practice of urban planning operates across various interconnected levels. At the broadest scale, strategic planning sets long-term visions for cities and regions, often spanning decades ^[44]. Regional planning addresses issues that transcend municipal boundaries, such as transportation networks and resource

management ^[45]. At the city level, comprehensive plans integrate various aspects of urban development, including land use, housing, and public services ^[46]. Community planning focuses on neighborhood-scale improvements and often involves substantial public participation ^[47]. Additionally, specialized planning addresses specific urban functions or challenges, such as environmental planning or historic preservation ^[48].

Across all these levels, the principles of sustainability and equity have become increasingly central to urban planning theory and practice ^[49]. The integration of environmental justice considerations into planning processes reflects a growing recognition of the unequal distribution of environmental benefits and burdens in urban areas ^[50]. This evolving focus underscores the critical role of public participation in ensuring that urban planning outcomes reflect the diverse needs and aspirations of city residents ^[51].

2.2 Theory of environmental justice

Environmental Justice Theory has evolved significantly since its inception in the 1980s, expanding from a focus on the disproportionate distribution of environmental hazards among minority and low-income communities to a more comprehensive framework encompassing various dimensions of justice ^[8]. The theory now integrates concepts of distributive justice, procedural justice, and recognition justice, providing a multifaceted approach to understanding environmental inequities ^[9]. Distributive justice, the most traditional aspect of environmental justice, focuses on the fair allocation of environmental benefits and burdens across different social groups ^[10]. This dimension has been extensively studied, revealing patterns of environmental inequality in various contexts, from the siting of hazardous waste facilities to access to green spaces in urban areas ^[11]. Procedural justice, another crucial component of environmental justice theory, emphasizes the importance of fair and inclusive decision-making processes ^[12]. This aspect highlights the need for meaningful participation of all stakeholders, particularly marginalized communities, in environmental policy-making and urban planning. Schlosberg argues that procedural justice is not merely about inclusion in existing processes, but also about transforming these processes to be more equitable and accessible ^[13]. Recognition justice, a more recent addition to the environmental justice framework, addresses the cultural and institutional processes that lead to the misrecognition or devaluation of certain groups ^[14]. This dimension underscores the importance of acknowledging diverse perspectives, knowledges, and cultural practices in environmental decision-making. Recent developments in environmental justice theory have also incorporated the concept of capabilities, drawing from Sen and Nussbaum's work ^[15]. This approach considers justice not only in terms of fair distribution or procedures but also in terms of the ability of individuals and communities to function fully in society and to have the freedom to achieve well-being ^[16].

Furthermore, environmental justice theory has expanded to encompass global issues, such as climate justice, recognizing the transboundary nature of many environmental challenges ^[17]. This global perspective has led to new considerations of intergenerational justice and the rights of nature, pushing the boundaries of traditional justice frameworks ^[18].

2.3 Public participation in urban planning

Public participation in urban planning has become increasingly recognized as a crucial element in creating sustainable, inclusive, and resilient cities ^[18]. This shift towards more participatory approaches in urban governance reflects a broader trend in democratic practices and responds to the growing complexity of urban challenges, including climate change, social inequality, and rapid urbanization ^[19]. The concept of public participation in urban planning has evolved significantly since Arnstein's seminal 'ladder of citizen participation' ^[20]. Contemporary approaches emphasize not only the degree of citizen power in decision-making processes but also the quality and inclusivity of participation ^[21]. Innes and Booher propose a collaborative model of participation that goes beyond traditional public hearings to include diverse

stakeholders in authentic dialogue and mutual learning ^[22]. Digital technologies have transformed the landscape of public participation, offering new platforms for engagement and data collection ^[23]. Geographic Information Systems (GIS) and social media have enabled more interactive and spatially-informed participation processes, although concerns about digital divide and representation persist ^[24]. The concept of 'smart cities' has further intensified discussions about technology-enabled citizen engagement in urban planning ^[25]. However, challenges remain in implementing effective public participation. Power imbalances, technical complexity of planning issues, and institutional inertia can hinder meaningful engagement ^[26]. Moreover, there is growing recognition that participation processes must be culturally sensitive and adaptive to local contexts ^[27].

Recent scholarship has also highlighted the importance of connecting public participation to broader issues of social justice and environmental sustainability ^[28]. This involves not only engaging diverse stakeholders but also addressing structural inequalities that may affect participation and outcomes ^[29]. Fainstein argues for a 'just city' approach that combines participation with equity and diversity in urban planning processes ^[30].

As cities grapple with complex challenges like climate adaptation and post-pandemic recovery, innovative approaches to public participation are emerging. These include co-creation methodologies, citizen science initiatives, and participatory budgeting, all aiming to deepen democratic engagement in shaping urban futures ^[31].

