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Research article

Enhancing Urban Livability in District 22 of Tehran: A Study on the Impact of Efficient Fuels Using Fuzzy Delphi and Cross-Impact Analysis Methods

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Abstract

Urban livability is a crucial measure of sustainable urban development. This study aims to analyze the factors influencing the livability of Tehran's 22nd metropolitan area using the Human City approach, the Fuzzy Delphi method, and structural analysis. Theoretical data was collected through documentary research, while experimental data was gathered through surveys using the Delphi technique. A total of 20 urban experts were sampled, and 41 propellant forces across five dimensions were identified. These propellants were categorized into economic, social, cultural, physical, environmental, managerial, and legal factors. The data was analyzed using Fuzzy Delphi and Cross Impact Analysis Methods in MICMAC software. The results revealed significant relationships among key propellants, indicating their strong influence. The analysis also showed a complex and interconnected network of propellant forces, with some clustering in specific areas. Seven key factors were identified as crucial for improving Job opportunities, Citizen participation, Public transport, Affordable housing, Public spaces, Walkability.

Keywords: Livability; Delphi fuzzy; structural analysis; Sustainable development; District 22; Tehran metropolitan area.

1. Introduction

Cities have been occupied by huge human modifications and they are vital centers of modern societies, embodying social, economic, and cultural progress. Therefore, the concentration of numerous activities has decreased and depleted valuable natural resources, resulting in pollution and changes in land use and land cover (Sodiq *et al.,* 2019; Green *et al.,* 2024). The fast growth of urbanization and the rise in urban population have resulted in environmental issues becoming key challenges (Beatley, 2012; Ghalehteimouri *et al.,* 2024). One strategy to tackle these challenges is to improve livability, which involves striking a balance between urban expansion and environmental preservation (Newman & Jennings, 2008).

The human city approach, as a comprehensive and broad perspective, can play a significant role in enhancing urban livability (Tayebeh *et al.,* 2023; Rahimzadeh and Jafarpour Ghalehteimouri, 2024; Schindler and Dionisio, 2024). In Iran, urbanization has seen rapid growth, particularly over the last four decades, with the urbanization growth rate exceeding 3.2 times in 2016 (Iran Statistics Center, 2016). However, urbanization is often seen as a sign of progress; in Iran, the surge in urban population has primarily concentrated in major metropolitan cities like Tehran (which accounted for 7.14% of the population in 2016) (Iran Statistics Center, 2016).

The rapid increase in Tehran's urban population has led to economic prosperity; however, it has also imposed significant human and environmental costs, resulting in unfavorable living conditions (Shamaei and Jafarpour Ghalehteimouri, 2024). District 22, spanning around 6,000 hectares, has been impacted by the rapid urbanization and development in Tehran. The area has garnered attention from urban planners and experts due to its bio-environmental capabilities, varied land structure, and relatively untouched natural surroundings, especially when compared to other parts of Tehran with non-standard density and architecture (Ghalehteimouri *et al.,* 2024; Ghasemi, 2024). Due to its unique characteristics, natural surroundings, and location in the capital area, Tehran is expanding towards District 22, emerging as a new city in terms of spatial development pattern (Remenyik *et al.,* 2021; Ghalehteimouri *et al.,* 2021; Bagheri and Soltani, 2023).

District 22 of Tehran municipality is seen as a model of sustainable development within the city. It was the first urban district designed with the aim of sustainable development. A plan was established for the area in 1999, with the initial goal of having the area span between 6 and 10 thousand hectares, with at least 51% designated as green and open spaces (Hosseini *et al.,* 2022; Zarie *et al.,* 2024; Khaliji and Jafarpour Ghalehteimouri, 2024). However, the plan underwent complete revision. The area boasts trans-regional and transnational elements and amenities, such as Chitgar Lake, Chitgar Park, Azadi Stadium, Botanical Garden, various research institutes, Olympic Village, Sharif University, Iran Mall, and Hezaro Yek Shab Cities (Akhshik *et al.,* 2022; Yekta *et al.,* 2023). Moreover, the area is intersected by key highways of Tehran city and is serviced by Tehran Metro Line 5. Over the past few decades, significant changes have taken place in the structure of District 22 due to urban expansion, attracting residents from various Districts, and its distance from pollution issues. Nevertheless, the rapid development of the area and the absence of urban development plans have resulted in several challenges, including inadequate public transportation, high population density, violations in sales density, issues related to land and housing exchanges, unplanned construction, unregulated high-rise buildings, water scarcity, declining service standards, limited access to various centers in Tehran, lack of business activity, migration, and weak social connections (Amini *et al.,* 2022).

In the past four decades, decision-making in District 22 has been influenced by market demand, prioritizing car-oriented development over sustainable initiatives. The future livability of District 22 in Tehran is a pressing concern, and addressing its complexities and advancements will pose challenges. To navigate this intricate landscape, new complementary paradigms and approaches for enhancing livability, such as the human city concept, must be embraced. Implementing the human city approach to enhance livability in Tehran's 22nd district is crucial for sustainable development. This study utilizes structural analysis and Delphi Fuzzy to identify the key factors and influences shaping livability with the human city approach in District 22. The study seeks to address two main questions: 1) What factors are driving livability with the human city approach in District 22?) What is the clustering system of key factors impacting livability with the human city approach in District 22?

1.1. Theoretical foundations and research background

Livability is a widely used term, but it lacks a clear and unified definition. This lack of consensus is attributed to ambiguities in the field, and Hillen suggests that differences in opinion are normal due to the diverse scientific backgrounds of researchers (Heylen, 2006). According to Veenhoven (2014), livability is the degree to which a living environment fits the adaptive repertoire of a species. When applied to human society, it denotes the fit of institutional arrangements with human needs and capacities. Livability theory explains observed differences in happiness in terms of need-environment fit. The term 'livability' is widely used but lacks a universally accepted definition. In the UK, "livable" is the preferred spelling, while in the US, "livable" is gaining global recognition. As a noun, "livability" refers to "the quality of being livable," while as an adjective, "livable" means suitable for human living. Livability is influenced by community-specific values and context, which are shaped by economic, social, and cultural factors, as well as residents' personal feelings. In the US, livability is related to quality of life and wellbeing, while in the UK, it focuses on cleanliness, safety, and the presence of plants in the local area (Javdan *et al.,* 2023; Maran, 2024; Ashley *et al.,* 2024).

Academic discussions often use terms like "vitality," "liveliness," and "sense of belonging," but these are qualities of a livable place rather than synonyms for livability. Livability is the measure of people's contentment with their environment and how they engage with it. It is shaped by elements such as economic well-being and societal harmony. Livability is primarily determined by the specific conditions in urban areas that improve overall quality of life and happiness. This encompasses access to amenities and services like education, healthcare, and housing. Effective urban planning and design play a key role in fostering livability (Vogt *et al.,* 2020; Sheikh and van Ameijde, 2022; Abdel-Razek *et al.,* 2024). Urban planning and design are crucial in promoting livability. Understanding livability involves assessing the subjective experience of living in different places and considering behavioral patterns in urban environments (Zanella *et al.,* 2015; Ahmed *et al.,* 2019; Movahed and Jafarpour Ghalehteimouri, 2019; Zaharijević, 2023; Butcher and Sircar, 2023; Sürücü and Yalçın, 2024). While some proponents claim that it is possible to define livability and identify consistent characteristics, others argue that livability varies significantly among different population groups and spaces. Livability is not only a result of favorable urban conditions but is also influenced by people's perceptions of urban life, making it challenging to provide a definitive definition (Stevens, 2009). Therefore, there is still no consensus among researchers on the definition of "livability," a concept that varies across cultures and social values.

