Creative city design / Vol. 4, No. 3, 2021, 69-78

Strategic Planning for The Creation and Development of Livable Underground Spaces in Hot and Dry Climates (Case Study: Zahedan)

Mostafa Ommati [1] ,Hossein Zabihi [2]*

1. Phd student in Urban Planning, Qazvin Branch, Islamic Azad University, Qazvin, Iran.
2. Associate professor, Department of Urban Development, Science and Research Branch, Islamic Azad University, Tehran, Iran

Submit Date: 2021-10-01, Accepted Date: 2021-12-20

ABSTRACT

Today, due to the growing urbanization process affected by the industrial revolution and the capitalist system, most cities in developing countries face many challenges, including unbalanced physical growth, poverty growth, worn-out urban fabric, traffic problems, declining quality of life indicators, and environmental pollution. These factors in practice have led to instability and reduced livability of these cities. In recent decades, planners and city managers have proposed various solutions and policies to reduce these challenges, including the use of subsurface spaces (such as subway stations) as an innovative strategy, an emerging concept.

The purpose of this study is to provide strategies for achieving livable underground spaces. The data collection method of this research is based on documental method and social survey. So, at first review articles were derived from a couple of significant databases including Scopus, Web of Science Core Collection, and Google Scholar, ensuring high quality and inclusiveness of search results. Also a questionnaire was used in the second step. On the other hand, a combination of SWOT-ANP models has been used.

The results of 19 indicators as factors affecting the biomass of subsurface spaces in hot and dry climate are presented in 5 groups including functional factors (flexibility, all-inclusiveness, efficiency and diversity, safety and security, walkability, Easy accessibility), perceptual (sensory richness, readability), environment (cleanliness, climate comfort), physical (human scale, continuity, enclosure) and social (vitality, belonging to place, sociability, attention to human needs). The results of structural equations show that the aggressive strategy for the city of Zahedan has scored.

***Keywords**: Hot & dry climate, Livability, SWOT technique, Underground.*

1. Introduction

Today, cities are facing rapid population growth. This phenomenon has brought up the development of urban underground space (UUS) which is an appealing approach to solve transport, environmental and land-use problems that occur during urban development process (1) .

Using urban underground spaces has helped to solve some problems of modern cities (2), it has also had a sound effect on urban planning (3).

Among the research branches, a prominent one addresses the assessment of urban livability conditions. Indeed, the topic could be significant in both empirical and normative senses. Naturally,

*Corresponding author: h.zabihi@srbiau.ac.ir

to assess urban livability, one should first establish a standard, or technically speaking an "indicator system" (4). Moreover, urbanism has paid attention to urban livability since the origination of the modern urban planning profession. The livability of each area is calculated according to the agent's preference over a particular set of livability indicators. So, the planning of additional space in current cities is a universal phenomenon because of urban sprawl being restricted (5). This is faced with numerous challenges associated with the provision of infrastructure, which grows proportionately with the size of the city (6)and impacts livability therein.

Most current research is limited to the analysis of the region's livability at a particular time section in the past, and there is a lack of analysis into the temporal dynamics of urban livability. Indeed, from a normative perspective, it would be significant to study how interventions to the existing urban environment would affect the livability of cities.

UUS improves the life quality, by improving the resilience of cities (7), building livable cities (8), and increasing sustainability (9) (10) (11).

Therefore, the study of the factors affecting the improvement of livability in underground spaces in order to highlight the existing strengths and provide a solution is something that can be effective to improve underground urban plans. In this regard, one of the strategies to increase urban life and vitality and optimal use of land is the development and use of public spaces and underground services.

This research has been carried out with the aim of strategic planning for the development of subsurface public spaces with the approach of enhancing the viability and presenting strategies for the hot and dry climates in Zahedan. So, the following research questions were targeted in the present research:

- What are the challenges of UUS utilization for a livable city?
- How can UUS utilization contribute to a livable city?