2.4 Relationship between the perception of environmental justice and public participation

The relationship between environmental justice perception and public participation in urban planning is complex and multifaceted, reflecting the intricate dynamics of social, environmental, and political processes in urban contexts ^[31]. Environmental justice perceptions can serve as a powerful motivator for civic engagement, particularly when communities feel disproportionately affected by environmental burdens or excluded from environmental benefits ^[32]. Studies have shown that communities with heightened awareness of environmental injustices are more likely to mobilize and participate in urban planning processes ^[33]. This increased participation often stems from a desire to address perceived inequities and advocate for fair distribution of environmental risks and resources ^[34]. However, the relationship is not always straightforward; factors such as trust in institutions, socio-economic status, and access to information can significantly moderate the link between perception and action ^[35]. Conversely, public participation processes can also shape environmental justice perceptions. Inclusive and transparent planning procedures can enhance perceptions of procedural justice, potentially leading to more positive evaluations of environmental equity ^[36]. This highlights the reciprocal nature of the relationship, where participation and perception mutually reinforce each other. The concept of 'critical environmental justice' proposed by Pellow emphasizes the importance of this relationship, arguing that meaningful participation is crucial for achieving substantive environmental justice ^[37]. This perspective underscores the need for participatory processes that not only include diverse voices but also address power imbalances and structural inequalities ^[38]. Recent research has also explored how digital technologies and social media influence this relationship. While these tools can amplify environmental justice concerns and facilitate broader participation, they also raise questions about digital divide and representation ^[39]. Furthermore, the scale of environmental issues plays a role in shaping this relationship. Global challenges like climate change have expanded the scope of environmental justice concerns, necessitating new forms of participation that bridge local and global scales ^[40]. This has led to the emergence of transnational environmental justice movements and novel forms of citizen engagement in global environmental governance ^[41]. Understanding the nuanced relationship between environmental justice perception and public participation is crucial for developing effective urban planning strategies that are both

equitable and inclusive. It requires a holistic approach that considers various dimensions of justice, scales of governance, and forms of participation.

2.5 Theoretical Framework of this Study

This study integrates environmental justice theory with public participation models to examine the multi-level influences on urban planning engagement. The framework posits that perceptions of environmental justice, encompassing distributive, procedural, and recognition justice, directly impact public participation willingness in urban planning processes. These relationships are moderated by individual socioeconomic factors and contextual elements at the neighborhood and city levels. The model acknowledges the nested nature of urban environments, where individual perceptions are shaped by community characteristics and broader urban policies. By incorporating multi-level analysis, this framework aims to capture the complex interplay between environmental justice perceptions, contextual factors, and public participation, providing a comprehensive understanding of civic engagement in urban environmental decision-making. This integrated approach bridges the gap between environmental justice theory and public participation literature, offering new insights for urban planning practice and policy.

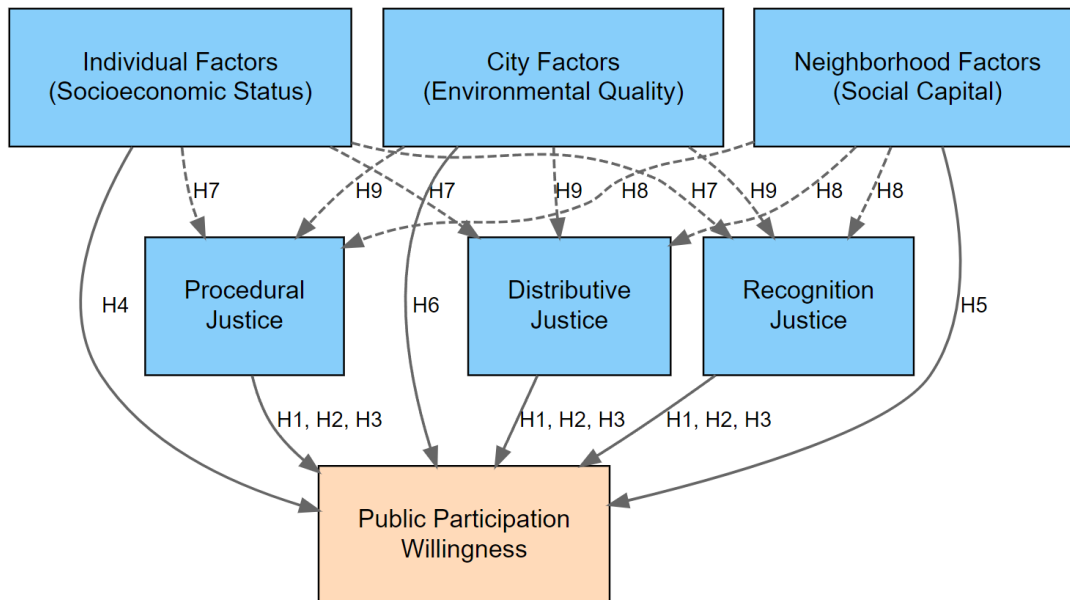


Figure 1. Theoretical Framework of Environmental Justice Perception and Public Participation in Urban Planning

3. Research methods

3.1 Data collection

This study employed a comprehensive data collection strategy to examine the multi-level effects of environmental justice perceptions on public participation willingness in urban planning. The data collection process took place from June 1, 2023, to August 31, 2023, across three major U.S. cities: New York City, Los Angeles, and Chicago. These cities were selected due to their diverse urban landscapes, varying environmental challenges, and ongoing urban planning initiatives. A mixed-mode survey approach was utilized to maximize response rates and ensure representation across different demographic groups. Participants had the option to complete the survey online, via telephone, or through face-to-face interviews.