Livability is a concept that has global relevance (Balsas, 2004), but its realization depends on local circumstances (Wang & Miao, 2022). It encompasses environmental quality, sustainability, quality of life, and well-being, and is connected to specific strategies for creating and managing public spaces. The theory of livability was originally rooted in Abraham Maslow's work on human needs (Radcliff, 2001) and has been further developed in subsequent research (Akbari, 2022).

Table 1. Tracing the conceptual relationship between livability and the human city.

	Livability	Human City	Similarities	Supplement	Contradictions
Scale	The local or regional scale gives priority to local activities.	The location is related to the human scale; It gives priority to local activities.	Recognizing the legitimacy of the current situation and the inadequacy of the individual to find a solution	Livability requires a human city approach to carefully examine the interests of the stakeholders.	-
	Encouraging behavioral changes at the micro level	Micro-level application of small-scale geographic conditions and behavior	Taking legitimacy from the current situation; Changing behavior is essential	-	-
	Short term; Direct impact on people, neighborhoods, and cities	Instantaneous; Direct effects on the people of the neighborhoods	A forward trend that requires the formulation of an immediate solution	The human city needs a livability approach so that the relevant local conditions can influence people's behavior change.	Who or an institution should define these concepts and who should benefit from them?
	Locally defined through civic engagement	Definition through empathy, cooperation and full participation of citizens	Collective translation of the defined concept into a common agenda	-	-
Background[1]	Weighing with local concerns and values; Consider the tastes of local stakeholders	Supporting all aspects of human life in accordance with the local environment and context to respond to the needs of local stakeholders.	Choice-based recommendations and informed assumptions about social justice vulnerability	Livability requires a human city approach to ensure that equity, economy and environment are considered in local tastes.	-
	It is dynamic and allows for changes over time	Dynamism and allowing for changes over time; Different weights are assigned to measures depending on the context.	Dynamic and flexible to changes	-	-
	Stakeholders are clearly identified; The solution to promote indicators	Stakeholders are directly represented; The roles and responsibilities of the stakeholders are clear.	Similar overarching goals are shared through perceptions and needs are identified.	-	-
	Direct motivation by those who benefit and those who are burdened.	Interests or concerns through those who benefit directly.	-	A human city needs livability to be relevant to specific stakeholders.	-
	Relatively easy to understand	An attractive and easy to understand concept	Both seek common recognition among stakeholders.	The human city needs livability to ground actions and investments for future changes.	-
The potential	Facilitate political support; Promote loyal stakeholders	Responsible for planning and political decisions	It requires organized actions and accountability to respond to political decisions.	-	-
	Being receptive to design and planning interventions, reacting to the transactional relationship between people and place	Planning and design based on contextual approach	It requires coordinated action and responsibility: accountability for planning and decisions	The human city needs livability to demonstrate its relevance and operational potential for change on a human scale.	What results of interventions and planning are considered relevant?
	Support for incremental, ultimately local development is allowed	Local development in accordance with the principles of human-centered urbanization	-	-	-

[1]The context emphasizes that each paradigm responds to the values of its stakeholders and how each adapts to changing circumstances and tastes.

Livability can be examined and assessed using various approaches, reflecting the broad meaning of the concept. Given the complexity of urban challenges and the scope of livability assessment, it is important to develop complementary approaches to assess livability, including the human city in urban planning literature. Leby *et al.,* (2010) defined a livable city as one that considers the needs of all its residents, regardless of age or ability, and emphasizes the importance of each individual. Krasny and Tidball (2012) introduced the livable city as one that is justice-oriented and humane, providing self-reliance and economic capability while emphasizing resources, health, and vitality.

Vinhoven also emphasized the importance of human-oriented urban planning in creating a livable society (Movahed and Ghalehteimouri, 2020). The concept of a livable city is often associated with a human-centered approach, focusing on the health, happiness, and well-being of its residents (Sheikh and Ameijde, 2022). A livable city is one that provides choice and variety in amenities within a short distance, promoting accessibility and convenience for its residents (Wheeler, 2014). Understanding the relationship between the human city approach and livability can help urban planners and policymakers address both short-term demands and long-term sustainable development goals (Sharifi *et al.,* 2024).

There has been a growing interest in the concept of livability and the human city in urban planning discussions. This has created an opportunity to improve policy communication and gain political support, as these concepts are now seen as measures of success based on local political realities and the preferences of local residents. Livability and the human city focus on creating walkable neighborhoods with safe public spaces, and local organizations and planners play a crucial role in shaping the environment based on the needs and desires of the people at a local and human scale. Livability and the human city are interconnected, and many livability indicators include elements that are considered indicators of the human city, such as a mix of uses, suitable housing, and security of public open spaces. These concepts are dynamic, and change based on the context and values of society, aiming to align the communication of stakeholders and decision makers towards sustainable goals.

The concept of livability within the human city approach encompasses the three pillars of the sustainability pyramid: environmental, economic, and social issues, along with physical considerations (Chen *et al.,* 2022; Russo and Cirella, 2020; Croes *et al.,* 2024). In this approach, environmental concerns are given priority and encompass other aspects. The key to creating livable cities lies in meeting the common needs of city residents, and if these needs are addressed on a human scale, a "good urban territory" can be established. Livability criteria, including economic, social, physical, and particularly environmental factors, should be aligned to tackle the challenges faced by humans.

Environmental resources are a fundamental and essential prerequisite for livability, and any disruption in the proper functioning of these areas can lead to a rapid deterioration of human settlements, resulting in a decline in the elements of the human city and giving rise to poverty, social conflict, and environmental problems. Therefore, livability reflects how the city system operates on a human scale. The coordination among the city's subsystems enhances the livability of the city and ultimately contributes to the development of human cities. The future livable city is one that is based on scenarios that revolve around and interact with human presence. Before delving into the research methodology and findings, a brief overview of the study's background can shed light on the topic and the research gaps.

Amini et al., (2021) identified ten key factors that will affect the future livability of Mahabad city, including the quality of the road network, access to public transportation, and the amount of air pollution. Paul (2020) developed methods to evaluate the livability potential of dense urban areas in Calcutta, India, and found that socio-cultural factors are more important than economic factors in making an area livable. Yang et al., (2021) studied the driving factors of urban livability in the Yangtze River Delta and suggested strengthening inter-city relations and developing relevant policies to improve the urban environment. Meshkini *et al*., (2018) analyzed the livability of different areas of Tehran metropolis and found that access to biological services is not equitably distributed. Bao *et al.,* (2020) assessed livability in Anhui province of China and found a high positive correlation between the quality of urban settlement environments and the level of urban social and economic status.

