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DOI
10.1016/j.foar.2024.09.009

Publication date
2025

Document Version
Final published version

Published in
Frontiers of Architectural Research

Frontiers of Architectural Research 14 (2025) 1076—1089

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.keaipublishing.com/foar

Higher Education Press

SOUTHEAST UNIVERSITY

RESEARCH ARTICLE

From empty to empowering: Leveraging vacant land for urban socio-ecological resilience

Maryam Naghibi [a,*], Mohsen Faizi [b], HamidReza Yazdani [c], Ahmad Ekhlassi [b]

[a] *Faculty of Architecture and the Built Environment, Delft University of Technology, Delft, The Netherlands*
[b] *School of Architecture and Environmental Design, Iran University of Science and Technology, Tehran, Iran*
[c] *Management College, University of Tehran, Tehran, Iran*

Received 30 November 2023; received in revised form 16 September 2024; accepted 18 September 2024

KEYWORDS
Green spaces;
Leftover spaces;
Social-ecological systems;
Preference;
Resilience;
Urban park

Abstract Urban vacancy, often seen as a challenge, offers unique opportunities for ecological and social enhancements in cityscapes. This study explores the role of small green spaces in urban resilience, particularly in high-density metropolises, through a social-ecological lens. We began with a critical review to develop and validate a questionnaire, drawing on theoretical frameworks and confirming the derived criteria with twenty-two experts. Key resilience attributes identified for urban landscapes included flexibility, efficiency, activity, connectivity, and diversity. Utilizing the Best-Worst Method (BWM), we discerned the most and least significant of these attributes. The study then employed Hierarchical Bayes analysis via XLSTAT software to analyze questionnaire responses ($n = 386$, 60.36% female) and calculate the part-worth utility and importance ratings for each attribute. Results highlighted water presence, high tree density, and activity areas as vital attributes for small urban parks. These insights are crucial for landscape architects, emphasizing attributes that enhance park visitation and usability. Additionally, the innovative methodological approach of this study offers a new pathway for research in urban planning and the built environment.

* Corresponding author.
E-mail address: m.naghibi@tudelft.nl (M. Naghibi).
Peer review under responsibility of Southeast University.

https://doi.org/10.1016/j.foar.2024.09.009

1. Introduction

Urban landscapes are increasingly marked by vacancy rates due to a variety of urban processes, such as de-industrialization (Kim, 2016), urban growth (Song et al., 2020), and changing residential preferences (Kremer et al., 2013). While these vacancies often present challenges, they also offer opportunities for ecological and social enhancements in cityscapes (Burkholder, 2012; Nemeth and Langhorst, 2014). Notably, small, vacant urban spaces, previously overshadowed by larger sites, are gaining attention due to urban densification and the scarcity of green spaces (Nordh and Østby, 2013). The role of user preferences is increasingly recognized in planning these spaces, underscoring the need for user-centric designs to prevent further vacancy (Trancik, 1986; Lynch, 1977; Noh et al., 2021; Costa et al., 2021; Naghibi et al., 2021).

Vacant urban spaces are not merely transient phenomena but represent a significant and strategic aspect of the urban landscape, influencing urban development policies (Bowman and Pagano, 2004). However, planning decisions, even in meticulously controlled environments, can lead to unintended social-ecological consequences, which can be detrimental to a city and its inhabitants (Cooper et al., 2007; Kahn, 1966; Colding et al., 2020). Addressing these issues requires a deeper understanding of the role of vacant land in fostering urban resilience.

Conflicts can arise when there is a disconnect between park users' expectations and planners' perceptions. Recognizing and incorporating people's subjective expectations and attitudes towards urban parks is essential for successful park design (Krajter Ostoić et al., 2020; Ma et al., 2021). Suhardi (2002) and Pasban Hazrat (2009) stress the importance of designing parks based on user needs and interactions with the environment. Additionally, Nassauer et al. (2021) highlighted the impact of microscale elements on preferences for vacant lands.

This study aims to enhance understanding of socio-ecologically sound landscapes and urban resilience in small urban areas. By integrating the concept of resilience into urban planning and decision-making, this research seeks to harmonize user preferences with expert opinions in the development of leftover spaces. The paper is organized as follows: (a) Literature Review discusses leftover space, socio-ecological resilience, and user preferences in urban spaces. (b) Case Study and Methodology outline the research context, methods, data collection instruments, and respondent demographics, detailing how 386 residents evaluated potential future scenarios for leftover spaces. This evaluation combined the Best-Worst Method (BWM) technique (Rezaei, 2015) with a scenario-based Choice-based conjoint analysis. (c) The Main Findings section presents the results, and (d) the Conclusion discusses the key findings in relation to the central research question and their future implications.

2. Literature review

Vacant urban lands, once viewed negatively and associated with urban decline, now hold significant potential for regeneration and revitalization (Kim, 2016; Newman et al., 2019). These spaces, often a byproduct of various urbanization processes, present unique opportunities for fostering community engagement, ecological benefits, and urban resilience (Naghibi et al., 2020).

The concept of urban resilience has gained prominence across multiple disciplines, emphasizing the capacity of urban systems to adapt and thrive amidst challenges (Pizzo, 2015; Chandler and Coaffee, 2016; Pirlone et al., 2020). Social-ecological resilience, or evolutionary resilience (Folke, 2006; Davoudi, 2012), encompasses the adaptive capabilities of complex socio-ecological systems. This concept, while still evolving in its definition and application (Tutor and Arch, 2015), has become integral to modern urban planning.

In this context, resilience is not just about the robustness of physical structures but also involves the socio-ecological networks that constitute urban spaces (Desimini, 2015; Collier et al., 2016). Social-ecological landscapes, linking cultural and biological diversity, play a pivotal role in creating sustainable and resilient urban environments (Walz, 2011; Gallopín, 2006). This linkage is especially relevant in the design and management of small urban parks, which can act as catalysts for ecological and social transformations (Jasmani, 2013).

The intricacies of social-ecological interactions in urban contexts have been examined extensively. Studies like those by Jasmani (2013) highlight the ecological potential of small urban parks in urban planning and nature conservation. Others, such as Afriyanie et al. (2018) and Kremer et al. (2013), explore how vacant lands, especially in residential areas, can be transformed into socially and ecologically beneficial spaces. These spaces can support urban sustainability and resilience, offering opportunities for leisure, resource use, and public infrastructure development (Schlüter et al., 2019).

