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Transforming Leftover Spaces into a Resilient Urban Landscape in Tehran: A MICMAC analysis of Key Social-Ecological Factors

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Abstract: Concerning resilient urban landscapes, current research emphasizes that we can no longer ignore ecological systems and social aspects. Thus, planning and design approaches must fundamentally address public needs and preferences. This research focuses on resilience from a community, infrastructure, social-ecological perspective, while there are still considerable gaps in integrated and holistic views on resilience. Moreover, providing more public spaces is a challenge, especially in cities with a high population density. Considering vacancy as an underexplored resource for socio-ecological benefits, this study intends to demonstrate how intervention in urban leftover spaces can transform into socio-ecological landscapes contributing to urban resilience. Moreover, choosing the design intervention will directly influence the vacancy; therefore, user preferences should be considered. With an analysis of critical aspects through experts' opinions of landscape resilience in leftover spaces, the paper shows that *Flexibility* was the most effective, while *Activity* affected most properties. Also, to focus on human preferences, a questionnaire was distributed among 386 residents. The findings suggest that the diversity and density of trees, type of activity, and water may create resilient urban landscapes and provoke satisfaction. The study results might inform particular research projects and interventions that consider landscape as a resource for resilience.

Keywords: Leftover spaces; Resilience; Social-ecological systems; Urban landscape

1. Introduction

Urbanisation is becoming a major modern problem, having widespread concerns for human well-being and natural ecosystems (Colléony & Shwartz, 2019). In the urban structure, parks can be considered the lungs of each city (Swierad & Huang, 2018) – both ecologically and socially. Green spaces implemented for ecological benefits (Klein et al., 2015; Kara & Oruç, 2021) also bring life to the urban area, enhance social quality, create opportunities for social interactions (Nordh & Østby, 2013), physical activity (Cohen et al., 2014; Klompmaker et al., 2018), recreation (Wen et al., 2018), health, and well-being (Wang & Rodiek, 2019; Chalmin-Pui et al., 2021). Thus, transformations in urban green spaces require incorporating particular humans need to be connected on multiple levels (Swierad & Huang, 2018). In this regard, previous studies have noticed that limited spatial access to green spaces (Barbosa et al., 2007; Rigolon et al., 2018), as well as those inadequate or poorly maintained (Bahriny & Bell, 2020) were some of the most critical concerns. Conversely, it is not easy and generally out of budget to find new public spaces (Lokman, 2017).

Besides conventional open (green) spaces, there are spatial discontinuities in urban landscapes, like leftover spaces that present areas of great potential for ecological research, social experiences, and the development of cities (Naghibi et al., 2020). In addition to providing alternative spaces where humans and nonhumans can interact (Pearsall & Lucas, 2014), vacant land can lead to community revitalisation and reclaiming neighborhoods (Gobster et al., 2020), and encourage multiculturalism. It also demonstrates how unoccupied land may contribute to urban greening.

Concerning resilient urban landscapes, current research emphasizes that neither ecological systems nor social factors can be ignored (Crowe & Foley, 2017). Social and ecological values can be intertwined; transforming unpleasing landscape spaces into community engagement, and opportunities for increasing the resilience of social-ecological systems may emerge (Folke, 2006; Kremer et al., 2013). In this regard, resilience theory presents insights into socio-ecological systems and their sustainable management (Folke, 2006).

Rather than problematizing these spaces (Gobster et al., 2020), leftover areas are proposed to be transformed into green and open space development and management (Kim, 2018). When occupancy and care replace signs of abandonment and neglect, repurposed leftover spaces within previously dense city regions can contribute to community cohesion and a sense of place (Stewart, 2019).

Considering vacancy as a potential socio-ecological resource (Kremer et al., 2013; Anderson & Minor, 2017), this study intends to demonstrate how intervention in urban leftover spaces could transform into socio-ecological landscapes contributing to urban resilience. Moreover, choosing the design intervention will directly affect limiting the unoccupied spaces; hence, public needs and priorities should be assessed (Palamar, 2010).