The rest of the paper is structured as follows: first, we describe the research methodology and review methods in the methodology section; then we discuss the research findings in the following sections; finally, we considered "underground" when changing the structure or accessing the volume would summarize key research findings and suggest future research directions in the Conclusion.

2.Research methodology

The purpose of this study is to provide strategies for achieving livable underground spaces. in the present applied research, a "Descriptive-analytical" Method was employed.

In the first section, Qualitative documents were used. So, this paper reviews articles derived from searches of significant databases including Scopus, Web of Science Core Collection, and Google Scholar, ensuring high quality and inclusiveness of search results. To do so, a combination of SWOT-ANP models were used. Also, the questionnaire was used as a research instrument for data collection.

Meanwhile, 30 panelists with the following inclusion criteria were selected via purposeful judgmental sampling having:

1. holding an academic education level of Associate Degree or higher
2. Having at least three years of related work experience or research contributions in accredited scientific communities
3. Having enough time to participate and having effective communicative skills
4. Being familiar with hot and dry climate and with environmental conditions of Zahedan

First, internal factors that include strengths and weaknesses were identified and developed and then external factors, including threats and opportunities, were identified and developed. We used absolute and relative weighting to quantify the model and selected the best strategy. Relative weighting in the ANP model is performed by pair-wise. Absolute weighting was performed employing a 5-point Likert scale. Finally, according to the choice of strategy based on its components, the selected strategy was written.

3.Literature review

- **Urban Underground Space (UUS)**

Urban underground spaces are the optimal urban space below the city level, which are created due to such factors as high land prices, migration, air pollution, overcrowding, traffic, etc.

What is considered to be "underground" or "subsurface" is rarely defined. One definition postulates that structures and volumes can be require removal of or drilling into – natural or altered – ground (6)Subsurface spaces are

based on indigenous knowledge that reflects socio-ecological perceptions and creates a cultural commitment of individuals to the proper interaction of the natural environment and the artificial environment (6). Table.1 shows the reasons of urban underground development. Also, it displays the relationship between urban underground developments.

Table .1. The reasons and necessities of (UUS)

Reasons and necessities	Relationship with urban underground development
Urban population growth, the emergence of metropolises and their dispersed growth	Prevent Urban Sprawl
The need for housing and the expansion of new suburbs, cities and towns	Development of underground housing
Requires a fast and diverse transportation system	Development of underground transportation
Environmental pollution	Transfer of contaminants to the basement
Economic land value	Using underground levels as wealth
Urgent need for urban infrastructure	Development of urban infrastructure in sub-cities and neighborhoods
The introduction of technology into urban planning	Use of technology in drilling, construction
The High density of construction, especially in urban centers	Increasing the density in the underground layers and preventing the vertical constructions of the city and urban centers

Source: researchers

Underground space background shown in table 2.

Table.2. background of urban underground space

Researcher	Result
Mao-sheng Zhang & et al., (2013)	- Geology, land prices, spatial conditions, the level of economic development are benefits of underground urban development. - higher the average prices of the regions, has a positive and significant relationship with the potential development of underground urban space
Babylov (2011)	- In this research reviewed the underground urban infrastructure problems in Moscow. He urged the reform of state administration to be implemented primarily at the federal level, in spatial planning, along with underground space planning and economic sectors.
Hunt et al., (2016)	- In a study consider the use of urban underground space in line with the policy of reducing the problems for better living in cities, such as: reducing carbon in international law.
Sassano et al., 2017	- Conserving old city; providing better living environment

- **Livability concept**

Livability is a general concept; it can be declared that it is related to other concepts and terminologies such as sustainability, quality of life, locative quality, and healthy communities. Based on the latest urban planning theories, it can be stated that many of the principles of these theories such as sustainable development (6), Smart Growth (6), and new urbanism (6) are associated with the goals and principles of livability and the promotion of quality of life, and the criteria and indicators considered in these theories can be used to make cities and residential quarters more livable.