Interdisciplinary dialogues emphasize the importance of integrating both ecological and social considerations in urban park design (Davoudi, 2012; Shahhosseini, 2015). High-quality urban nature not only enhances the physical environment but also influences user behavior and park usage. Therefore, a comprehensive framework for the identification, improvement, maintenance, and monitoring of small urban parks is essential (Shahhosseini, 2015; Jasmani, 2013).

This study builds upon these insights to apply the social-ecological resilience concept in urban landscapes, with a focus on small green areas in high-density metropolises. Out of the numerous attributes associated with urban resilience, this research narrows down to five key attributes: flexibility, efficiency, activity, connectivity, and diversity as follows:

- Flexibility: Decentralization is a key factor in enhancing security, flexibility, and efficiency. However, an excessive focus on engineering risk measures can reduce the long-term flexibility and adaptability of urban systems (Liu et al., 2019). Flexibility is crucial for the temporary use management framework, where projects are tied to specific time periods rather than specific locations. These processes are typically bottom-up with no preexisting infrastructure (Mariani and Barron, 2013). Dynamic landscapes adapt and change with altered conditions rather than continuing in the same manner (Folke, 2006; Davoudi et al., 2012).

- Efficiency: Achieving efficiency requires balancing elements like diversity, connectivity, redundancy, and modularity (Novotny et al., 2010). Efficiency involves structural complexity across all scales, necessitating a hierarchical organization of urban elements (Salat and Bourdic, 2012; Feliciotti et al., 2016).
- Activity: Increasing place attachment through frequent activities and uses boosts satisfaction, leading to maintenance and activity (Maharani and Evawani, 2019). Providing pathways for walking in neighborhoods is essential (Fields, 2005), while the lack of defined activity in urban spaces is harmful (Doron, 2000). Inaccessible spaces need planning, and temporary programs can be considered (Trancik, 1986; Memarian and Niazkar, 2014). Activities should evolve through user participation without disrupting pedestrian activity (Loukaitou-Sideris, 1996). They enhance surveillance, security, and social interactions (Qamaruz-zaman et al., 2012), and recreational and cultural needs should be balanced (Ling et al., 2007). Designing pathways to encourage presence and reduce social threats is crucial (Akkerman and Cornfeld, 2010). Social and aesthetic aspects should be considered together (Unt et al., 2014), as human-created spatial hierarchies impact activities (Maharani and Evawani, 2019). Development grants and infrastructure can enhance spaces economically (Bowman and Pagano, 2004), and attention to temporary uses in macro-planning is important (Drake and Lawson, 2014). Renovation should consider social and economic impacts, and physical infrastructure supports activities, requiring examination at both micro and macro levels (Carr, 1992; Lin, 2012).
- Connectivity: Facilitating movement within and between systems enhances activity and interaction among individuals, influencing the urban fabric significantly (Marcus and Colding, 2014; Mehaffy et al., 2010). Structural connections within the urban environment are crucial (Salat and Bourdic, 2014). Abandoned spaces should not act as physical barriers, hindering connectivity (Mariani and Barron, 2013). Both porosity and network continuity must be considered simultaneously (Brighenti, 2013). Continuity is often overlooked in planning, leading to challenges in connecting small spaces to larger areas (Addas, 2015). Urban acupuncture principles can improve connectivity to public spaces and enhance cultural and historical networks (Petrova et al., 2016). Ensuring the continuity of remote spaces at all scales is vital (Permato, 2014), and regional and local policies should be examined for their connectivity impacts (Lewis, 2005). Residential peripheral spaces should be seen as crucial sources of ecological continuity (Kremer et al., 2013). Preparing land physically, socially, and environmentally to create suitable habitats for various species is essential (Foster, 2014). Enhancing people's connection to the natural environment promotes participation in eco-friendly activities (Rashid and Ara, 2015). Differences in the scale and connectivity of urban natural spaces ensure their distribution, continuity, and sustainability, while creating new and temporary ecosystems can significantly increase urban continuity (Threlfall and Kendal, 2018).
- Diversity: The application of various adaptive strategies (Marcus and Colding, 2011), which are often linked to the use and structure of the urban form (Montgomery, 1998; Tarbatt, 2012). Urban trees help manage rainfall and prevent flooding, with the diversity of tree species enhancing resilience against rainfall. As cities face climate change, ecological strategies like diversity and redundancy become crucial (Walker and Salt, 2006; Ahern, 2013). Various animal and plant species find unique nesting areas, contributing to biodiversity and ecological diversity over time. Street design elements impact landscape structure, particularly plot size, influencing species diversity and distribution. Fragmentation can be measured against environmental objectives using criteria like proportion, size, form, density, and natural approaches.

There are different definitions in the literature based on previous and vast studies. These were selected based on their relevance to urban form, dependency, and driving power. Furthermore, the study delves into the critical role of vegetation density, a factor closely linked to both ecological and human experiences (Chiang et al., 2017; Zhang et al., 2021).

3. Methodology

This study investigates socio-ecological resilience in small urban areas through three central research questions:

- What are the defining attributes of socio-ecologically sound landscapes in the context of vacant lands?
- How do experts prioritize these attributes based on site characteristics of leftover spaces?
- What are community preferences regarding the resilience attributes of small urban landscapes?

To address these questions, the methodology is structured into four parts: procedure, case study introduction, Best-Worst Method (BWM), and choice-based conjoint analysis.

3.1. Procedure

To address the first research question, the following steps were undertaken:

(a) A critical review and analysis of syntheses and relevant literature were conducted. (b) To assess the validity of the questionnaire and evaluate the significance of various properties, criteria extracted from the theoretical foundations were confirmed by twenty-two experts from regions including Australia, Chile, Iran, Italy, Japan, the Netherlands, New Zealand, the UK, the United Arab Emirates, and the USA. (c) To determine the best and worst attributes for the second question, the BWM, a multi-criteria decision-making (MCDM) method, was employed, with the participation of sixteen experts. (d) A questionnaire, based on the most relevant attributes and levels identified in the previous step, was then administered. (e) The reliability of the questionnaire was assessed using the Test-Retest approach. In the pilot study, participants provided responses on two separate occasions, several days apart. A Z-test was conducted to compare the results, which showed no significant differences in the responses. (f) Additional pilot testing was conducted before proceeding with the full-scale study. (g) To address the third research question, respondents were provided with an anonymous questionnaire. The framework of the research process is illustrated in Fig. 1.