2. Materials and methods of research

This section describes the research method employed in the study, focusing on the preparation of theoretical and experimental data, the selection of experts, and the validation and reliability of the questionnaire:

1. Research Method
    - This study adopts a descriptive-analytical approach with practical applicability. Descriptive analytics is a statistical analysis of historical data to identify patterns and relationships, aiming to describe events, phenomena, or outcomes. It helps track trends by summarizing data points to reveal patterns in recent and past data. Descriptive research methods, such as surveys or case studies, collect qualitative or quantitative data to provide insights for future research. Urban planning and environmental studies utilize descriptive research to understand how different demographics react to behaviors or services, such as studying how target markets respond to competitor housing quality to infer their behavior (Taherdoost, 2022; Ghalehteimouri and Khaliji, 2024; Mousavi *et al.,* 2024).
    - Theoretical data is gathered through the documentary method, while experimental data is obtained using the survey method. The preparation of development propellants involves the use of documentary study and empirical data from the Delphi method.
2. Expert Selection
    - The Delphi team is selected through the snowball sampling method.
    - Criteria for expert selection include theoretical mastery, practical experience, willingness, ability to participate, and access.
    - The number of experts is determined to ensure comprehensive views.
3. Identification of Propellant Forces
    - The study identifies 41 primary propellants affecting the future livability of Tehran's 22nd district, categorized into economic, social and cultural, physical, environmental, and managerial/legal forces.
    - The identification process involves homogenizing findings from various sources and interviews.
4. Expert Panel and Fuzzy Delphi Method
    - The first expert panel seeks opinions on propellants and refines them for the 22nd district using the fuzzy Delphi method.
    - A closed-ended (Likert) questionnaire is designed based on Delphi method rounds, involving 17 experts selected through snowball sampling.
5. Questionnaire Validation and Reliability
    - The questionnaire design undergoes validation checks, with experts examining and correcting potential defects and misinterpretations.
    - Results indicate a common understanding among experts, validating the questionnaire's structure.
    - Reliability is confirmed through Cronbach's alpha value (0.87), exceeding the threshold of 0.7
6. Data Processing Methods
    - MICMAC and SPSS software are employed for data processing.
    - Fuzzy Delphi and Cross Impact Analysis (CIA) methods are used in conjunction.

This research method section provides a clear breakdown of the approach, expert selection, propellant identification, questionnaire design, and data processing methods used in the study (Hoseinpour *et al.,* 2024).

3. Results and Discussion

3.1. The scope of the study

In 2015, Region 22 had a population of 175,398, resulting in a population density of around 30 people per hectare, which is approximately one-fifth of the average population density of Tehran in 2015 (140 people per hectare). Region 22 is notable for its landmarks such as Tehran's Azadi Stadium, Chitgar Forest Park, Khargush darreh, Chitgar lake, The Kan River, Iran's National Botanical Garden, research and university centers, major medical facilities, commercial and recreational complexes, and the intersection of important highways of Tehran city as well as the Tehran

Metro line 5. This area was included in the comprehensive urban plan of Tehran city (approved in 1991) within the city limits of Tehran.

District 22 acts as a gateway to the west and north of the country, with connections to Tehran-Karaj, Azadegan, Tehran-North, and Kharazi freeways. Currently, the 22nd district of Tehran comprises 12 neighborhoods and 4 districts. However, assessments have revealed that the spatial structure and organization of region 22 have not been adequately developed so far, due to factors such as the delayed release of military lands, the incomplete development of Chitgar lake, and the alteration of some key points due to flaws in the design criteria. Approximately 65% of the land in region 22 is designated for urban development, while 35% of the area remains undeveloped natural land (Figure 1).

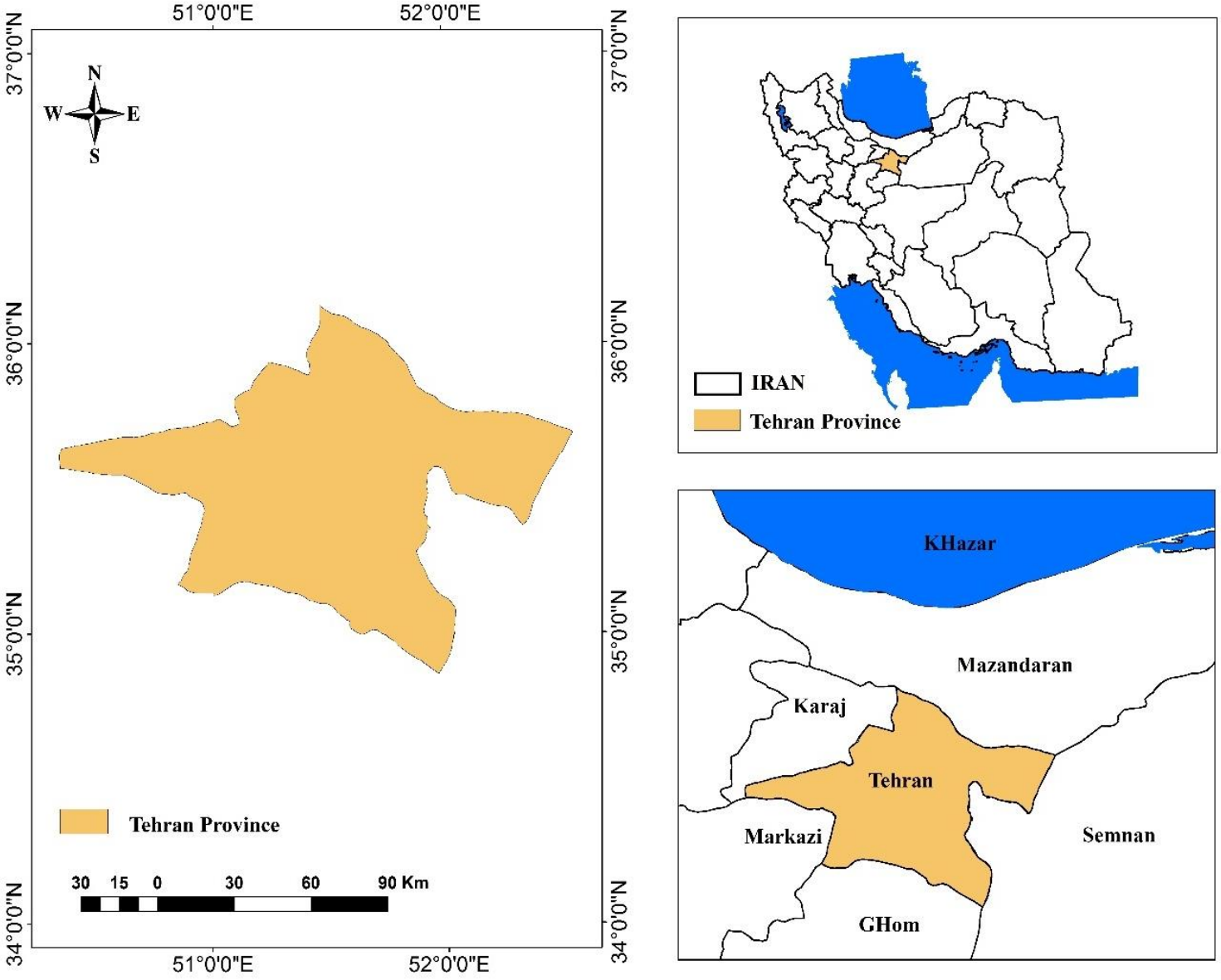

Figure 1. Geographical location of District 22 of Tehran metropolitan.

3.2. Finding and Discussion

The environmental scanning and screening process of key propellants using the fuzzy (triangular) Delphi method involved evaluating the importance of various propellants based on the opinions of the Delphi group. By comparing the de-phased values of the questions to the average of the questionnaire spectrum (threshold index), significant propellants were identified. Propellants with de-phased values equal to or greater than the threshold index were deemed important and influential, while those with values below the average were considered less effective and subsequently eliminated.