The current study addressed a socio-ecological framework through the mixed methodology recognising cities as human-centered environments developed and maintained for citizens. It is suggested that by assessing vacancy, socio-ecological characteristics of neighborhoods that contain leftover spaces, landscape architects and urban planners may support resilient landscapes more effectively (Kremer et al., 2013).

2. Theories and Methods

Trancik's *Finding Lost Space* (1986) introduced the notion of prescriptive lost space, in which he proposes that lost spaces are unpleasant and unproductive zones devoid of community. Because the cultural environment is linked to the people's character, Trancik believes it is critical to comprehend their perceptions. Despite the relevance of this study, he did not conduct any interviews with users to further inform his concept of space or place, whether lost or not.

According to Lynch (1960), rather than considering the city as an object, how the city is perceived by its residents is critical. Moudon (2003) highlights the urban design discipline's dilemma, namely the dichotomy between its prescriptive and descriptive natures, arguing that the former emphasizes the "what should be" while the latter emphasizes the "what is." Urban design is as much about understanding "what should be" as it is about understanding "what is," and one of her recurring criticisms of this dichotomy is that urban designers often overthink the prescriptive "should be" without a strong knowledge of the descriptive "what is."

Based on the theoretical background, this study implements a mixed-methods research design in relation to a case study in Tehran, Iran, addressing both experts' and community opinions. Opinions were collected in the form of professionals' revisions (selection of the properties, instructions on how to fill out the tables, mapping the leftover sites), and a survey was conducted with a mix of professionals and non-professionals.

The current study conducted a three-phase methodological framework as follows:

Phase 1: A questionnaire for selecting variables of interest by twenty-two experts. Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) was used to analyse data. Michel Godet (1997) developed MICMAC, a structural analysis tool for structuring ideas. MICMAC is a qualitative system dynamics technique that allows researchers to connect all the components (Mirakyan & Guio, 2015). MICMAC can be used as a tool for reflection, decision-making, a component of a more advanced analysis process, and attempts to locate the independent and dependent factors.

Phase 2: Identify the most relevant attributes and levels using a Multi-Criteria Decision-Making (MCDM) method.

Phase 3: Distribute a questionnaire for community preferences.

2.1. Tehran case study

The study examined socio-ecologically resilient interventions on micro-leftover spaces in Tehran, Iran's capital, a densely populated metropolis with limited space (Naghibi et al., 2021). The selection of micro-leftover spaces was based on the existing facilities (mapping the sites) and possible project improvements (regarding each site's characteristics and city regulation). Considering the limited availability of open spaces in the city, developing a hierarchy among various interventions in micro-leftover spaces and identifying the essential elements representing residents' preferences in public places was critical. Spaces in Tehran were among the remaining places selected for this study. Citizens were interviewed in advance to identify the location as vacant space. Considering real cases in Tehran supports participants' better imaginations of the space and accurately evaluates the variables and preferences.