Recent studies proved that the urban underground space is a part of livability components in order to promote a livable space and sustainable environment. Also, the livable city benefits from its citizens, by meeting its purpose in promoting sustainable access and linkage for all its citizens within a neighborhood. Thus, the underground space is an effective tool in order to increase the city's livability, by improving the accessibility, mobility, safety and environment that make the city a good quality place to all its inhabitants.

As the livability identifies the quality of life; in order to evaluate a good quality place, whether a street, a playground or a plaza; Project for Public Spaces organization (PPS) developed the place diagram, as a tool to define the quality of space. The Diagram consists of four main quality criteria, which are classified as follow: Accessibility, Comfort & Image, Sociability and Uses & activities (see Fig. 1). Each criterion holds a number of quantitative and qualitative aspects that can be measured either statistically or practically (12)

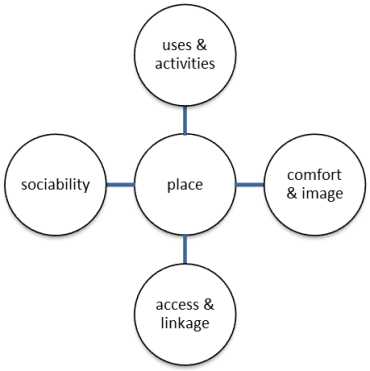


Fig.1. place diagram developed by PPS(6)

4. Finding research

- **Determining the internal factors related to the creation of public underground spaces in the city of Zahedan**

In this section, first the strengths, and then the weaknesses were studied. Finally, the matrix of internal factors was prepared.

- **Strengths**

Public underground space has Strengths in hot and dry climate. Strengths are listed in the Table 3

Table.3. strong points

Strengths		
1	Protection of the environment and areas of cultural heritage value	S1
2	Increasing the climate comfort of citizens	S2
3	Creating a continuous urban structure	S3
4	Decreased density on the surface	S4
5	Reducing environmental stresses	S5
6	Avoid affecting the natural and physical conditions of the areas	S6
7	Reduce noise pollution	S7

- **Weaknesses**

Table 4 shows weakness factors.

Table.4. weak points

Weaknesses		
1	Soft ground in the region	W1
2	Limited external control	W2
3	Failure to identify suitable locations for the connection of underground spaces with the surface	W3
4	Tough working conditions in underground environments	W4
5	There is a problem connecting to other surface transport networks	W5
6	There are hidden costs	W6
7	There are high initial costs	W7

- **Determining the External factors related to the creation of public underground spaces in the city of Zahedan**

In this section, first the Opportunity points, and then the Threats were studied. Finally, the matrix of external factors was prepared

- **Opportunity**

Table.5. opportunity points

Opportunity		
1	Moderation of adverse climatic effects on urban space	O1
2	energy saving	O2
3	Reduce the cost of implementing underground spaces	O3
4	Cost-effectiveness of construction in difficult areas	O4
5	Increase urban security	O5
6	Increase the defensive safety of the city	O6
7	Use the whole city in location to create public spaces	O7
Threats		
1	Decreased adaptation to the conditions of the disabled	T1

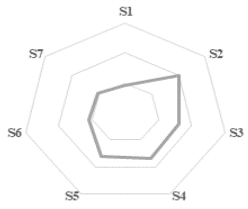
2	Groundwater level drops	T2
3	Soil pollution risk	T3
4	High risk of natural disasters (earthquakes)	T4
5	High construction costs in soft fields	T5
6	Inability to raise capital	T6
7	High management and maintenance costs	T7

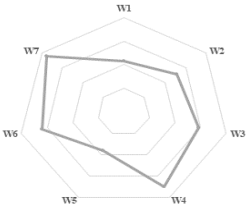
- **Determining the relative weight of internal and external factors**

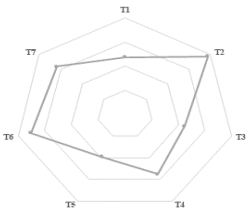
Interview tools were used to determine the relative weight of the criteria. Expert Choice software was used to analyze Pairwise comparison matrix. The result of Pairwise comparison is shown in Table 6.