The online questionnaire did not require any installations or applications. Respondents were selected using a snowball sampling technique. Over 800 residents were randomly contacted via Email, WhatsApp, and Telegram, and were encouraged to share the survey link with other interested residents. Data collection spanned three weeks in May 2021. Based on Cochran's formula, a minimum sample size of 385 was deemed appropriate. A total of 386 respondents participated, yielding a response rate of 70%. The average completion time for the questionnaire was 6.35 min.

The first section of the questionnaire gathered demographic details of the residents. The second part assessed preferences using the Likert scale, and the third part consisted of 12 questions designed to select the most preferred scenario.

3.2. Case study

This research examines the application of urban resilience concepts, concentrating specifically on the management of small green spaces within a high-density urban framework. Tehran, Iran, serves as the case study context, exemplifying a metropolitan environment constrained by limited spatial resources. The exploration of resilience in such urban vacancies is critical, offering insights into the potential of enhancement interventions at various urban scales and their adaptability across diverse settings (Mondini et al., 2018).

Tehran, positioned between the Alborz Mountains and the central desert, provides a unique setting for studying urban resilience. The city's varied types of vacant spaces align well with the research objectives, making it an apt choice for this study. The selected sites include marginal spaces, transitional zones, and vacant lots, each offering distinct characteristics pertinent to urban resilience. These categories, elaborated in Table 1, underscore the diversity of urban vacancies in Tehran and their potential in resilience-focused urban planning.

3.3. BWM method

This section outlines the application of the Best-Worst Multi-Criteria Decision-Making approach, introduced by Rezaei in 2015, for prioritizing intervention variables in our study. The BWM method efficiently handles decision-making scenarios involving multiple parameters by identifying the most (best) and least (worst) favorable or significant parameters, which serve as benchmarks for evaluating all other criteria through a pairwise comparison. This streamlined process improves the precision of prioritization by directly determining the relative importance of each decision-making factor.

The methodology ensures the reliability of these evaluations with a consistency ratio, which verifies the

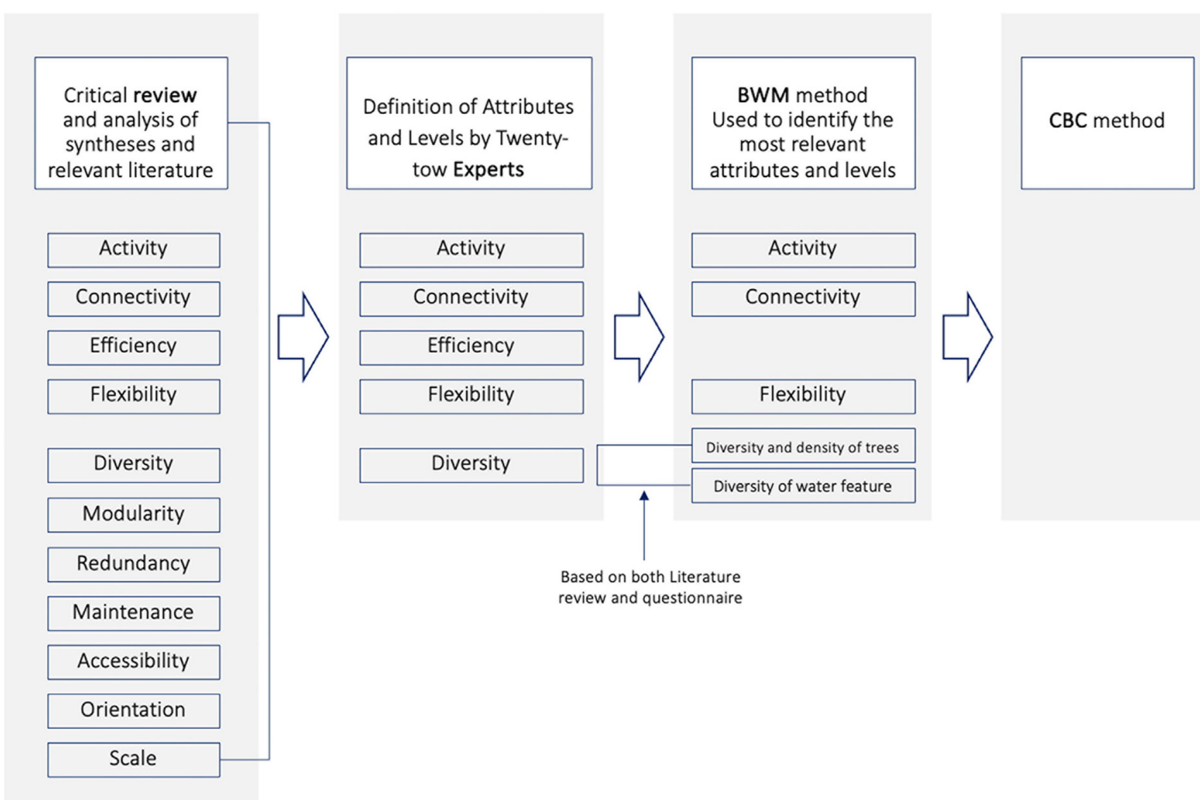
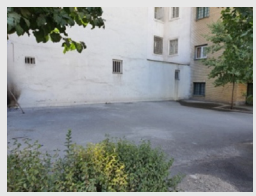
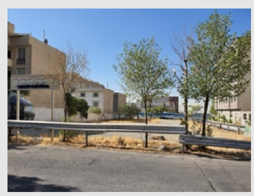


Fig. 1 The framework of the research procedure.

Table 1 The various categories of leftover spaces and their respective characteristics.