3.3. Summary of Expert Responses to the First Question

In the assessment of the first question, none of the participants selected very low (1), low (2), or medium (3) values. However, three experts chose a value of (4) for the first question, as indicated by the number 3 associated with it. Additionally, 14 experts selected the highest range (5) for the first question (Table 2).

Table 2. Compilation of experts' fuzzy Delphi questionnaire.

Rank	Questions	Range of importance				
		very low (1)	low (2)	medium (3)	high (4)	too high (5)
1	In your opinion how much propellant of having a good job and income contributed to the livability of Tehran's 22nd district with a human city approach?				2	15
2	In your opinion how much propellant of affordable and accessible housing play a role in the livability of Tehran's 22nd district with a human city approach?				5	12
3	In your opinion how much propellant of existence of various job opportunities in the neighborhood contribute to the livability of District 22 with the human city approach?			1	4	10
4	In your opinion how much propellant variety of commercial uses play a role in the livability of District 22 with the human city approach?			5	7	5
5	In your opinion how much propellant of willingness of residents to invest in the neighborhood contribute to the livability of District 22 with the human city approach?			3	8	6
6	In your opinion how much propellant of having job security play a role in the livability of District 22 with the human city approach?				4	13
7	In your opinion how much propellant of respect and social inclusion play a role in the livability of District 22 with the human city approach?			2	7	8
8	In your opinion how much propellant of social cohesion and integration play a role in the livability of District 22 with the human city approach?			3	5	8
9	In your opinion how much propellant of strengthening the sense of belonging to a place play a role in the livability of District 22 with the human city approach?			1	3	13
10	In your opinion how much propellant of creating a sense of security and comfort contribute to the livability of District 22 with a human city approach?				6	11
11	In your opinion how much propellant of access to cultural and religious spaces contribute to the livability of District 22 with the human city approach?			5	7	5
12	In your opinion how much propellant of strengthening of public trust between citizens contribute to the livability of District 22 with the human city approach?			3	3	11
13	In your opinion how much propellant of protection of cultural heritage play a role in the livability of District 22 with the human city approach?			8	6	3
14	In your opinion how much propellant of supporting existing communities contribute to the livability of District 22 with the human city approach?			8	5	4
15	In your opinion how much propellant o creation of active public spaces contribute to the livability of District 22 with the human city approach?			1	2	14
16	In your opinion how much propellant of increasing walkability contribute to the livability of District 22 with the human city approach?				4	13
17	In your opinion how much propellant of mixing of uses and local services contribute to the livability of District 22 with the human city approach?			0	3	14
18	In your opinion how much propellant of increasing the optimal density in the context contribute to the livability of the 22nd District with the human city approach?			3	6	8
19	In your opinion how much propellant of the improvement of public transportation contribute to the livability of District 22 with the human city approach?				4	13
20	In your opinion how much propellant of the improvement of educational services contribute to the livability of District 22 with the human city approach?				6	11
21	In your opinion how much propellant of improvement of health services contribute to the livability of District 22 with the human city approach?				5	12
22	In your opinion how much propellant of improving the quality of roads and squares contribute to the livability of District 22 with a human city approach?			2	4	11
23	In your opinion how much propellant of access to recreational and leisure spaces play a role in the livability of District 22 with the human city approach?			2	5	10
24	In your opinion how much propellant of access to technology and communication play a role in the livability of District 22 with the human city approach?				6	11
25	In your opinion how much propellant of the organization of the image and urban landscape play a role in the livability of District 22 with the human city approach?			3	6	8
26	In your opinion how much propellant of compactness and optimal use of space contribute to the livability of District 22 with the human city approach?			2	7	8
27	In your opinion how much propellant of considering construction design considerations play a role in the livability of District 22 with a human city approach?			4	7	8

Table 2. (Continued).

Rank	Questions	Range of importance				
		very low (1)	low (2)	medium (3)	high (4)	too high (5)
28	In your opinion how much propellant of the preservation and development of green spaces contribute to the livability of District 22 with the human city approach?			5	5	7
29	In your opinion how much propellant of the support of environmental resources play a role in the livability of District 22 with the human city approach?			2	7	8
30	In your opinion how much propellant of access to clean and healthy air contribute to the livability of District 22 with a human city approach?			1	3	13
31	In your opinion how much propellant of access to safe drinking water play a role in the livability of District 22 with the human city approach?			3	6	8
32	In your opinion how much propellant of the reduction of types of pollution (air, sound, water, etc.) contribute to the livability of District 22 with the human city approach?			0	6	11
33	In your opinion how much propellant of the collection of sewage and surface water contribute to the livability of District 22 with the human city approach?			1	5	11
34	In your opinion how much propellant of the use of clean energy contribute to the livability of District 22 with the human city approach?			1	5	11
35	In your opinion how much propellant of improving neighborhood health contribute to the livability of District 22 with the human city approach?			1	4	12
36	In your opinion how much propellant of attention to environmental hazards play a role in the livability of District 22 with the human city approach?			5	7	5
37	In your opinion how much propellant of democracy and citizens' participation play a role in the livability of District 22 with the human city approach?				4	13
38	In your opinion how much propellant of benefiting from the high level of presence of expert personnel contribute to the livability of District 22 with the human city approach?			2	5	10
39	In your opinion how much propellant of reducing traffic contribute to the livability of District 22 with the human city approach?			2	5	10
40	In your opinion how much propellant of the use of an efficient information system contribute to the livability of District 22 with the human city approach?			3	8	6
41	In your opinion how much propellant of public education and the application of incentive policies play a role in the livability of District 22 with the human city approach?			4	6	7

Table 3. Fuzzy value and defuzzification value of the third questionary.

No	Questions	Fuzzy value questions			Diphasic value	The status of the questions	Weight	Consensus percentage	rank
		L	M	U					
1	Having a decent job and income	5	870/4	5	685/4	Accepted	0.0267	88.235	1
2	Affordable and accessible housing	5	682/4	5	591/4	Accepted	0.0262	70.588	7
3	There are various job opportunities in the neighborhood	5	553/4	5	277/4	Accepted	0.0244	66.667	17
4	Variety of commercial uses	5	925/3	5	962/3	Accepted	0.0226	41.176	37
5	Residents' willingness to invest in the neighborhood	5	114/4	5	057/4	Accepted	0.0231	47.059	33
6	Having job security	5	744/4	5	622/4	Accepted	0.0263	76.471	3
7	Respect and social inclusion	5	295/4	5	148/4	Accepted	0.0236	47.059	25
8	Social cohesion and integration	5	237/4	5	119/4	Accepted	0.0235	50	28
9	Strengthening the sense of place	5	665/4	5	332/4	Accepted	0.0247	76.471	15
10	Create a sense of security and comfort	5	621/4	5	561/4	Accepted	0.026	64.706	9
11	Access to cultural and religious spaces	5	925/3	5	962/3	Accepted	0.0226	41.176	37
12	Strengthening public trust among citizens	5	393/4	5	196/4	Accepted	0.0239	64.706	24
13	Protection of cultural heritage	5	634/3	5	817/3	Accepted	0.0218	47.059	41
14	Support existing communities	5	682/3	5	841/3	Accepted	0.0219	47.059	40

Table 3. (Continued).