Table.6. Relative weight of Strengths

Strengths	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	
relative weight	.092	.201	.161	.170	.162	.109	.103	
Inconsistency	.00701							
Weakness	W1	W2	W3	W4	W5	W6	W7	
relative weight	.108	.128	.146	.175	.091	.159	.189	
Inconsistency	.0031							
Opportunity	O1	O2	O3	O4	O5	O6	O7	
relative weight	.209	.118	.107	.091	.127	.202	.145	
Inconsistency	.00201							
Threats	T1	T2	T3	T4	T5	T6	T7	
relative weight	.118	.193	.112	.138	.098	.176	.159	
Inconsistency	.00308							







As shown in Table 6,

- Based on the relative weights obtained from pairwise comparisons, S2 has the highest weight with 0.201 and S1 has the lowest weight; these weights are acceptable due to the obtained incompatibility rate which is less than 0.1.
- Based on the relative weights obtained from pairwise comparisons, W7 has the highest weight with 0.189 and W5 has the lowest weight; these weights are acceptable due to the obtained incompatibility rate which is less than 0.1.
- Based on the relative weights obtained from pairwise comparisons, O1 has the highest weight with 0.209 and O4 has the lowest weight; these weights are acceptable due to the obtained incompatibility rate which is less than 0.1.
- Based on the relative weights obtained from pairwise comparisons, T2 has the highest weight with 0.176 and T5 has the lowest weight; these weights are acceptable due to the obtained incompatibility rate which is less than 0.1.

- **Absolute weight of internal and external factors**

Likert scale was used in this section. The value and importance of each item was evaluated according to the following pattern from the lowest value (1) to the highest value (5).

Table.7. Likert scale

Determining the absolute value of factors					
Descriptive value	**The least**	**Low**	**Average**	**High**	**The most**
Numerical value	1	2	3	4	5

Table 8 shows the absolute weights related to internal factors as well as external factors.

Table.8. Absolute weights of internal and external factors

Factor	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
Weight	3.90	5	4.81	4.90	4.90	4.81	3.90
Factor	W1	W2	W3	W4	W5	W6	W7
Weight	3.9	3.9	4	4.63	3.81	4.63	4.81
Factor	O1	O2	O3	O4	O5	O6	O7
Weight	5	4.72	4	3.63	4.72	4.90	4.18
Factor	T1	T2	T3	T4	T5	T6	T7
Weight	3.90	4.90	3.90	4	3.81	4.81	4.09

-The final weight of the internal and external factors

To calculate the final weight of each of the internal factors, the relative weight obtained is multiplied by the absolute weight and then the final weight of each factor is obtained.

Table.9. Internal Factor Evaluation Matrix

Internal Factor Evaluation Matrix				
Internal strategic factors		**Relative weight**	**Absolute weight**	**Final weight**
S1	Protection of the environment and areas of cultural heritage value	.092	3.90	.36
S2	Increasing the climate comfort of citizens	.201	5	1.01
S3	Creating a continuous urban structure	.161	4.81	.77
S4	Decreased density on the surface	.170	4.90	.83
S5	Reducing environmental stresses	.162	4.90	.79
S6	Avoid affecting the natural and physical conditions of the areas	.109	4.81	.52
S7	Reduce noise pollution	.103	3.90	.40
W1	Soft ground in the region	3.9	.108	.42
W2	Limited external control	3.9	.128	.49
W3	Failure to identify suitable locations for the connection of underground spaces with the surface	4	.146	.58
W4	Tough working conditions in underground environments	4.63	.175	.81
W5	There is a problem connecting to other surface transport networks	3.81	.091	.34
W6	There are hidden costs	4.63	.159	.73
W7	There are high initial costs	4.81	.189	.90