Typology	Definition	Examples		Form	Management
Building frontage (marginal space)	Vegetated space presently not used for residential or commercial purposes; vegetation is rarely removed or maintained; public access, use mostly restricted		Marginal spaces along buildings	Point	Regular vegetation maintenance by private stewardship, corporate or governmental stewardship
Space in-between	Vegetated land that is not currently used for residential or commercial purposes; typically, no, or very rare removal and maintenance of vegetation; public access, often limited use		Transitional zones between buildings	Block	Irregular vegetation removal, long removal intervals; governmental stewardship
Lots	Vegetated lots not currently used for residential or commercial purposes; typically, vegetation removed to the ground cover if maintained; public access and limited use. Vacant lots, abandoned lots, previous developed site		Vacant lots, abandoned lots, previously developed sites	Block	Irregular vegetation removal, medium to long removal intervals; private stewardship

consistency of the pairwise comparisons. Below, we summarize the steps employed to calculate the weights of various criteria:

Stage 1: Define a set of decision criteria {c1, c2, ..., c*n*}.

Stage 2: Identify the best and the worst criteria.

Stage 3: Use the BWM questionnaire to compare the best criterion against all others, resulting in a "best-to-others" vector: AB= (aB1, aB2, ..., aB*n*).

Establish priorities relative to the worst criterion, leading to an "others-to-worst" vector: Aw= (a1w, a2w, ..., anw).

Stage 5. Optimize weights using the equation:

Min max j $\{|\frac{\mathrm{WB}}{\mathrm{W}j} - \mathrm{aB}j|\ ,\ |\frac{\mathrm{WB}}{\mathrm{W}j} - \mathrm{a}j\mathrm{w}|\}\ \sum \mathrm{W}j = 1\ \mathrm{W}j \geq 0;\ f$ for all j.

The consistency ratio helps verify the accuracy of these comparisons (Rezaei, 2015):

$$\text{Consistency Ratio} = \frac{\varepsilon*}{\text{Consistency Index}}.$$

3.4. Choice-Based Conjoint Analysis

This section e provides a succinct overview of the Choice-Based Conjoint Analysis, a method critical for understanding preferences in our study's context. By requiring participants to choose from options defined by different attributes, this analysis pinpoints the most influential factors on decision-making.

The analysis employs a two-step procedure:

1) Develop profiles using fractional factorial designs or D-optimal designs.
2) Distribute these profiles among groups using incomplete block designs, allowing for an effective utility assessment of each attribute.

By integrating elements of Discrete Choice Models and traditional Conjoint Analysis, Choice-Based Conjoint Analysis offers a practical tool for mimicking real-life decisions,

Table 2 The priority of key factors.

Weight Ksi*	Diversity and density of tree	Diversity and density of bushes	Diversity of covering	Diversity and density of flowers	Diversity of planting	Diversity of pavement	Water	Connectivity	Flexibility	Activity	Efficiency
0.1104	13.42	6.90	6.45	2.71	6.43	6.58	9.07	9.32	22.81	9.44	6.68

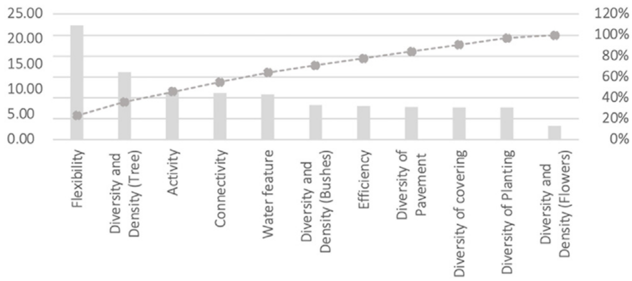


Fig. 2 Relevant attributes and levels for the Conjoint Analysis.

Table 4 Description of the model used in CBC.		
Attributes	In connection with ranks or scores	Number of levels
Water	Discrete	3
Tree	Discrete	3
Connectivity	Discrete	2
Activity	Discrete	6
Flexibility	Discrete	2

enhancing the validity and relevance of the findings (Cohen 1997; Bahamonde et al., 2017).

4. Results

The initial phase of the study involved conducting a critical review and analysis of relevant literature to ascertain key attributes associated with resilience in urban vacant lands. This review led to the identification of specific resilience attributes. Subsequently, consultations with experts, comprising academic and practical professionals in landscape architecture, architecture, urban design, and urban planning, helped refine these attributes.

The identified essential components of socio-ecological resilience, along with their corresponding levels, are as follows: Diversity and Density of Trees, Bushes, and Flowers; Diversity of Pavement and Covering; Diversity of Planting and Water Features; Connectivity; Flexibility; Efficiency; and Activity.

4.1. Weighting criteria with BWM

Consistent with the methodology outlined earlier, the BWM was utilized for weighting the identified resilience criteria. This method's selection was due to its advantages, including reduced comparative complexity, enhanced accuracy in comparisons, and overall reliability in results.

In the BWM process, "Flexibility" emerged as the most significant criterion, while "Diversity and Density of Flowers" was identified as the least significant. This prioritization involved experts evaluating the relative importance of each criterion compared to the best and worst criteria. The outcomes of this assessment, including the specific weightings of each criterion, are detailed in Table 2.

4.2. Attributes and levels

Relevant attributes and levels for the Conjoint Analysis were elicited through a BWM process. To effectively reduce the number of attributes and facilitate prioritization, a Pareto chart was used. Based on the cumulative percentage line, flexibility, diversity, and density of tree, water, activity, and connectivity feature prioritize to get the most overall improvement (Fig. 2).

The scenarios were explored after identifying the primary attributes (such as flexibility, diversity and density of trees, type of activity, connectivity, and water). Residents will decide on the best scenario using the CBC method. Based on the research objective, the prioritized criteria were assessed and evaluated for use in the scenario-based questionnaire. This study conducted twelve scenarios by combining five research attributes and levels (Table 3).

The findings from this section offer novel insights into the complex interplay of urban resilience factors and their perceived importance among urban residents. These results not only reflect on individual preferences but also illustrate broader trends in urban planning and the essential role of green infrastructure in fostering resilient urban environments.

Table 4 shows the attributes and their description in the correlation analysis model. In correlation or symmetry analysis, variables are defined as discrete or linear. The discrete attributes are used in this study. Accordingly, the levels of variables are either definite (unconditional) or

Table 3 Attributes and levels of interest in this research.

Water	Tree	Connectivity (physical)	Activity	Flexibility
Small fountain	Dense trees	High connectivity	Individual activity (passive)	Flexible spaces
Mirror pond	Some trees	Low connectivity	Social activity	Rigid spaces
No water	A few trees		Mixed activity	
			Recreational activity	
			Economic activity (community garden)	
			Green space for walking	

Table 5 An example of a choice task (two scenarios) for comparison.