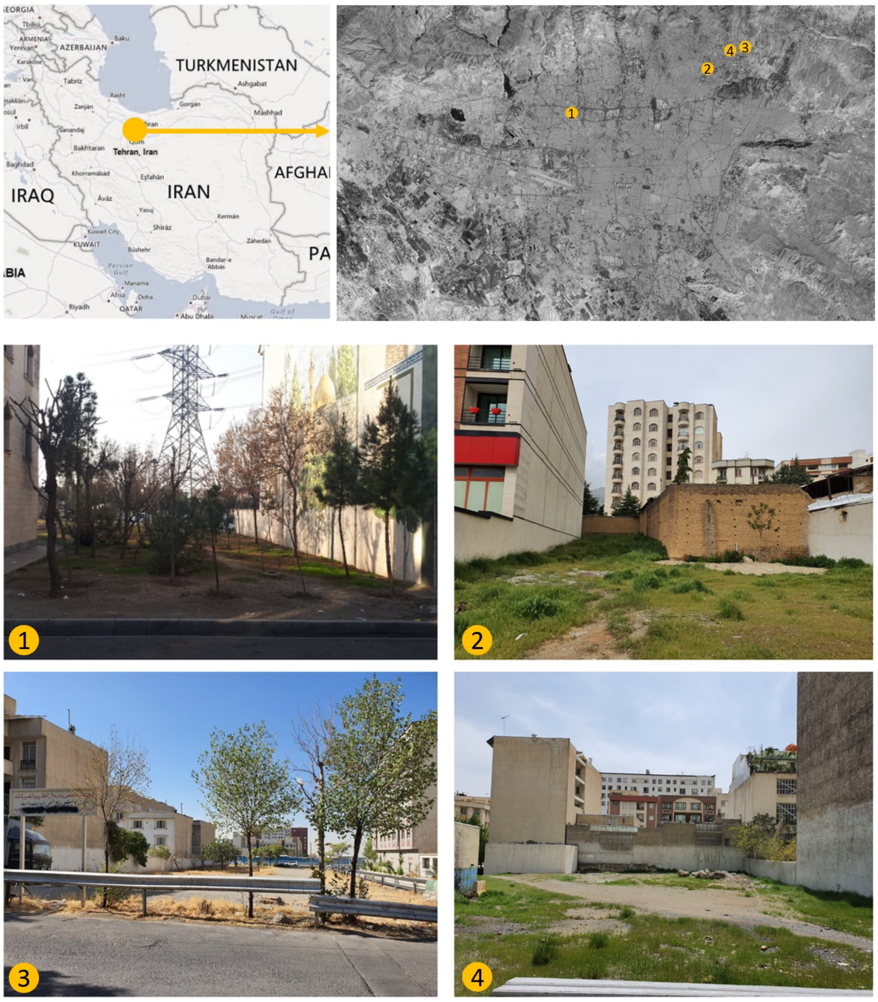

Figure 1. The location of the case study (https://www.whereig.com/iran/where-is-tehran.html)

2.2. Phase 1: Questionnaire Design for MICMAC analysis

A literature review provided the main factors to verify content validity (Lynn, 1998), and the experts evaluated the first version regarding its relevance, clarity, meaningfulness, and completeness. Thus, the first step depended on expert opinion. Twenty-two specialists were invited from several disciplines and domains (landscape architecture, architecture, urban planning, and urban design). The data were statistically analysed in MICMAC to examine the inter-relationships between characteristics for the resilience landscape of left-over spaces. Through a graphical illustration in multiple clusters, the characteristics may be divided into four categories: autonomous, linkage, dependent, and driving.

2.3. Phase 2: Identifying the most relevant attributes and levels

In this section, the experts select the most important attributes in general. A Multi-Criteria Decision-Making (MCDM) method was used to find the optimal weight.

2.4. Phase 3: Questionnaire structure for residential preferences

As previously stated, one of the main objectives of the research was to explore the residential preferences for small urban green spaces in residential neighborhoods. This study assessed respondents' opinions of different attributes separately and explicitly, and the relative importance weight of each attribute based on residents' responses. The research was conducted in the form of a questionnaire due to the value of this approach in gathering opinions/preferences, especially when the sample size was relatively large. The questionnaire is also affordable and well-known to the majority of participants. The experimental questionnaire was divided into two sections: The first section was meant to record demographic information, while the second comprised questions about preferences for small urban green spaces. The preference questions were compiled and elaborated from the MICMAC and experts' decision presented in the previous section in five items: Flexibility, Connectivity, Activity, Density of Trees, and the Water dimension. In this section, participants were asked to evaluate each factor of leftover spaces on a four-point Likert scale (1=No Preference, 2=Slightly Prefer, 3=Strongly Prefer, 4=Very Strongly Prefer)

3. Results

3.1. Interpretation of the MICMAC questionnaire

In order to recognise the influence of each factor, it is necessary to define a hierarchal structure of the factors based on the driving and dependency power (Figure 2). Some factors may significantly influence, while others may stand alone or have just a minor role. MICMAC is an approach for better achieving the goal. It also shows how various factors are organised into distinct groups graphically. Autonomous, Dependent, Linkage, and Driving variables are the four types of factors (Kannan et al., 2009). The autonomous variables are typically ineffective drivers. Weak driver and strong dependent variables make up the dependent quadrant. The linkage variables are strong drivers and dependents, making them extremely unstable. Strong drivers that are independent are found in the independent quadrant.