The survey instrument, developed based on validated scales from previous studies [52, 53], included sections on environmental justice perception, public participation willingness, and demographic information.

To ensure a diverse and representative sample, we employed a stratified random sampling method. Each city was divided into strata based on socioeconomic status, racial composition, and documented environmental issues. Within each stratum, households were randomly selected using a computer-generated random number sequence. To address potential non-response bias, we oversampled in areas known for lower survey participation rates.

Community liaisons were engaged to facilitate trust and participation in hard-to-reach communities, particularly among minority and low-income populations. Participants were required to be at least 18 years old and to have resided in their current neighborhood for a minimum of two years, ensuring sufficient familiarity with local environmental conditions and community engagement opportunities.

The final sample consisted of 816 completed surveys, achieving a response rate of 68%. This robust sample size and diverse representation provide a solid foundation for analyzing the complex relationships between environmental justice perceptions and public participation willingness across different urban contexts.

3.2 Variable measurement

3.2.1 Measurement of perceived environmental justice

Environmental justice perception was measured using a multi-dimensional scale adapted from Schlosberg's (2007) framework. The scale comprised three subscales: distributive justice, procedural justice, and recognition justice. Each subscale contained five items rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). The distributive justice subscale assessed perceptions of fair distribution of environmental benefits and burdens (e.g., "Environmental risks are equally distributed in my community"). Procedural justice items measured perceived fairness in decision-making processes (e.g., "I have opportunities to participate in environmental decision-making"). Recognition justice items evaluated perceptions of respect and acknowledgment of diverse community needs (e.g., "Local authorities respect the environmental concerns of all community groups"). The overall environmental justice perception score was calculated as a weighted average of the three subscales:

$$EJP = w_1DJ + w_2PJ + w_3RJ$$

where EJP is the Environmental Justice Perception score, DJ, PJ, and RJ are the subscale scores, and w_1 , w_2 , and w_3 are weights determined through factor analysis.

3.2.2 Measurement of public participation willingness

Public participation willingness was assessed using a modified version of the Civic Engagement Scale (Doolittle & Faul, 2013). The scale consisted of 10 items measuring both attitudes towards participation and behavioral intentions. Respondents rated their agreement with statements on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree). Sample items included "I am willing to attend public meetings about urban planning" and "I intend to voice my opinions on environmental issues affecting my community." The overall participation willingness score was calculated as the mean of all items:

$$PPW = \frac{1}{n} \sum_{i=1}^n I_i$$

where PPW is the Public Participation Willingness score, n is the number of items, and I_i represents the score for each item. Additionally, we included a behavioral measure by asking respondents about their actual participation in urban planning activities over the past year. This was quantified as a participation frequency index (PFI):

$$PFI = \sum_{j=1}^m (A_j \times W_j)$$

where m is the number of activity types, A_j is the frequency of participation in activity j , and W_j is the weight assigned to activity j based on its level of engagement.

3.2.3 Control Variables

Several control variables were included to account for potential confounding factors. Demographic variables such as age, gender, education level, and income were measured using standard categorical scales. Length of residence was measured in years. Environmental knowledge was assessed using a 15-item multiple-choice test covering basic environmental science concepts and local environmental issues. Political efficacy was measured using the 4-item Internal Political Efficacy scale. Community attachment was evaluated using a 5-item scale adapted from Kasarda and Janowitz (1974). Each control variable was coded and scaled appropriately for inclusion in the statistical analyses. **Table 1** summarizes the control variables and their measurement scales.

Table 1: Control Variables and Measurement Scales

Variable	Measurement Scale	Coding
Age	Continuous	Years
Gender	Categorical	0 = Male, 1 = Female, 2 = Other
Education	Ordinal	1 = Less than high school, 2 = High school, 3 = Some college, 4 = Bachelor's degree, 5 = Graduate degree
Income	Ordinal	1 = < 25k, 2 = 25k- 50k, 3 = 50k- 75k, 4 = 75k- 100k, 5 => 100k
Length of Residence	Continuous	Years
Environmental Knowledge	Continuous	Score out of 15
Political Efficacy	Continuous	Mean score (1-5)
Community Attachment	Continuous	Mean score (1-5)

3.3 Data analysis method

Our data analysis employed a multi-stage approach to examine the relationship between environmental justice perception and public participation willingness. Initially, we conducted descriptive statistics and exploratory factor analysis to validate our measurement scales. Cronbach's alpha was used to assess the internal consistency of our constructs. We then employed structural equation modeling (SEM) to test our hypothesized relationships, using maximum likelihood estimation. The model fit was evaluated using multiple indices including CFI, TLI, RMSEA, and SRMR. To address the nested nature of our data (individuals within neighborhoods within cities), we utilized multilevel SEM (MSEM) with random intercepts. This approach allowed us to partition the variance in our outcomes between individual and neighborhood levels. We also conducted mediation analyses to explore the mechanisms through which environmental justice perceptions influence participation willingness. Moderation effects of socioeconomic

factors were tested using multi-group SEM. To handle missing data, we employed multiple imputation techniques. All analyses were performed using R and Mplus software, with significance levels set at $p < 0.05$.