	Park 1	Park 2
Water	Small fountain	No water
Tree	Dense tree	Some trees
Connectivity	High connectivity	Low connectivity
Activity	Individual activity	Mixed activity
Flexibility	Flexible spaces	Flexible spaces

conventional. In the discrete state, there is no hypothesis in terms of the relationship between the levels of variables and data.

After determining the levels of the variables, the CBC questionnaire was designed in Excel using the XLSTAT statistical software. Then, the analysis was set up according to the designed questionnaire. The fundamental concept of choice-based conjoint (CBC) analysis relies on selections made within a set of profiles. Instead of assigning ratings or arranging them in order, individual participants make choices among various presented scenarios. CBC operates by contrasting these profiles, which are put together in many comparison groups (Table 5). The questionnaire was visited by 837 residents and finally completed by 386 respondents. The response rate to the questions was approximately 70% (the number of people who submitted the answer to the number of people who did not complete the questionnaire). The average response time was 6.35 min.

The relevant comparisons for the scenarios were determined in the questionnaire. The number of scenarios was limited as much as possible to improve the accuracy of the responses. Finally, twelve comparisons were made to determine the variables' priority (Table 6).

The time required to finalize the entire questionnaire, including background and follow-up questions, was relatively brief. The respondents stated that they had no problem visualizing the various scenarios; nevertheless, several stated that they found the choice challenges to be somewhat difficult.

4.3. Questionnaire data analysis

4.3.1. The participants' demographic attributes

The characteristics of the sample are presented in Table 7. The participants ($n = 386$) were 60.36% female. Most of the participants were under 34 years old. Most respondents ($n = 200$, 51.81 %) had a master's degree as their educational level, and most of them ($n = 165$, 42.74%) were student.

XLSTAT-Conjoint analysis software provides for each respondent and each comparison. According to the preferences, water ponds, high density of trees, green space

Table 7 The socio-demographic information of the participants.

	Overall
Age	
18–24	103
25–34	181
35–44	63
45–54	20
55–64	13
Older than 65	6
Gender	
Female	233
Male	153
Education	
High school or diploma	16
Associate degree	16
Undergraduate	106
Master	200
PhD	48
Occupation	
Employed	153
Retired	16
Student	165
Housewife	27
Unemployed	25
Professional	
Yes	113
No	73

for walking, and small fountains have been the most desirable attributes (Fig. 3 and Table 8).

The conjoint study compares one attribute to another in terms of importance within three steps.

4.3.2. Calculate Attribute Utility Range

Utility Range = Highest Utility Value of an attribute − Lowest Utility Value of an attribute.

Flexibility: $0.231 - (-0.231) = 0.462$;
Activity: $0.448 - (-0.391) = 0.839$;
Connectivity: $0.215 - (-0.215) = 0.430$;
Tree: $0.516 - (-0.773) = 1.289$;
Water: $0.556 - (-0.891) = 1.447$.

4.3.3. Calculate Total Attribute Utility Range

Total Utility Range $= \sum$ Utility Range;
Total Attribute Utility Range $= 0.462 + 0.839 + 0.430 + 1.289 + 1.447 = 4.467$.

4.3.4. Importance of the levels of the attributes

A count test was conducted to determine the frequency of selection for each attribute level, as compared to its

Table 6 Designs for conjoint analysis comparison.

Comparison	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Scenarios No	S. 1	S. 2	S. 3	S. 4	S. 5	S. 6	S. 7	S. 8	S. 9	S. 10	S. 11	S. 12
	S. 2	S. 1	S. 2	S. 3	S. 4	S. 5	S. 6	S. 7	S. 8	S. 9	S. 10	S. 11

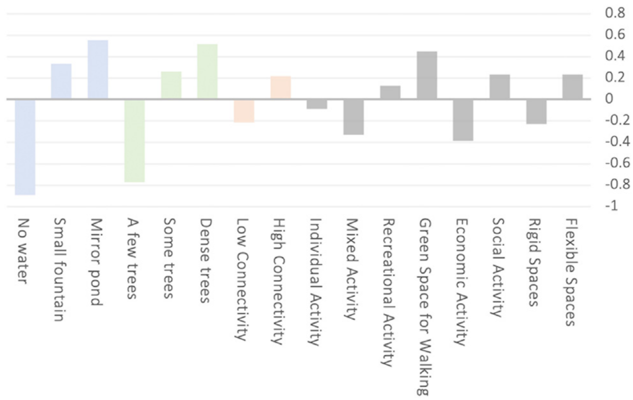


Fig. 3 Aggregated utilities of levels.

overall occurrence across all optional tasks. We noticed that distinct levels with slightly varying frequencies were picked for each attribute (all *p*-values 0.01). This indicates that the attribute ratios accurately captured relevant distinctions for our respondents.

4.3.5. Calculating relative importance of attributes

Relative Importance of attribute = (Attribute Utility Range/Total Attribute Utility Range) ×100%.

Based on the utility calculations and the average importance, the water emerged as the most significant component in preferences among park options, contributing to over 20% of the total significance. Trees and activity came as second and third, respectively. On the other hand, flexibility was given somewhat higher scores than connectivity, albeit the difference was not statistically significant at the conventional criterion (Fig. 4).

Based on the residents' desire, it can be assumed that the most preferred scenarios include flexible spaces, green areas for walking, or social activities such as visiting friends. These parks will have to be connected to other urban areas. High or medium-density trees with ponds or water fountains will also be required.

Table 8 Aggregated utilities of levels.

Attribute	Levels	Aggregated utilities	Standard deviations
Flexibility	Flexible spaces	0/231	0/041
	Rigid spaces	−0/231	0/041
Activity	Social activity	0/230	0/073
	Economic activity (community garden)	−0/391	0/065
	Green space for walking	0/448	0/111
	Recreational activity	0/130	0/112
	Mixed activity	−0/328	0/069
	Individual activity	−0/090	0/140
Connectivity	High connectivity	0/215	0/033
	Low connectivity	−0/215	0/033
Tree	Dense trees	0/516	0/084
	Some trees	0/257	0/078
	A few trees	−0/773	0/098
Water	Mirror pond	0/556	0/070
	Small fountain	0/334	0/065
	No water	−0/891	0/058

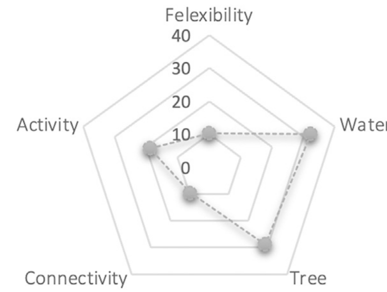


Fig. 4 Segmentation of average importance value.