The matrix must converge towards stability at the end of a certain number of iterations to demonstrate the validity. In the matrix of effective factors with three rotations of data, it is 100% desirable, indicating the high validity of the questionnaire.

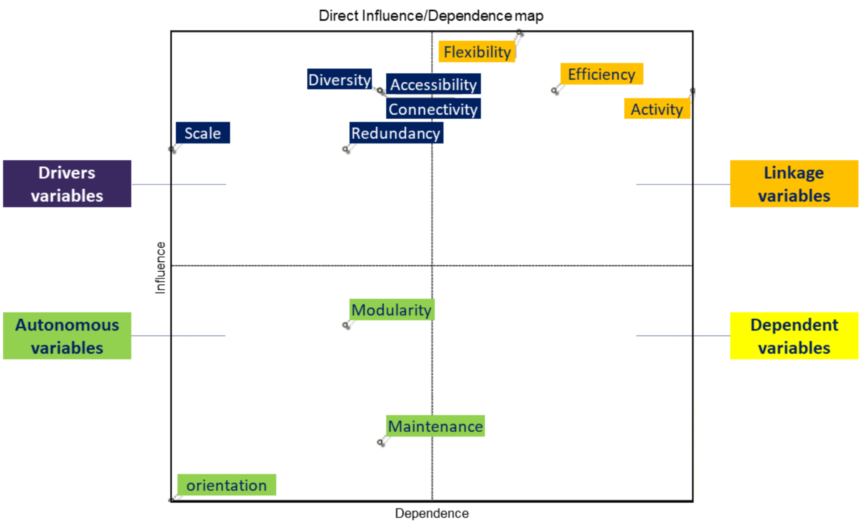

Figure 2. Pattern of variables dispersion of direct influence/dependence map

MICMAC analysis revealed further information about each factor's driving and dependency power, indicating relative importance and interdependence. The key findings of the study have been organised into four main clusters reported by MICMAC:

1. Variables with autonomy

Modularity, Maintenance, and Orientation variables have low driving and dependent power. These variables are disconnected from another resilience system in the landscape because they have so few linkages. These connections might be crucial in the long term.

2. Variables that are dependent

Quadrant-driving's power is weak, despite its high dependency power. The competence of these variables for achieving other variables is considered insignificant.

3. Linkage variables

Linkage variables such as Flexibility, Activity, and Efficiency are strong and intense in dependency and driving force. These variables are inherently unstable, and their actions will influence others.

4. Driving variables

Despite their weak dependency, Accessibility, Connectivity, Diversity, Redundancy, and Scale have high driving power, making them significant variables (Figure 2). These factors are classified as linking and driving variables.

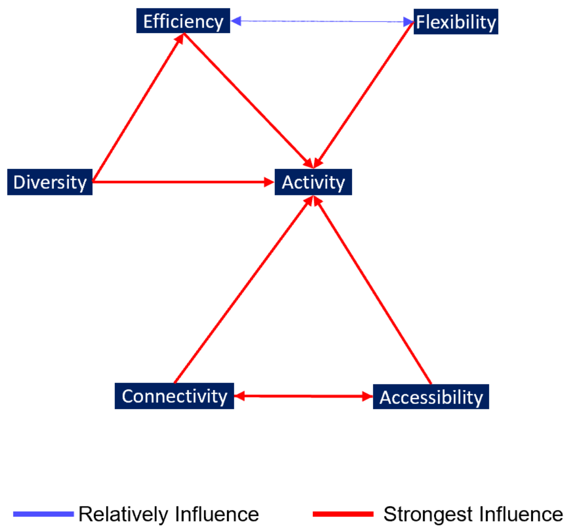

Figure 3. Direct influences graphs.

Accessibility, Efficiency, Flexibility, and Connectivity may all impact Activity, as seen in Figure 3. Efficiency is directly influenced by Flexibility, Diversity, and Activity. Furthermore, Efficiency can be influenced indirectly by Flexibility, Connectivity, Accessibility, and Activity.