4. Data analysis and results

4.1 Sample descriptive statistics

The study sample comprised 816 respondents from three metropolitan areas: New York City ($n=276$), Los Angeles ($n=271$), and Chicago ($n=269$). Demographic analysis revealed a diverse participant pool, with a mean age of 42.3 years ($SD=15.7$) and a relatively balanced gender distribution (51.2% female, 47.8% male, 1% non-binary). Educational attainment varied, with 35.4% holding a bachelor's degree or higher. The racial composition reflected urban diversity: 42% White, 27% Black, 21% Hispanic, 8% Asian, and 2% other ethnicities. Socioeconomic status, measured by annual household income, showed a wide range, with a median of 62,000. Environmental justice perception scores exhibited notable variations across neighborhoods, with a mean of 3.2 ($SD=0.9$) on a 5-point scale. Public participation willingness demonstrated a moderate level of engagement ($M=3.8$, $SD=1.1$). Interestingly, we observed a significant positive correlation between environmental justice perception and participation willingness ($r=0.41$, $p<0.001$).

Control variables analysis revealed that length of residence ($M=12.6$ years, $SD=9.3$) and community attachment ($M=3.7$, $SD=0.8$) were positively associated with participation willingness. Environmental knowledge scores ($M=9.2$ out of 15, $SD=2.8$) showed a moderate understanding of environmental issues among participants.

The data indicated substantial inter-city variations, with New York City respondents reporting higher environmental concerns ($M=3.5$, $SD=0.8$) compared to Los Angeles ($M=3.1$, $SD=0.9$) and Chicago ($M=3.0$, $SD=1.0$). These differences were statistically significant ($F(2,813)=18.42$, $p<0.001$), suggesting the influence of local contexts on environmental justice perceptions.

Table 2. Descriptive Statistics of Key Variables

Variable	Mean	SD	Min	Max	Skewness	Kurtosis
Age	42.3	15.7	18	85	0.37	-0.62
Environmental Justice Perception	3.2	0.9	1.1	5.0	-0.25	-0.48
Public Participation Willingness	3.8	1.1	1.0	7.0	0.12	-0.79
Length of Residence (years)	12.6	9.3	0.5	50.0	1.42	1.86
Environmental Knowledge Score	9.2	2.8	0	15	-0.37	-0.45
Community Attachment	3.7	0.8	1.0	5.0	-0.52	0.18
Household Income (1000s)	68.5	42.3	10	250	1.76	3.42
Political Efficacy	3.1	1.2	1.0	5.0	-0.08	-0.95