4.3.6. The effects of demographic variables of respondents

The study revealed a preference among individuals with professional experience for activities such as green space for walking and social activity, in comparison to those without such experience (mean rank for professional experience = 23.88, mean rank for non-professional experience = 15.22). In contrast, participants with no experience valued connectivity and flexibility more than those with expertise (for connectivity: professional experience mean rank = 7.75, non-professional experience mean rank = 11.68; for flexibility: professional experience mean rank = 8.69, non-professional experience mean rank = 11.89).

In terms of water preferences and small fountain, professional experience preferred mirror pond more than non-professionals, while non-professionals gave higher rank to small fountain (for mirror pond: professional experience mean rank = 0.71, non-professional experience mean rank = 0.42; for small fountain: professional experience mean rank = 0.16, non-professional experience mean rank = 0.49) (Fig. 5).

Regarding occupation status, this study found that retired participants gave the highest rank to trees, while students and homemakers chose water feature (retired mean rank = 36.79; for water: student mean rank = 35.47, housewife mean rank = 33.47). Except for students, all participants ranked connectivity as the least important feature (Fig. 6).

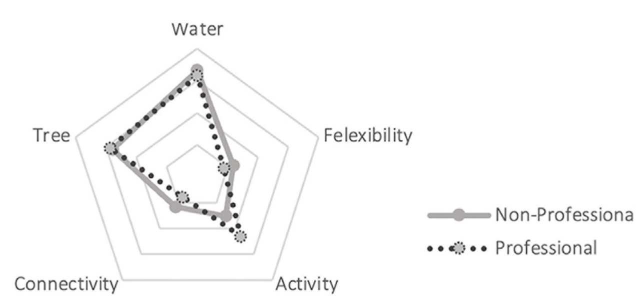


Fig. 5 Average significance ratings are segmented by experience.

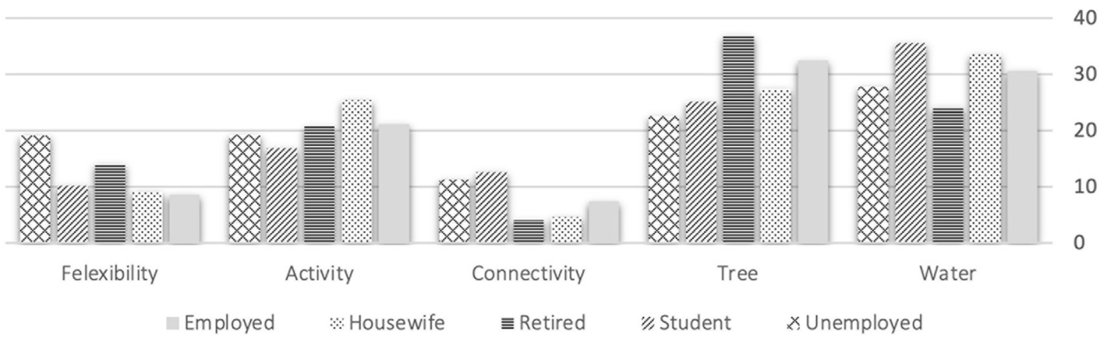


Fig. 6 Comparison of the importance of attributes between occupation status.

Importance differed among respondents grouped according to age was determined. 45—54 years old participants gave the highest rank to water (importance rank = 45.59), 55—64 years old participants gave the highest rank to the tree (importance rank = 43). Participants older than 65 gave the highest rank to activity (importance rank = 39.04). They also preferred green space for walking (aggregated utilities = 1.88) (Fig. 7).

Significant differences in education status were discovered in terms of tree preferences. More educated people, the importance of trees had also increased. The activity was ranked as the most significant feature by Diploma (importance rank = 39.81) and associate (importance rank = 33.17). Recreational activity (aggregated utilities = 5.01) and small fountain (aggregated utilities = 3.31) was ranked as the most preferred features by Diploma. Significant differences were found between participants with a Diploma degree and other groups in terms of their preference (Fig. 8)

Surprisingly, when preferences were considered by gender, it was shown that males (importance mean rank = 11.68) valued connectivity substantially more than women (importance rank = 8.4). In contrast, note that women gave higher importance to activity than men (women mean rank = 20.25; men mean rank = 17.43). However, it is important to notice that the choices for water (no water, small fountain, mirror pond) had no specific difference between genders. Substantial gender-related distinctions were observed concerning preferences for individual activity (aggregated utilities: women = −0.24, men = 0.14) (Fig. 9).

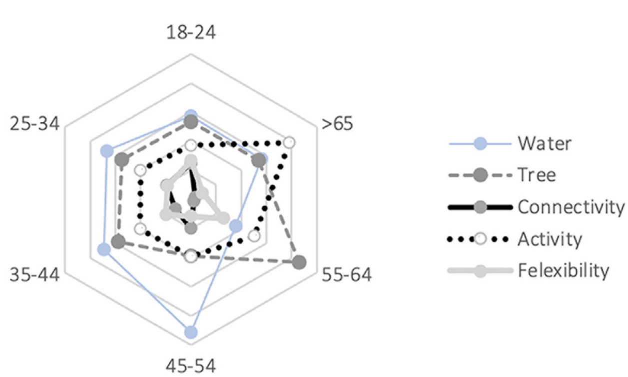


Fig. 7 Average importance values are segmented by age group.

5. Discussion

The findings from the choice-based conjoint analysis indicated that water features, tree density, and types of activities significantly influence park selection. This outcome underscores the importance of vegetation, particularly in densely built urban environments, informing urban planning practices. While these outcomes may initially seem intuitive, their empirical substantiation provides critical validation of urban planning practices that prioritize these elements. Trees, characterized by their long establishment period compared to other decorative elements such as flowers and bushes, necessitate strategic planning and foresight. This underlines a unique aspect of urban green infrastructure planning—long-term ecological and aesthetic values that trees bring to urban environments, which are often overlooked in more short-term planning frameworks. To address the need for innovative approaches in spatial resilience, we propose integrating dynamic, adaptable landscape features that can evolve based on community needs and environmental changes.