3.1. Weighting Criteria

According to the experts' point of view, five factors were chosen as the critical attributes of socio-ecological resilience. The mentioned key factors of socio-ecological resilience and their levels are illustrated: Diversity and Density of Tree, Bushes, Flowers; Diversity of Pavement; Diversity of Covering; and Diversity of Planting, Water, Connectivity, Flexibility, Efficiency, and Activity.

Following the experts decided on the criterion's choice, the main attributes (flexibility, tree diversity and density, type of activity, Connectivity, and water) were determined based on the questionnaires.

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	

Figure 4. Attributes and levels of interest in this research

3.2. Residential preferences

This study had 386 participants. The majority of participants (n = 181) were between the ages of 25 and 34, followed by 18 to 24 years (n = 103), 35 to 44 years (n = 63), 45 to 54 years (n = 20), 55 to 64 years (n = 13), and over 65 years (n = 6). On average, 60.4 percent of participants were female, while 39.6 percent were male. The majority of the participants (n = 200) had a master's degree, and the majority of them were either students (n = 165) or employed (n=153).

Friedman's test is used to understand the hierarchy of preferences. The mean of the factors is shown according to participants' priority (Table 1). Priority ranking reveals that Activity indicators such as Individual Activity, Social Activity, and Walking achieved the highest average. The indicators with the lowest average are No-water, Low density of trees, and Rigid spaces that follow the experts' opinion.

Table 1. Friedman test results for participants' Preferences.

Index	Indicators	Mean	Std. Deviation	Mean Rank
Activity	Individual Activity	3.63	.607	12.12
	Social Activity	3.40	.722	11.01
	Walking	3.35	.729	10.75
	Mixed Activity	3.28	.715	10.40
	Play-Sport	3.25	.740	10.21
	Economic Activity	2.64	.842	7.15
Water	Fountain	3.11	.816	9.47
	Pond	3.03	.812	9.02
	No water	1.54	.739	3.07
Connectivity	High Connectivity	3.10	.828	9.45
	Low Connectivity	2.65	.879	7.35
Flexibility	Flexibility	3.09	.749	9.41
	Rigid Space	2.39	.735	6.00
Tree - density	Tree- High density	3.15	.791	9.65
	Tree- Medium density	2.65	.729	7.25
	Tree- Low density	1.73	.789	3.68

Activity reached the highest rank based on the results, followed by Water dimension, Tree density, Flexibility, and the state of Connectivity. To study the most preferred indicators of each factor, the Individual Activities ranked as the first in terms of Activity. In terms of planting density, parks with a high density of trees have the highest priority. To determine the water elements priority, the highest mean belonged to Fountain, followed by Pond. Flexibility is the fourth factor, and the least important factor is Connectivity.

The Mann-Whitney U test is applied to compare significant differences between gender groups. The test revealed that there were significant differences in preferences of Flexibility (sig: .029), Play-Sport (sig: .003), and Mixed Activity (sig: .001). Females were more interested in Flexible spaces (Mean Rank: female 203.11, male 178.87), Mixed Activities (Mean Rank: female 207.70, male 171.87), and surprisingly Playing or exercising (Mean Rank: female 206.08, male 174.34).

In terms of Mixed Activity, the Mann-Whitney U test is employed to understand the significant differences based on gender; however, the result of the ANOVA test showed that occupation status affects participants' preferences (Levene Statistic shows that they have equal variances). There are no significant differences between professionals and non-professionals, and the education degree did not affect participants preferences (Levene Statistic shows that they have equal variances).

Table 2. The ANOVA test regarding experience

	Test of Homogeneity of Variances		ANOVA					
	Levene Statistic	Sig.		Sum of Squares	df	Mean Square	F	Sig.
occupation	.236	.918	Between Groups	5.77	4	1.443	2.88	.023
			Within Groups	190.88	381	.501		
			Total	196.65	385			
education	.763	.550	Between Groups	.88	4	.220	.42	.788
			Within Groups	195.77	381	.514		
			Total	196.65	385			

The outcomes of the Mann-Whitney U test indicated notable differences between professionals' status and preferences of trees in terms of high and medium density. A significant difference could not be detected statistically between crossed variables regarding low density. Both groups preferred a high density of trees. Both groups demonstrated a lower preference for a low density of trees.