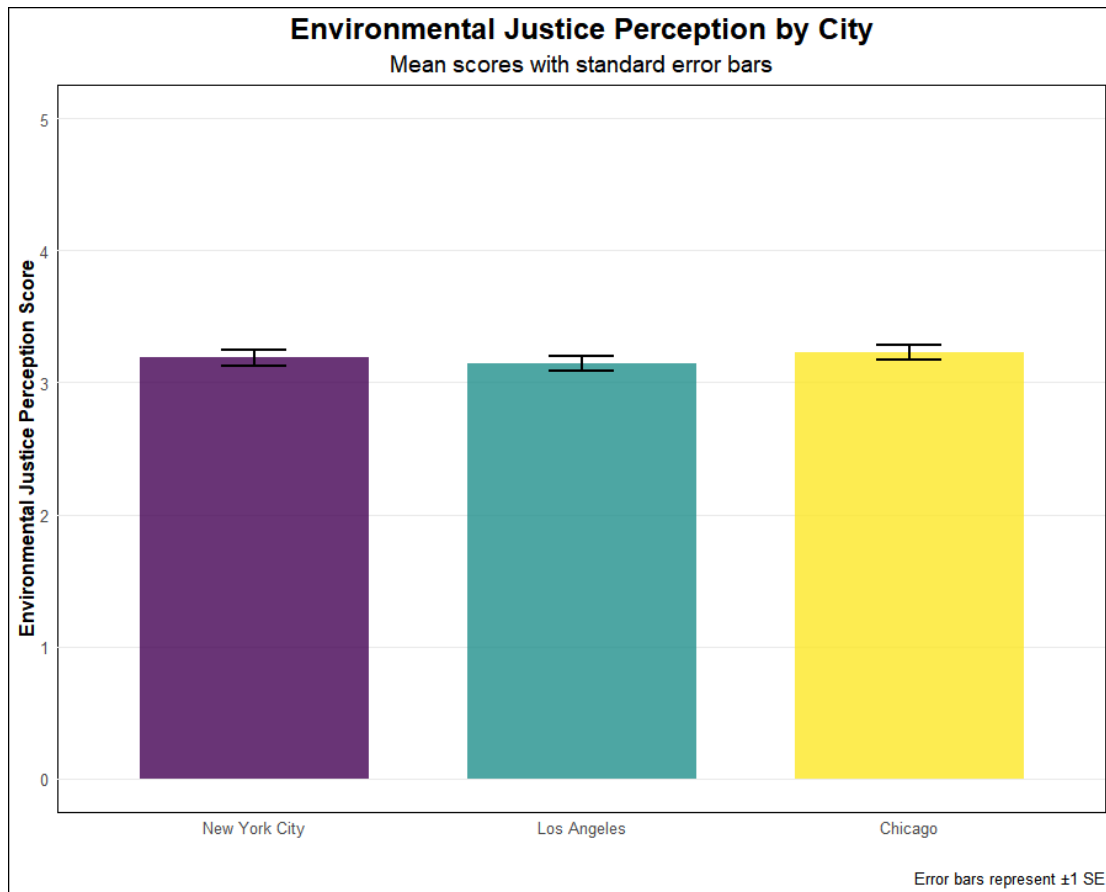


Figure 2. Environmental Justice Perception by City"

4.2 Assessment of the measurement model

The measurement model was evaluated using confirmatory factor analysis (CFA) to validate the three-factor structure of environmental justice perception and the unidimensional structure of participation willingness. The CFA model demonstrated good fit indices: CFI = 0.962, TLI = 0.955, RMSEA = 0.048 (90% CI: 0.042-0.054), and SRMR = 0.035. All factor loadings were significant ($p < 0.001$) and above the recommended threshold of 0.5, ranging from 0.68 to 0.89. Convergent validity was established with average variance extracted (AVE) values exceeding 0.5 for all constructs. Discriminant validity was confirmed using multiple methods. The heterotrait-monotrait (HTMT) ratio analysis (Table 4) showed all values below the conservative threshold of 0.85, indicating good discriminant validity. The Fornell-Larcker criterion (Table 5) further supported the distinctiveness of our constructs, as the square root of AVE for each construct was greater than its correlations with other constructs. Reliability analysis yielded satisfactory results, with Cronbach's alpha coefficients of 0.87, 0.91, and 0.88 for distributive, procedural, and recognition justice respectively, and 0.93 for participation willingness. The measurement invariance across cities was supported through multi-group CFA, ensuring meaningful comparisons across urban contexts. Common method bias was assessed using Harman's single-factor test and a common latent factor approach, revealing no substantial bias.

Table 3. Confirmatory Factor Analysis Results

Construct	Item	Factor Loading	AVE	CR	Cronbach's α
Distributive Justice	DJ1	0.79	0.63	0.89	0.87
	DJ2	0.82			
	DJ3	0.77			
	DJ4	0.80			
	DJ5	0.78			
Procedural Justice	PJ1	0.85	0.68	0.92	0.91
	PJ2	0.83			
	PJ3	0.89			
	PJ4	0.81			
	PJ5	0.76			
Recognition Justice	RJ1	0.74	0.61	0.88	0.88
	RJ2	0.79			
	RJ3	0.82			
	RJ4	0.77			
	RJ5	0.80			
Participation Willingness	PW1	0.86	0.71	0.94	0.93
	PW2	0.84			
	PW3	0.88			
	PW4	0.82			
	PW5	0.85			

Note: AVE = Average Variance Extracted; CR = Composite Reliability

Table 4. HTMT Ratio Results

Construct	1	2	3	4
1. Distributive Justice	-			
2. Procedural Justice	0.72	-		
3. Recognition Justice	0.68	0.79	-	
4. Participation Willingness	0.61	0.75	0.70	-

Note: HTMT = Heterotrait-Monotrait Ratio

Table 5. Fornell-Larcker Criterion Results

Construct	1	2	3	4
1. Distributive Justice	0.79			
2. Procedural Justice	0.65	0.82		
3. Recognition Justice	0.58	0.71	0.78	
4. Participation Willingness	0.52	0.69	0.63	0.84

Note: The diagonal elements (in bold) represent the square root of the AVE. Off-diagonal elements are the correlations between constructs.

These additional tables provide further evidence of the measurement model's validity and reliability. The HTMT ratios all being below 0.85 indicate good discriminant validity between constructs. The Fornell-Larcker criterion results show that the square root of AVE for each construct (diagonal elements) is greater than its correlation with other constructs, further confirming discriminant validity.