No	Questions	Fuzzy value questions			Diphasic value	The status of the questions	Weight	Consensus percentage	rank
		L	M	U					
15	Creating active public spaces	5	726/4	5	363/4	Accepted	0.0249	82.353	13
16	Increase walkability	5	744/4	5	622/4	Accepted	0.0263	76.471	3
17	Mixing local uses and services	5	807/4	5	653/4	Accepted	0.0265	82.353	2
18	Increasing the optimal density in the tissue	5	223/4	5	111/4	Accepted	0.0234	47.059	29
19	Improving public transportation	5	744/4	5	622/4	Accepted	0.0263	76.471	3
20	Promotion of educational services	5	621/4	5	561/4	Accepted	0.026	64.706	9
21	Promotion of health services	5	682/4	5	591/4	Accepted	0.0262	70.588	7
22	Improving the quality of roads and squares	5	468/4	5	234/4	Accepted	0.0241	64.706	20
23	Access to recreational and leisure spaces	5	409/4	5	205/4	Accepted	0.024	58.824	21
24	Access to technology and communication	5	621/4	5	561/4	Accepted	0.026	64.706	9
25	Organizing the image and urban landscape	5	223/4	5	111/4	Accepted	0.0234	47.059	29
26	Compactness and optimal use of space	5	295/4	5	148/4	Accepted	0.0236	47.059	25
27	Consideration of construction design considerations	5	136/4	5	068/4	Accepted	0.0232	42.105	32
28	Preservation and development of green spaces	5	029/4	5	015/4	Accepted	0.0229	41.176	36
29	Protection of environmental resources	5	295/4	5	148/4	Accepted	0.0236	47.059	25
30	Access to clean and healthy air	5	683/4	5	341/4	Accepted	0.0238	77.778	14
31	Access to safe drinking water	5	223/4	5	111/4	Accepted	0.0234	47.059	29
32	Reducing types of pollution (air, noise, water, etc.)	5	622/4	5	561/4	Accepted	0.026	64.706	9
33	Collection of sewage and surface water	5	544/4	5	272/4	Accepted	0.0244	64.706	18
34	Use of clean energy	5	544/4	5	272/4	Accepted	0.0244	64.706	18
35	Improving neighborhood health	5	604/4	5	302/4	Accepted	0.0245	70.588	16
36	Attention to environmental hazards	5	925/3	5	962/3	Accepted	0.0226	41.176	37
37	Democracy and citizen participation	5	744/4	5	622/4	Accepted	0.0263	76.471	3
38	Benefiting from the high level of presence of specialist staff	5	409/4	5	205/4	Accepted	0.024	58.824	21
39	reduction of traffic	5	409/4	5	205/4	Accepted	0.024	58.824	21
40	Use of efficient information system	5	114/4	5	057/4	Accepted	0.0231	47.059	33
41	Public education and implementation of incentive policies	5	098/4	5	049/4	Accepted	0.0231	41.176	35
	Sum of values	175.41		1					

Table 3 displays the findings of the calculations for the third period. It is clear that the majority of the research questions are less clear than the average value of the spectrum (value 3). Thus, it can be inferred that the questions in the third questionnaire concerning the future livability in the 22nd district of Tehran metropolis with the human city approach are important and impactful. Furthermore, similar to the previous period, no new questions have been suggested by the experts.

3.4. Identifying the importance of each of the questions (primary propellants)

After determining the fuzzy value of the questions, the significance of each primary propellant can be established by using the average value of the spectrum (value 3). Expert opinions suggest that questions (propellants) with a de-phased value higher than the average value of the spectrum

(3) are deemed important for the structural analysis method (Cross Impact Analysis), while questions (propellants) with a fuzzy value lower than the average value of the spectrum (3) are considered less important. Therefore, question 1 (employment and adequate income) among economic propellants, with the highest de-phased value (4.685), is the most crucial question, while question 13 (protection of cultural heritage) among socio-cultural propellants, with the lowest de-phased value (3.817), is considered the least important.

3.5. Examining the consensus condition of the questions

Table 4 shows the experts' consensus levels for each question, calculated by dividing the number of experts who chose a specific option by the total number of experts (17) and multiplying by 3 (the average weight of each expert's opinion). To meet the initial agreement criterion, at least 60% of the experts had to select the same answer for each question. About 51% of the questions (21 questions) met this criterion, while the other 49% (20 questions) did not.

Table 4. The table of consensus or expert agreement for each question.

Criteria	Propellants	Consensus percentage	Rank	Code
Economic	Having a decent job and income	88.235	1	Var1
	Affordable and accessible housing	70.588	7	Var2
	There are various job opportunities in the neighborhood	66.667	17	Var3
	Having job security	76.471	3	Var4
Sociocultural	Strengthening the sense of place	76.471	15	Var5
	Create a sense of security and comfort	64.706	9	Var6
	Strengthening public trust among citizens	64.706	24	Var7
physical (infrastructure)	Creating active public spaces	82.353	13	Var8
	Increase walkability	76.471	3	Var9
	Mixing local uses and services	82.353	2	Var10
	Improving public transportation	76.471	3	Var11
	Promotion of educational services	64.706	9	Var12
	Promotion of health services	70.588	7	Var13
	Improving the quality of roads and squares	64.706	20	Var14
	Access to technology and communication	64.706	9	Var15
environmental	Access to clean and healthy air	77.778	14	Var16
	Reducing types of pollution (air, noise, water, etc.)	64.706	9	Var17
	Collection of sewage and surface water	64.706	18	Var18
	Use of clean energy	64.706	18	Var19
	Improving neighborhood health	70.588	16	Var20
Administrative-institutional	Democracy and citizen participation	76.471	3	Var21

3.6. Analysis of the cross effects of propellants affecting the livability of the 22nd district of Tehran metropolis with the human city approach

In the second step, 21 key propellant forces were identified out of the 41 primary propellant forces calculated using the fuzzy Delphi method. These key propellant forces will play a crucial role in determining the future livability of the 22nd district of Tehran metropolis with a human city approach. The cross-effect method (Cross Impact Analysis (CIA)) in MICMAC software was then utilized to map out the connections and interactions among these propellants.

Table 5. Initial analysis of the matrix data of the mutual effects

Indicator	The size of the matrix	The number of repetitions	Number zero	Number one	Number two	Number three	Total	degree of filling
amount	21	2	133	112	113	83	308	% 72/32

The results of the mutual effects of the 21 livability factors, represented in a 21x21 matrix across five main dimensions. The table shows a 70.32% filling degree and a repetition number of 2, indicating a significant impact of the selected propellants on each other. Out of the 308 possible relationships in the matrix, 133 have a value of zero, meaning no influence between the propellant factors. There are 112 relationships with a value of 1, indicating a weak influence, 113 relationships with a value of 2, suggesting a relatively strong influence, and 83 relationships with a value of 3, signifying a very high and significant influence among the key propellants (Table 5). The matrix of this research has 100% desirability and optimization based on statistical propellants with 2 rotations, which indicates the high validity of the questionnaire and its answers (Table 6).

Table 6. Degree of desirability and optimization of the matrix.

being influenced	influence	Rotation
106%	102%	1
100%	99%	2

3.7. Evaluation of the impact plan and effectiveness of livability propellants with the approach of human city in the 22nd district of Tehran metropolitan city

The distribution pattern of livability propellants in the 22nd district of Tehran metropolis, as observed on the scatter plane using the human city approach, indicates the level of stability or instability of the system. The structural interaction analysis method with MIC MAC software identifies two general dispersion models: stable and unstable systems. In the stable system model, the dispersion of variables is in the form of L, where some variables have high effectiveness and some are less affected. In unstable systems, the situation is more complicated, with propellant forces scattered around the diagonal axis of the plane, resulting in an intermediate state of influence and effectiveness, making it difficult to identify the key propellants. Y represents influential scale and X dependant scale as they shown (Figures 2 and 3).