Table 3. Mann-Whitney U test in terms of tree density

	Tree- High density	Tree- Medium density	Tree- Low density
Mann-Whitney U	12631.500	15046.500	18201.500
Wilcoxon W	30022.500	35146.500	35592.500
Z	-5.836	-3.543	-.398
Asymp. Sig. (2-tailed)	.000	.000	.690

Table 4 shows which continuous variable had the highest average value (column Mean Rank). It is, however, done only where a determined statistically meaningful difference between the crossing variables is determined. Compared to medium to high density of trees, the professionals were more interested in medium-density, demonstrating a lower preference for high density.

Table 4. Compared to medium to high density of trees

	Professional	N	Mean Rank	Sum of Ranks
Tree- High density	Yes	186	161.41	30022.50
	No	200	223.34	44668.50
	Total	386		
Tree- Medium density	Yes	186	212.60	39544.50
	No	200	175.73	35146.50
	Total	386		

Although most participants preferred flexibility for small urban parks, the results of one-way ANOVA revealed significant differences between age groups and preferences of rigid spaces (F 2.719, 5; α= 0.02). It can be seen that participants above 54 years old had the lowest preference for rigid spaces (Mean= 2). However, participants between the ages of 35 and 44 have the highest preference for these rigid spaces (Mean= 2.54).

4. Discussion

According to Forgaci (2020), urban designers and planners must translate a city's complex social-technical environmental system into resilience-building spatial changes. The dichotomy is enhanced through large-scale planning without community engagement, which originating from top-down urban concerns. This study challenges the polarised mindsets currently evidenced within planning by hypothesizing that it is not the small-scale lots concepts as problematic, but rather the dichotomizing framework and modernist legacy that characterise the concepts. The study's main objective is to explore and discuss more approaches to small-scale vacant structures. In this regard, the concept of resilience was utilised as a theoretical umbrella and applied to the case study. The recent study has highlighted that socio-ecological aspects are particularly relevant for vacant lands. They open up for community involvement and contribute more integrative and practical approaches to produce resilience thinking helpful in addressing the urban landscape dichotomies.

The categorisation of variables provides a foundation for understanding the phenomena of changes in any variable and their consequences on others. Improvements in links and dependent variables will result from incremental changes in independent variables. The study will assist transdisciplinary research in collecting data and possible multidimensional studies.

The "Flexibility" variable significantly influences on the other variables since it has a considerable impact on the future of the resilience landscape in leftover spaces (see Figure 2). Flexibility has a lot of driving and dependence power as a linking variable. Overconcentration on engineering measures puts urban systems' qualities of flexibility and adaptability at risk in the long term. The significant difference lies in the bottom-up structure of the organisation and commitment involved and the absence of a ready-made pre-existing infrastructure. Therefore, based on the findings of Mariani & Barron (2014), flexibility appears to be one of the emerging criteria for a working plan of interim use management. Thus, flexibility should be considered on both infrastructural and minor scales.

This study strives to reveal the possibilities latent in small leftover spaces, but not dictate a particular consequence. In this regard, to trace landscape in the fabric of vacancy in the city, ideas were illustrated in Figure 5. Concerning human-centered development, proposed ideas are adapted to create strategic interventions and develop knowledge on how the nature of cities can be better recognised and extended in the contemporary, unpredictable era.