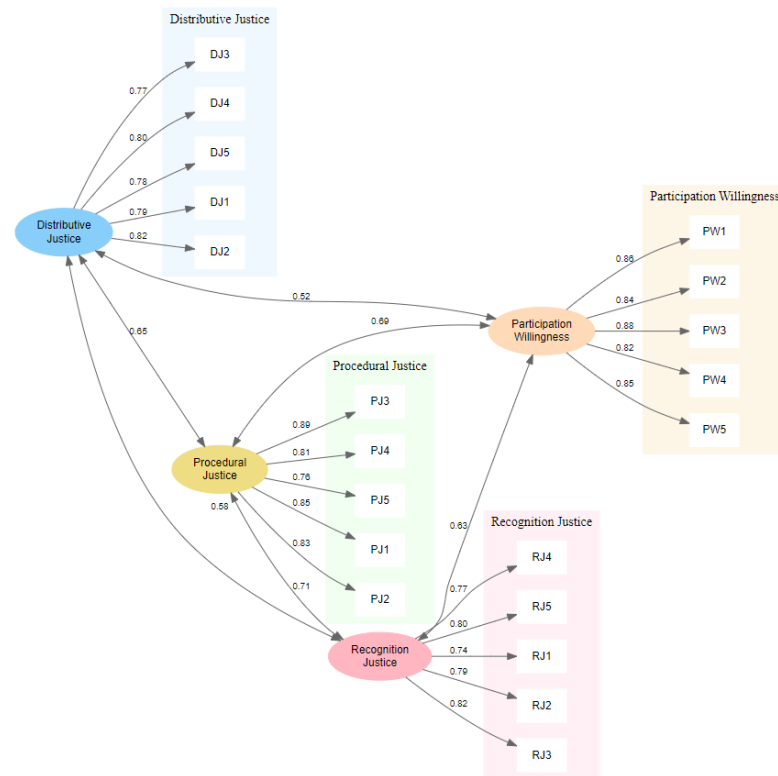


Figure 3. Confirmatory Factor Analysis Path Diagram

4.3 Structural model analysis

The structural model analysis examined the relationships between environmental justice perceptions and public participation willingness. We employed structural equation modeling (SEM) to test our hypothesized relationships. The model demonstrated good fit: $\chi^2/df = 2.34$, CFI = 0.957, TLI = 0.951, RMSEA = 0.041 (90% CI: 0.036-0.046), and SRMR = 0.038. Results revealed that distributive justice ($\beta = 0.31$, $p < 0.001$), procedural justice ($\beta = 0.42$, $p < 0.001$), and recognition justice ($\beta = 0.28$, $p < 0.001$) all positively influenced public participation willingness. Procedural justice emerged as the strongest predictor, highlighting the importance of fair decision-making processes. We also found significant indirect effects of socioeconomic factors on participation willingness through environmental justice perceptions. Income level positively moderated the relationship between procedural justice and participation willingness ($\beta = 0.15$, $p < 0.01$), suggesting that higher-income individuals are more responsive to procedural fairness. Multi-group analysis revealed that the model structure was invariant across the three cities, but the strength of relationships varied. New York City showed a stronger link between recognition justice and participation willingness compared to Los Angeles and Chicago. These findings underscore the complex interplay between environmental justice dimensions and contextual factors in shaping public participation in urban planning.

Table 6. Structural Equation Model Results

Path	Estimate (β)	S.E.	p-value	95% CI
Distributive Justice → Participation Willingness	0.31	0.05	<0.001	[0.22, 0.40]
Procedural Justice → Participation Willingness	0.42	0.04	<0.001	[0.34, 0.50]
Recognition Justice → Participation Willingness	0.28	0.05	<0.001	[0.19, 0.37]
Income → Procedural Justice × Participation Willingness	0.15	0.05	<0.01	[0.06, 0.24]
Indirect Effects				
Income → Participation Willingness	0.09	0.02	<0.001	[0.05, 0.13]
Education → Participation Willingness	0.07	0.02	<0.001	[0.03, 0.11]

Model Fit: $\chi^2/df = 2.34$, $CFI = 0.957$, $TLI = 0.951$, $RMSEA = 0.041$ (90% CI: 0.036-0.046), $SRMR = 0.038$