Nassauer et al. (2021) highlighted that microscale elements like plants, landforms, and water significantly influence residents' perceptions of care, safety, and community well-being. Our study extends these findings by quantitatively assessing how these elements contribute to community resilience and well-being, offering a novel perspective on targeted urban design and investment that is informed by rigorous conjoint analysis methodology. Future inquiries might explore varying canopy forms and species porosity, as suggested by Khodayari et al. (2021). Additionally, innovative spatial designs that incorporate flexible use of space and multifunctional areas could further enhance urban resilience.

A comparison of expert prioritization (BWM method) with resident preferences (CBC method) revealed differing perspectives. This discrepancy not only highlights the importance of considering diverse stakeholder inputs in urban planning but also introduces a nuanced understanding of how expert and lay perspectives can be integrated to enhance functionality and environmental equilibrium. This analysis points to the potential for developing hybrid design strategies that align expert knowledge with resident insights to create spatially resilient environments.

Experts focused on flexibility, tree diversity and density, continuity, and water features. In contrast, residents prioritized water, tree diversity and density, activity,

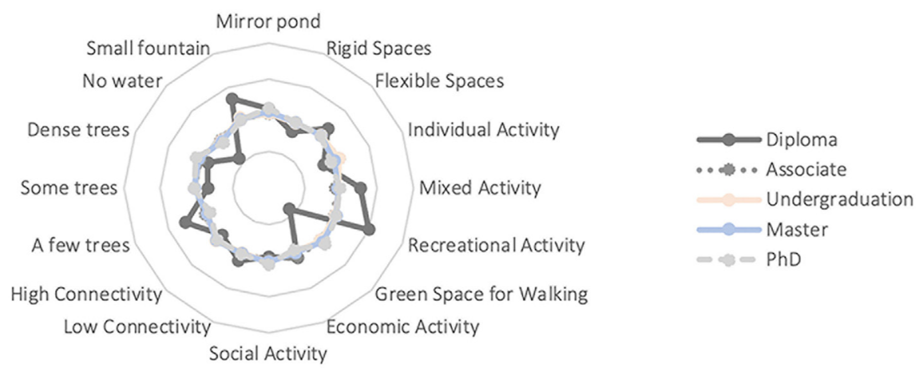


Fig. 8 Average importance values are segmented by age group.

flexibility, and connectivity. This discrepancy highlights the importance of considering user demographics and environmental interactions to enhance functionality and environmental equilibrium, thereby creating resilient living spaces (Bahriny and Bell, 2021).

The analysis of average utility values identified dense trees, water fountains, and green walking spaces as key features, which challenges common assumptions in landscape architecture regarding gender-based preferences in urban park design. Interestingly, no significant gender differences were observed in preferences for trees, water, and flexibility. However, scenarios featuring water elements were generally preferred, aligning with findings by Nordh et al. (2011). This preference points to a broader trend in environmental design, emphasizing the role of water features in enhancing urban livability, a finding that contributes uniquely to the literature on urban form and function. To innovate further in spatial resilience, future research could explore the health benefits of artificial water features like ponds and fountains (Xie, 2021), contributing to the development of health-promoting and healing urban environments on small scales.

Socio-cultural characteristics also influenced park attribute preferences. Notably, older residents (above 55 years) placed greater importance on the type of activity. This aligns, and adds to, research by Özkan and Yilmaz (2019), emphasizing the impact of physical and social attributes of open spaces on place attachment, thus highlighting a demographic-specific strategy for park design.

This study also aimed to uncover the latent potential of small leftover spaces without imposing predefined outcomes. Concerning socio-ecological resilience, visual concepts illustrating the integration of landscapes within urban voids (Figs. 10 and 11) propose strategic interventions in small vacant lands, contributing to our understanding of urban nature in contemporary, unpredictable times.

However, the conjoint analysis results are contingent upon the number and combinations of variables used. Future studies might examine additional features and their interaction effects. The insights gained here, particularly regarding resident preferences for small urban parks, can guide landscape architects and urban designers in creating highly resilient park designs.

The methodologies employed in this study, notably the integration of the BWM and CBC analysis, open new pathways in landscape architecture and urban design research. This innovative approach allows for a nuanced exploration of how various attributes influence user preferences and resilience in urban parks. For instance, Veitch et al. (2017) applied conjoint analysis to understand park attributes that attract adolescents. Another conjoint analysis has obtained additional information about the relationships between the levels of specific landscape indicators and the landscape preferences, which are not always linear (Schirpke, 2019). Similarly, Nordh et al. (2011) identified grass, trees, and the presence of other people as influential factors in choosing restorative spaces.

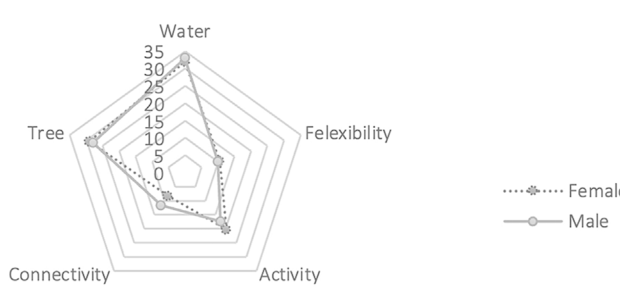


Fig. 9 Average importance values are segmented by gender.

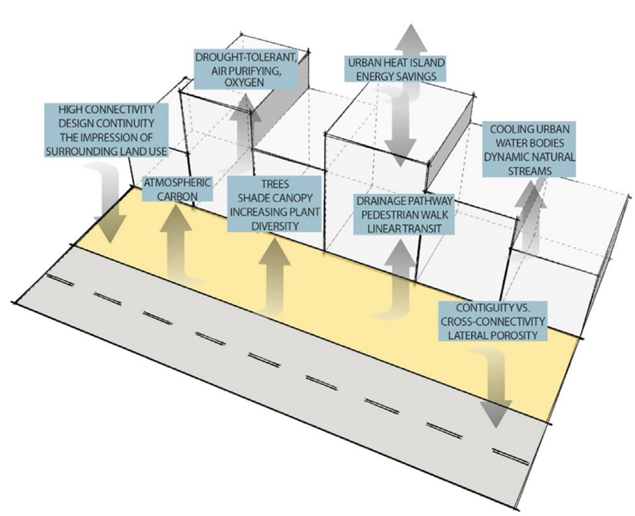


Fig. 10 The compatible proposals with Marginal Spaces potentials (Authors, 2023).