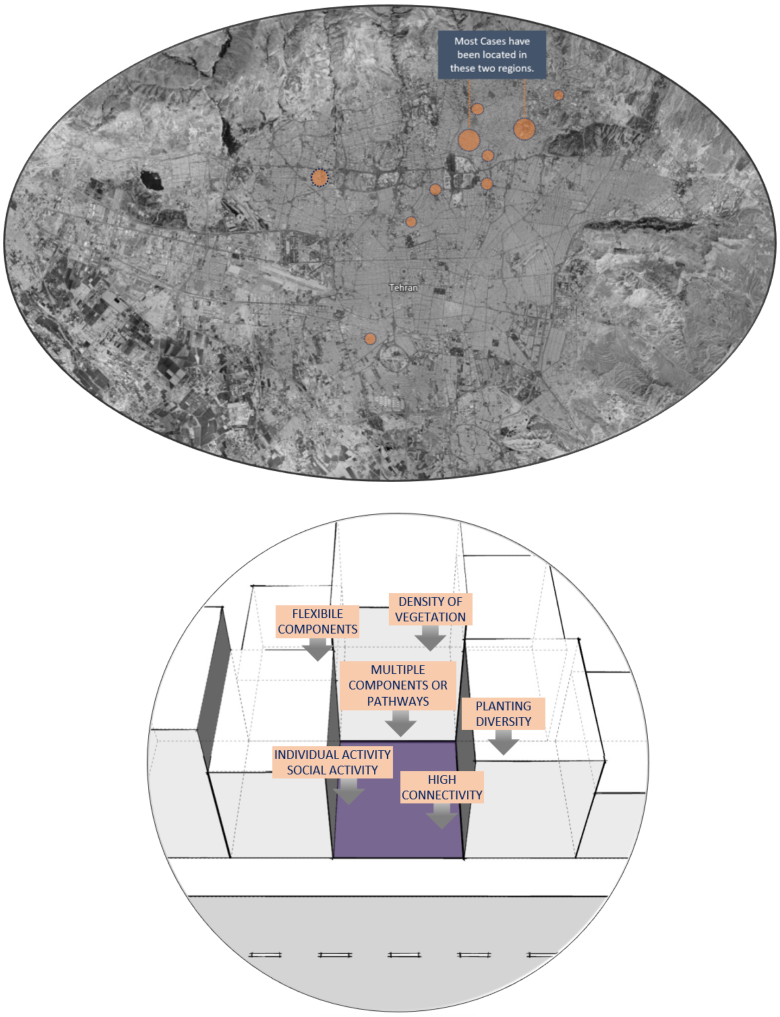

Figure 5. The compatible proposals with the sites' potentials

This study has revealed further directions in extending knowledge on leftover space through real cases. Also, future research directions would be conducted for vacant lands in varying contexts and climates to understand whether the same properties still emerge as preferences. Accordingly, future research will be required to evaluate the effects of these strategies on design decisions and monitor how resilience impacts the design process. Also, a set of design principles to measure instruments and developed in different cases could be considered. Based on the methodological challenges in the urban landscape, a design-driven research approach could shed more light on the effects of design principles derived from the findings of this paper.

In the light of recognising and intervening in small spaces for various people, methods that involve more participants will be more effective. It is also necessary to consider qualitative aspects of leftover spaces to promote resilience. It might be helpful to consider extended visual landscape quality assessment methods with user preferences to prevent these spaces from being unoccupied.

5. Conclusions

The novelty of the current study is implementing a mixed-method, a theoretical analysis concerning a case study in Tehran, concerning experts and community preferences to interpret the needs and interests of open space. Focusing on leftover spaces in Tehran, Iran, this research strengthens the idea that flexibility improves vacancy conditions. Furthermore, the findings propose that leftover spaces greening projects may achieve social and ecological goals.

Vacant land greening enhances neighborhood conditions while transferring vacancies to urban spaces can recover advantages to the neighborhoods. In comparing medium to the high density of trees, the professionals were more interested in medium-density, while they demonstrated a lower preference for high density.

Small-scale designs promote the success of city-wide programs. Large-scale approaches might not consider particular regions or areas, such as residual spaces, brownfields, and leftover spaces. In contrast, appropriate area programs can afford more opportunities and details to respond to community concerns.

Concerning the planning and design for leftover spaces, community engagement may be the critical step to determining the problem of urban spaces. The current study looked at the differences between the opinions of experts and non-professionals. While the experts consider flexibility the most critical factor, non-professionals consider activity the most important factor. Thus, multiple socio-ecological factors in metropolitan settings have resulted in the vacancy. Municipalities should be receptive to proposing suggestions from communities to use the abandoned property.

Contributor statement

Maryam Naghibi: Conceptualization, Writing – Original Draft, Visualisation, Software. **Mohsen Faizi:** Supervision, Methodology, Writing - Review & Editing. **Claudiu Forgaci:** Supervision, Writing - Review & Editing, Methodology. **Ahmad Ekhlassi:** Supervision, Validation.

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