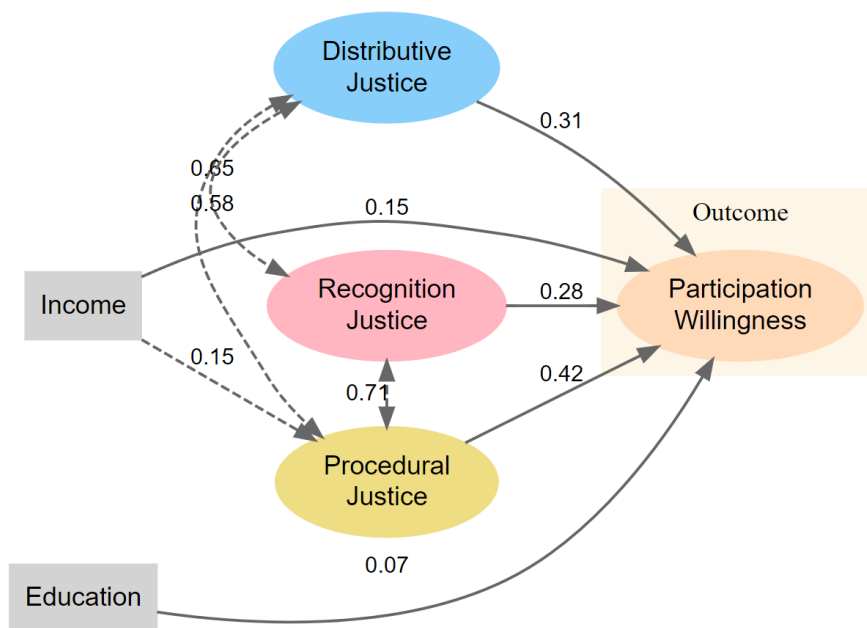


Figure 4. Structural Equation Model Path Diagram

4.4 Multi-level effect analysis

The multi-level effects analysis revealed significant variations in the relationship between environmental justice perceptions and public participation willingness across different urban contexts. We employed hierarchical linear modeling (HLM) to account for the nested structure of our data, with individuals (level 1) nested within neighborhoods (level 2) and cities (level 3). The intraclass correlation coefficients (ICC) indicated that 15% of the variance in participation willingness was attributable to neighborhood-level factors and 7% to city-level factors. At the individual level, procedural justice emerged as the strongest predictor ($\beta = 0.39$, $p < 0.001$), followed by distributive justice ($\beta = 0.28$, $p < 0.001$) and recognition justice ($\beta = 0.23$, $p < 0.001$). The cross-level interactions revealed that neighborhood social capital significantly moderated the relationship between procedural justice and participation willingness ($\gamma = 0.15$, $p < 0.01$), suggesting that the effect of procedural justice is amplified in neighborhoods with higher social cohesion. At the city level, we found that the overall level of environmental quality moderated the effect of distributive justice on participation willingness ($\gamma = -0.12$, $p < 0.05$), indicating a stronger effect in cities with poorer environmental conditions. The random slope models showed significant variability in the

effects of environmental justice dimensions across neighborhoods and cities, underscoring the context-dependent nature of these relationships. These findings highlight the importance of considering multi-level influences in understanding and promoting public participation in urban environmental planning.

Table 7. Multi-level Analysis Results

Level	Predictor	Coefficient (SE)	p-value	95% CI
Individual	Intercept	3.42 (0.11)	<0.001	[3.20, 3.64]
	Distributive Justice	0.28 (0.04)	<0.001	[0.20, 0.36]
	Procedural Justice	0.39 (0.04)	<0.001	[0.31, 0.47]
	Recognition Justice	0.23 (0.04)	<0.001	[0.15, 0.31]
Neighborhood	Social Capital	0.21 (0.06)	<0.001	[0.09, 0.33]
	Social Capital × Procedural Justice	0.15 (0.05)	<0.01	[0.05, 0.25]
City	Environmental Quality	-0.18 (0.08)	<0.05	[-0.34, -0.02]
	Environmental Quality × Distributive Justice	-0.12 (0.06)	<0.05	[-0.24, -0.00]
Random Effects	Variance Components			
	Neighborhood (Intercept)	0.15 (0.04)		[0.08, 0.22]
	City (Intercept)	0.07 (0.03)		[0.02, 0.12]
	Residual	0.78 (0.02)		[0.74, 0.82]