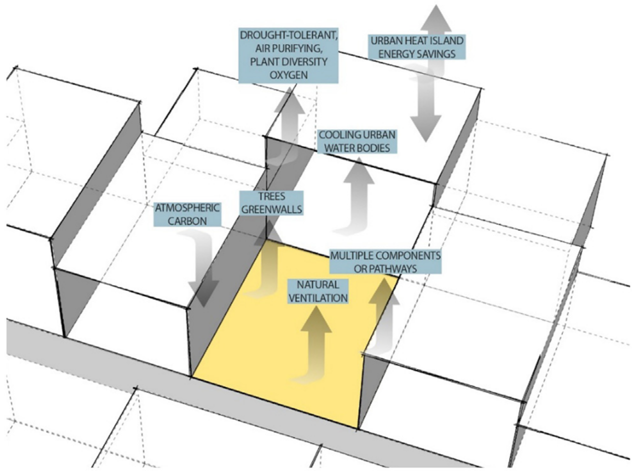


Fig. 11 The compatible proposals with In Between Spaces and Lots potentials (Authors, 2023).

Our study builds on these insights by highlighting flexibility, water, and trees as critical variables in socio-ecological resilience. This focus is particularly pertinent given the current urban design challenges, where flexibility in design can accommodate the evolving needs of urban spaces, and the inclusion of natural elements like water and trees enhances both ecological and social well-being. Landscape architects and urban designers can leverage these findings to create parks that not only meet aesthetic standards but are also resilient and responsive to the needs of their users.

Research by Zhang et al. (2020) revealed a significant gap in public understanding of the ecosystem services provided by small urban green spaces in China, suggesting a global challenge in environmental education. In contrast, Norouzian-Maleki et al. (2018) found that residents are capable of effectively evaluating the factors that contribute to livability in participatory planning models. These contrasting findings highlight the importance of engaging communities in the design and management of urban spaces, ensuring that these interventions are inclusive and effectively meet local needs.

The introduction of pocket parks as private yards in Stapleton by Gibson and Canfield (2016) serves as an innovative example of how small-scale interventions can significantly enhance urban livability. This approach aligns with the principles of smart growth, which advocates for compact, efficient urban design that optimizes the use of available spaces while promoting communal living. The challenge remains in ensuring these spaces are designed in ways that are perceived favorably by the residents as viable alternatives to private yards, thereby enhancing the social fabric of communities.

Finally, the growing concerns over resource and energy efficiency, especially in cities where space is at a premium, necessitate a shift towards smarter growth strategies. Our findings suggest that understanding and integrating user preferences and ecological benefits into the planning and design of urban green spaces are crucial. Such efforts not only support sustainability but also foster a deeper connection between urban residents and their environments, potentially transforming urban landscapes into more resilient and enjoyable spaces.

6. Conclusion

This study set out to identify key variables of urban resilience and understand their influence on public preferences for park features. Employing the Best-Worst Method (BWM), we determined that Flexibility, Diversity, Density of Trees, and Activity are pivotal resilience attributes. Subsequently, through Choice-Based Conjoint (CBC) analysis, this research illuminated how various park scenarios, reflective of these attributes, influenced public preferences. Thus, advancing our understanding of resilience as a fundamental determinant in preference formation—moving beyond traditional views that often separate ecological design from user-centric perspectives. However, it is crucial to note that preference does not directly equate to resilience quality. To enhance the innovative aspect of our findings, we propose the integration of modifiable landscape components that can be adapted over time to meet the evolving needs of urban communities, emphasizing not only flexibility in design but also the potential for parks to serve as active components in urban resilience strategies.

While the findings might initially appear intuitive, their value lies in the empirical substantiation of complex interactions between human preferences and environmental features, particularly in contexts of increasing urban densification. For instance, Water and trees emerged as the most influential elements in alternative park selection. This emphasizes the need for strategically planned green infrastructure as cities become denser, aligning with cutting-edge trends in sustainable urban design, and long-term strategies. Structural components, such as trees, take longer to establish than ornamental elements, such as water, and hence require more preparation. Concerning community preferences, soft materials and landscape elements have a more significant role than physical characteristics.

The integration of BWM and CBC methodologies in this research represents an innovative approach to assessing landscape characteristics, offering a nuanced understanding of how these factors foster park visitation. This study contributes to the broader understanding that park design encompasses a variety of considerations, extending beyond the mere incorporation of individual features.

However, the study faces limitations, including the underrepresentation of individuals under eighteen, which might have narrowed its scope. Future research should consider the perspectives of younger demographics, particularly in rural settings, as preferences and park characteristics are known to differ between urban and rural areas (Veitch et al., 2013). Additionally, the absence of observational studies to test the influence of environmental changes on behavior is a limitation, albeit one rooted in practical challenges related to cost and feasibility.

In conclusion, this research significantly enriches the field of urban resilience by employing mixed methodologies to identify and understand the impact of environmental components on park visitation and preference. It reinforces the importance of integrating natural elements like water and trees in the development of small urban parks and underscores the role these features play in enhancing urban resilience. This study offers valuable insights for future urban planning and design, particularly in the effective incorporation of resilience attributes in small urban green spaces.

Ethics statement

The authors declare that their Institutional Ethics Committee confirmed that no ethical review was required for this study. Written informed consent for participation was not required because all participants' data was anonymized before the statistical analyses were done. However, before asking any questions, all participants were informed about the study's goal and agreed to collaborate in this study anonymously.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author used CHATGPT to check for typos and grammar errors. After using this tool/service, the author(s) reviewed and edited the content as necessary and take(s) full responsibility for the contents of the publication.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Maryam Naghibi on behalf of other authors reports was provided by Delft University of Technology. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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