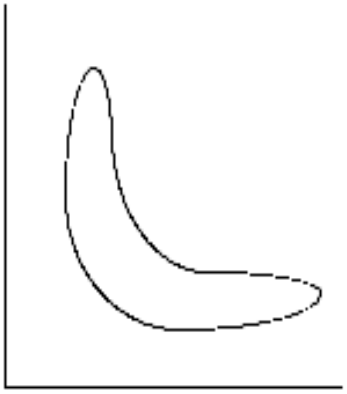

Figure 2. Stable system.

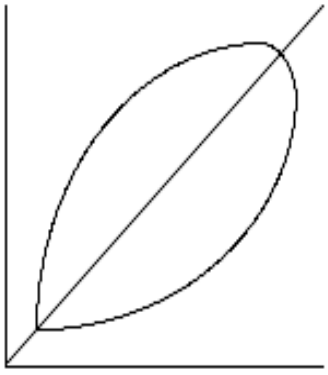

Figure 3. Unstable system.

Figure 5 illustrates the distribution pattern of livability propellants using the human city approach. This dispersion pattern generally indicates an unstable system. The viability drives, with the exception of a few propellants that have a high impact on the system, are generally situated in a similar manner around the diagonal axis (Figure 4).

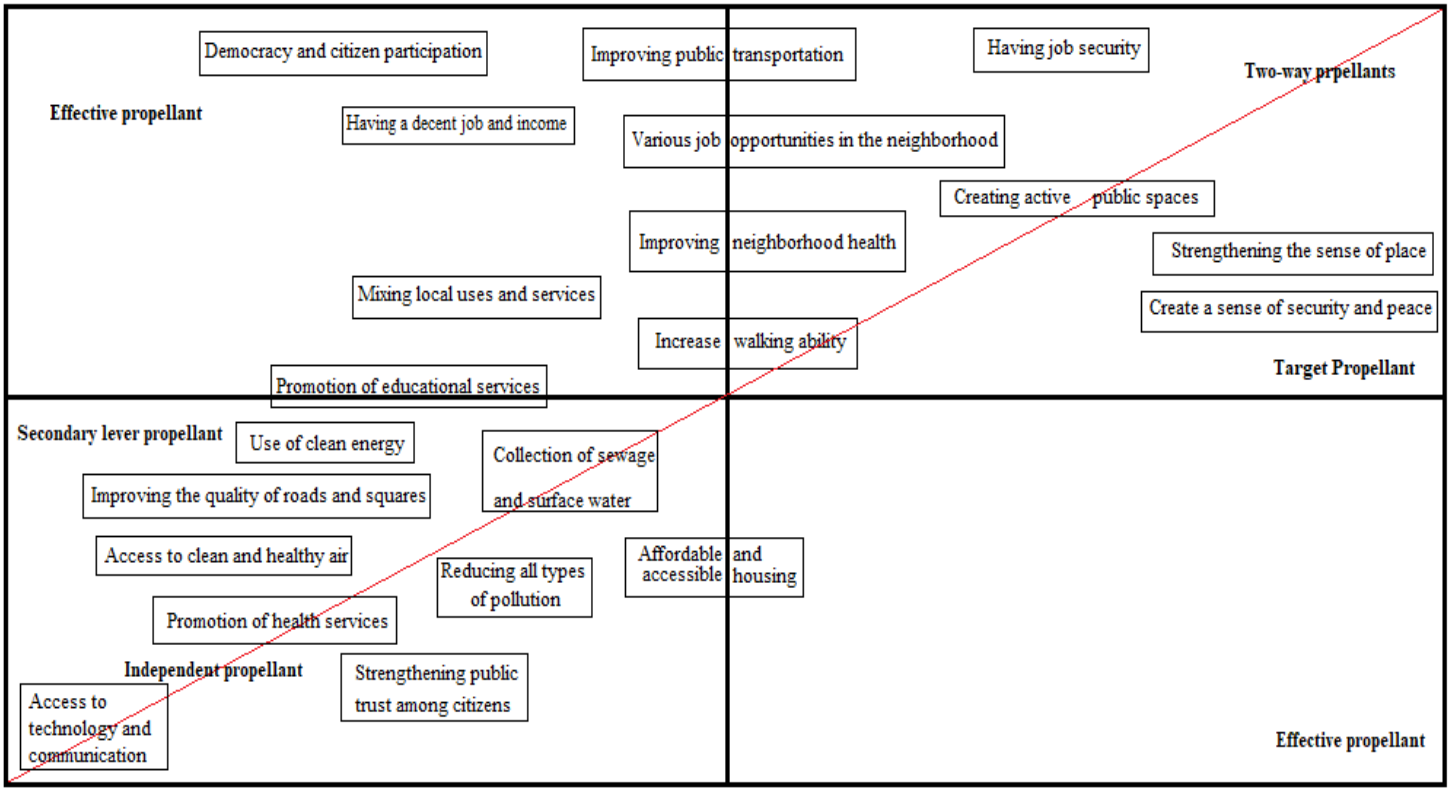

Figure 4. Distribution of drivers of livability with the human environment of district 22.

3.8. Clustering propellants of livability with a human city approach in the 22nd district of Tehran

Five types of unstable state propellants have been identified, including influential, two-faceted (risk and target), regulatory, influential, and independent propellants. These propellants are listed in order of their effects. According to the distribution of propellants in Figure 4 categories of propellants can be identified.

Determining or influencing propellants: These propellants play a crucial role in the viability system, with a significant impact that goes beyond their effectiveness. They are located in the northwest District of the dispersion plane, and the stability of the system heavily depends on them. They are seen as key drivers and determinants of system behavior. The lower concentration of propellants in this area indicates the system's instability and its potential impact on the future livability of District 22 with a human city approach. Factors such as having a decent job and income, democracy and citizens' participation, integrating local uses and services, improving neighborhood health, and enhancing walkability are all important drivers of the livability system in District 22 with a human city approach.

Two-faceted propellants: These propellants function in a highly effective and impactful manner simultaneously. They are situated in the northeastern section of the diagram. The nature of these propellants is characterized by a combination of instability, as any action or change in them leads to a reaction and change in other propellants. These propellants can be categorized into two groups: risk propellants and target propellants. The propellants related to job security, enhancing public transportation, creating vibrant public spaces, the presence of diverse job opportunities in the neighborhood, strengthening the sense of belonging, and increasing the sense of security and comfort are located in this area. Two-sided propellants consist of two components: risk and target propellants:

Risk propellants*:* As depicted in the diagram, these propellants are positioned above the diagonal line in the northeastern area and have the potential to become key players in the system. One propellant is located in this section.

Target propellants: These propellants are situated below the northeastern diagonal area of the diagram; they represent the evolutionary outcomes of the system and signify the potential objectives within a system. By manipulating and making changes to these propellants, the evolution of the program system and its objectives can be achieved. No propellant is located in this area.

Table 7. The amount of direct and indirect effects of the propellants on each other.