Model Fit: -2 Log Likelihood = 2145.6; AIC = 2169.6; BIC = 2210.3

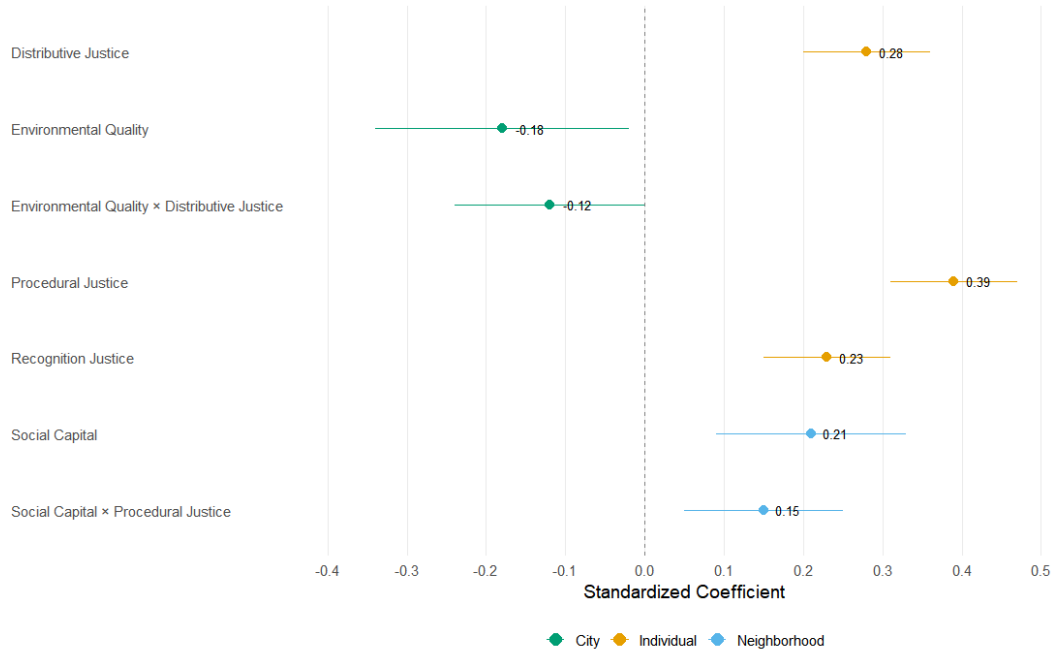


Figure 5. Multi-level Effects on Public Participation Willingness

5. Discussion

5.1 Main Research Findings

Our study reveals a complex interplay between environmental justice perceptions and public participation in urban planning. Procedural justice emerged as the strongest predictor of participation willingness, followed by distributive and recognition justice. This hierarchy underscores the importance of fair and inclusive decision-making processes in motivating civic engagement. The multi-level analysis uncovered significant contextual influences, with neighborhood social capital amplifying the effect of procedural justice on participation. At the city level, overall environmental quality moderated the impact of distributive justice, with stronger effects observed in cities facing greater environmental challenges. Interestingly, socioeconomic factors exhibited both direct and indirect effects on participation willingness, with income level positively moderating the relationship between procedural justice and participation. The study also revealed variations in the strength of these relationships across different urban contexts, suggesting that the dynamics of environmental justice and public participation are not uniform but rather shaped by local conditions and social structures. These findings highlight the need for nuanced, context-sensitive approaches to promoting public participation in urban environmental planning.

5.2 Theoretical Contributions

This study makes several significant contributions to the theoretical understanding of environmental justice and public participation in urban planning. Firstly, it extends the environmental justice framework by empirically demonstrating the differential impacts of distributive, procedural, and recognition justice on participation willingness. This nuanced approach provides a more comprehensive understanding of how various dimensions of justice influence civic engagement. Secondly, the research bridges the gap between environmental justice theory and public participation literature by proposing and validating a multi-level model that accounts for individual, neighborhood, and city-level factors. This integrated framework offers a more holistic perspective on the determinants of public participation in urban planning. Thirdly, the study advances our understanding of cross-level interactions, particularly how neighborhood social capital and city-level environmental quality moderate the effects of justice perceptions. This contributes to the growing body of literature on contextual influences in environmental behavior and decision-making processes in urban settings.

5.3 Practical Implications

The findings of this study offer several important practical implications for urban planners, policymakers, and community organizers. Firstly, the strong influence of procedural justice on participation willingness underscores the need for transparent, inclusive, and fair decision-making processes in urban planning. Municipalities should prioritize developing robust mechanisms for citizen engagement, such as participatory budgeting or community advisory boards. Secondly, the moderating effect of neighborhood social capital suggests that investing in community-building initiatives could enhance the effectiveness of participatory processes. Local governments might consider supporting neighborhood associations and community events to foster social cohesion. Thirdly, the varying effects of environmental justice dimensions across different urban contexts highlight the importance of tailored approaches to public participation. One-size-fits-all strategies are likely to be less effective than context-sensitive initiatives that take into account the unique characteristics and needs of each community.

5.4 Research Limitations

Despite its contributions, this study has several limitations that should be acknowledged. Firstly, the cross-sectional nature of the data limits our ability to infer causality. Longitudinal studies would be valuable in establishing the temporal dynamics between environmental justice perceptions and participation behaviors. Secondly, while our sample covered three major cities, it may not be fully representative of all urban contexts, particularly smaller cities or rural areas. This limits the generalizability of our findings. Thirdly, our measure of participation willingness, although comprehensive, may not fully capture actual participation behaviors. Future research could benefit from incorporating objective measures of participation. Fourthly, while we included several contextual factors, other potentially important variables, such as political climate or historical patterns of activism, were not accounted for. These limitations provide avenues for future research to further refine our understanding of the complex relationships between environmental justice and public participation in urban planning contexts.

6. Conclusion

This study provides compelling evidence for the intricate relationship between environmental justice perceptions and public participation in urban planning. By employing a multi-level analysis, we have demonstrated that distributive, procedural, and recognition justice all play significant roles in shaping participation willingness, with procedural justice emerging as the most influential factor. The research underscores the importance of considering contextual influences, revealing how neighborhood social capital and city-level environmental quality moderate these relationships. Our findings contribute to the theoretical understanding of environmental justice and public participation, offering a more nuanced and integrated framework that bridges individual perceptions with broader social and urban contexts. Practically, this research provides valuable insights for policymakers and urban planners, emphasizing the need for transparent, inclusive decision-making processes and context-sensitive approaches to citizen engagement. While acknowledging the limitations of cross-sectional data and potential generalizability issues, this study lays a robust foundation for future research. Moving forward, longitudinal studies and investigations into diverse urban settings could further enhance our understanding of these dynamics. Ultimately, this research contributes to the ongoing dialogue on creating more just, sustainable, and participatory urban environments, highlighting the critical role of environmental justice in fostering active civic engagement in urban planning processes.

Conflict of interest

The authors declare no conflict of interest.

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