Direct				Indirect				
Influence	Variable	Being influenced	Variable	Influence	Variable	Being influenced	Variable	Rank
749	Having a decent job and income	817	Democracy and citizen participation	742	Affordable and accessible housing	792	Strengthening the sense of place belonging	1
749	Democracy and citizen participation	732	Having a decent job and income	706	Democracy and citizen participation	706	Increasing the sense of security and comfort	2
698	Mixing local uses and services	647	Having security job	666	Improving public transportation	634	Affordable and accessible housing	3
698	Improving public transportation	579	Creation of active public spaces	659	Having job security	587	Creation of active public spaces	4
647	Affordable accessible housing	562	Improving public transportation	638	various job opportunities in the neighborhood	532	Having job security	5
596	Creation active public spaces	511	There are various job opportunities in the neighborhood	561	Creation of active public spaces	511	Increasing Walkability	6
528	Increasing Walkability	511	Increasing Walkability	545	Mixing local uses and services	509	There are various job opportunities in the neighborhood	7
521	Increasing sense of security and comfort	494	Increasing sense of security and comfort	509	Increasing Walkability	508	Improving public transportation	8
496	Having security job	494	Improving neighborhood health	507	Increasing sense of security and comfort	505	Improving neighborhood health	9
489	Various job opportunities in the neighborhood	459	Affordable accessible housing	502	Strengthening the sense of place belonging	467	Having job security	10
477	Strengthening the sense of place belonging	442	Promotion of educational services	481	Collection of sewage and surface water	452	Promotion of educational services	11
459	Improving neighborhood health	425	Collection of sewage and surface water	480	Improving neighborhood health	429	Collection of sewage and surface water	12
425	Use of energies clean	408	Use of energies clean	398	Use of clean energies	409	Improving the quality of roads and fields	14
374	Improving quality of roads and fields	408	Strengthening the sense of place belonging	373	Improving quality of roads and fields	402	Improving health services	15
357	Access to clean and healthy air	391	Mixing local uses and services	368	Having job security	398	Use of clean energies	16
323	Promotion of educational services	391	Improving health services	364	Access to clean and healthy air	396	Strengthening public trust among citizens	17
306	Improving health services	391	Improving the quality of roads and fields	310	Improving health services	395	Mixing local uses and services	18
255	Reducing all types of pollution	357	Strengthening public trust among citizens	276	Reducing all types of pollution	382	Reducing all types of pollution	19

Table 7. (Continued).

Direct				Indirect				
Influence	Variable	Being influenced	Variable	Influence	Variable	Being influenced	Variable	Rank
204	Strengthening public trust among citizens	306	Access to clean and healthy air	234	Strengthening public trust among citizens	289	Access to clean and healthy air	20
187	Access to technology and communication	255	Access to technology and communication	207	Access to technology and communication	268	Access to technology and communication	21

Influenced propellants or results: These propellants are situated in the southeastern section of the chart. They have minimal impact but are influenced by others. As a result, they are highly responsive to the development of efficient and bimodal propellants. They are output propellants, and there are no other propellants located in this area.

Independent propellants: These propellants have a low impact and are not easily influenced by other factors. They are located in the southwest part of the propellant dispersion plane and do not cause reactions in other propellants. The propellants related to improving educational services, enhancing health services, using clean energy, collecting sewage and surface water, providing affordable and accessible housing, ensuring access to clean and healthy air, improving the quality of roads and fields, reducing various types of pollution (air, noise, water, etc.), strengthening public trust among citizens, and access to technology and communication are in this area. However, two categories of propellants require attention in this area:

"Secondary leverage" propellants: These propellants have a significant influence but are not easily influenced by others. They are located in the southwest part of the diagram and above the diagonal line. No propellant is located in this area.

"Adjusting" propellants: These propellants are located near the center of gravity of the diagram and can act as "secondary leverage," "weak targets," and "secondary risk propellants" in succession. No propellant is located in this area. Figures 5 and 6 depict the graphic representation of development propellants, specifying the direct and indirect effects of the propellants on other propellants in the system, ranging from weakest to strongest effects.

3.9. Selection of key propellants effective on the future state of the livability of District 22 with a human city approach

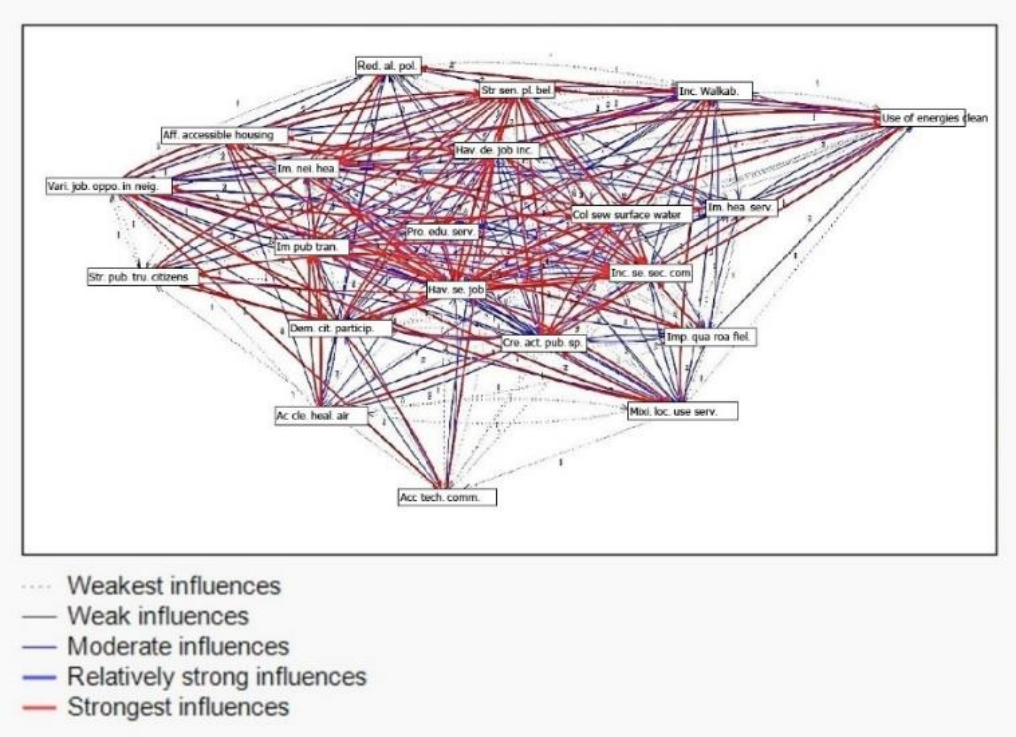

Figure 5. Direct relationships between variables (from very weak to very strong).

As mentioned earlier, the opinions of experts were used to identify the propellant forces affecting the future livability of District 22 with the human city approach, using the Delphi method. In the end, out of the total of 21 influential factors, 7 factors are having a job and adequate income, democracy and citizen participation, mixing of uses and local services, improving public transportation, affordable and accessible housing, creating active public spaces and increasing walkability. They were selected as the key propellants affecting the future state of the system, and most of these propellants were repeated in both direct and indirect influencing methods (Figures 5 and 6).

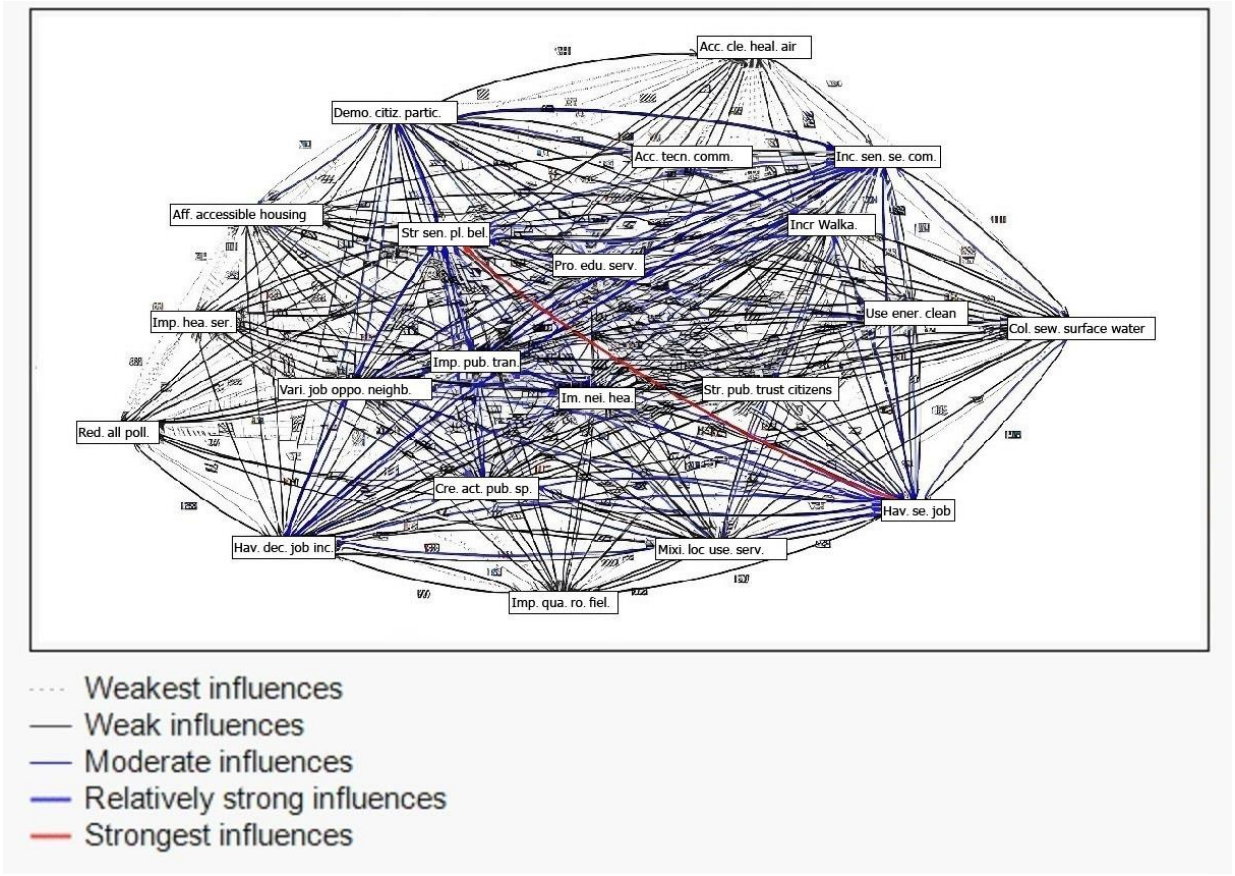

Figure 6. Indirect relationships between variables (from very weak to very strong).

Examining the values of the indirect relationships of the key propellants in Table 6 indicates that the rank values of the direct effects of the key propellants have been repeated in the indirect effects with little changes (Table 8).

Table 8. Direct and indirect Key propellants affecting the future state of the livability.

Rank	Propulsion	Direct influence	Propulsion	Indirect influence
1	Having a decent job and income	749	Affordable and accessible housing	742
2	Democracy and citizen participation	749	Democracy and citizen participation	706
3	Mixing local uses and services	698	Improving public transportation	666
4	Improving public transportation	698	Having job security	659
5	Affordable and accessible housing	647	Various job opportunities in the neighborhood	638
6	Creation of active public spaces	596	Creation of active public spaces	561
7	Increasing the Walkability	528	Mixing local uses and services	545
8	Increasing the sense of security and comfort	521	Increasing the Walkability	509

4. Conclusions

District 22 in Tehran is known for its environmental attractions, such as a forest park, hills, a lake, and a river, making it one of the greenest parts of the city. Initially planned as a tourist destination, the area was set to feature projects like the Tehran Waterfall, Javanmardan Park, Persian Gulf Lake, and the Thousand City Project. However, illegal construction and pollution have harmed

the ecological balance of district 22, leading to the destruction of natural areas and parks. The lack of an urban sewage network is a common issue in the neighborhoods, exacerbating environmental problems. Land subsidence, water depletion, pollution from factories, extensive construction, and traffic congestion are all contributing to environmental degradation. Future highway development is expected to bring additional challenges to the district. In summary, the emphasis on urbanization rather than urban development, along with poor spatial organization, inadequate distribution

of residential services, and a car-centric approach, has negatively impacted the quality of life in

District 22, leaving it in a less desirable state.

This study examines the livability factors of the 22nd district of Tehran metropolis using the human city approach. The research findings highlight the significant influence of key livability factors, with 3 out of 83 relationships identified in the overall system environment analysis. The mutual effects analysis reveals a complex dispersion of propellant forces, with a concentration of independent propellants in the clustering system. Seven factors, including job and adequate in

come, democracy and citizen participation, mixing of uses and local services, improving public transportation, affordable and accessible housing, creating active public spaces, and increasing walkability, have been identified as crucial for development. The research suggests that the development of the 22nd district has been market-driven rather than planned for sustainable urban development, resulting in an imbalance in investment between local and regional services and facilities. This has led to most residents seeking employment and income outside the district, exacerbated by economic sanctions and a lack of facilities. As a result, the economic participation rate of the district decreased from 39% to 37.1% between 2010 and 2015. The majority of the population in this area belongs to the middle or lower middle classes and is engaged in service occupations.

According to the 2015 census and housing population statistics of Tehran city, this District has the third-highest unemployment rate, with 5 percent of the population being unemployed, following Districts 21 and 2. Additionally, in terms of the tendency to rent a residence in Tehran, district 22 ranks second after district 15, with more than 45.1% of residents renting their homes. In 2015, it had the lowest share of ordinary resident households and a group with property ownership among all households in Tehran, at less than 45%. The housing prices in this area grew by 327% from September 2012 to August 2018, and 60% of the income and savings of the area's tenants are spent on rent. Currently, the scattered and uneven growth of District 22 does not align with the indicators of human-oriented cities, including social participation and cohesion, walking orientation, security, the concept of neighborhood, and spirituality, due to the development of new parts of this area such as Sharif University Town, Sarvazad, and Havaniro.

Despite the existing urban plans and the focus on improving car mobility in the area, the social and human-centered aspect of urban space has been neglected. Challenges such as high levels of immigration, limited communication between high-rise residential buildings and other neighborhoods, inadequate security measures, and a decline in the social quality of urban spaces, particularly in newly developed areas, have resulted in a lack of cohesion in the community. The emphasis on the central highway has further diminished social gathering spaces and human interaction in the district. To create a more livable environment with a focus on people, it is essential to involve the community in decision-making processes and address issues such as public transportation, green spaces, cultural and recreational facilities, and infrastructure improvements. The haphazard development and lack of organization in the district have exacerbated these challenges, along with feasibility and legal issues hindering the provision of local services. As a result, the livability of District 22 does not align with the principles of a human-centered city, leading to car-centric rather than people-centric neighborhoods. A comprehensive plan for the district should prioritize these concerns to enhance the quality of life for residents.

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Conflict of interest

All authors declare that they have no conflicts of interest.

Data availability

Data is available upon Request.

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