Table.10. Internal Factor Evaluation Matrix

Internal Factor Evaluation Matrix				
External strategic factors		**Relative weight**	**Absolute weight**	**Final weight**
O1	Moderation of adverse climatic effects on urban space	.209	5	1.05
O2	energy saving	.118	4.72	.56
O3	Reduce the cost of implementing underground spaces	.107	4	.43
O4	Cost-effectiveness of construction in difficult areas	.091	3.63	.33
O5	Increase urban security	.127	4.72	.60
O6	Increase the defensive safety of the city	.202	4.90	.99
O7	Use the whole city in location to create public spaces	.145	4.18	.61
T1	Decreased adaptation to the conditions of the disabled	.118	3.90	.46
T2	Groundwater level drops	.193	4.90	.95
T3	Soil pollution risk	.112	3.90	.44
T4	High risk of natural disasters (earthquakes)	.138	4	.55
T5	High construction costs in soft fields	.098	3.81	.37
T6	Inability to raise capital	.176	4.81	.85
T7	High management and maintenance costs	.159	4.09	.65

- Determine Selective strategy

In this section, according to the final weights, SO, ST, WO, WT strategies are evaluated and the appropriate strategy is selected. Table 14 shows the weight coefficient and the percentage of influence of internal and external factors.

Between external and internal factors, strengths with a weight of 4.69 and a weight percentage of 26.33 are the first priority and threats with a weight of 4.26 and a weight percentage of 23.9 are the last priority.

Table .11. Weight coefficient and Effectiveness percentage of internal and external factors

	External factors		Internal factors	
	O	T	S	W
Final weight	4.56	4.26	4.69	4.30
Weight percentage	25.6	23.9	26.33	24.14

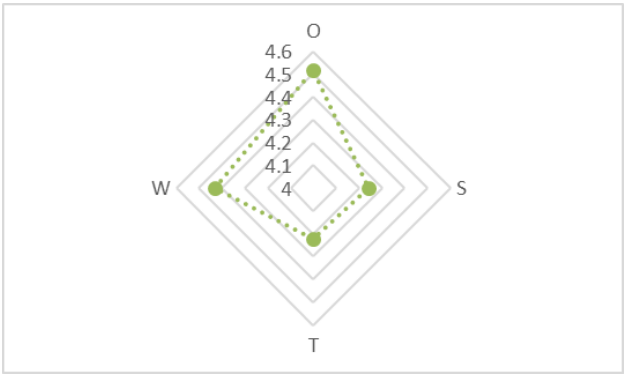


Fig.9. Evaluation of internal and external factors (SWOT)

Table 11 shows the weight coefficient and effectiveness of the four strategies. The SO strategy has the most weight and is the first priority. The weight percentage of this strategy is equal to 26.71 which has a higher weight percentage than other strategies.

Table 12. Weight coefficient and effectiveness percentage of the four strategies

	Coefficients of composite factors			
	WO	WT	ST	SO
Final weight	8.86	8.56	8.95	9.25
Weight percentage	24.19	23.37	24.44	26.71

The SO strategy has the highest score. Therefore, the proposed strategy resulting from the SWOT technique is the SO strategy.

5. Findings

The concept of 'livability' here is focused on a city being suitable for human habitation based on underground spaces conditions (6). While there are several important factors affecting how livable a city is, such as natural, social, and economic factors (6), the current study focuses on urban underground space. Whether or not the living environment is comfortable is one of the important criteria for individual and industrial stakeholders to evaluate the livability of cities (6).

- **Reducing environmental stresses by creating and developing livable underground spaces in terms of climate comfort (S5 S2 O1)**

One of the basic principles in the development of urban areas is that designs that lead to severe human hazards should be avoided. Accordingly, due to the increasing growth of cities, which in turn leads to rising temperatures, environmental and noise pollution, the environment is exposed to serious hazards. In addition, in hot and dry climates, presence in urban spaces is impossible for users and citizens in most seasons due to unfavorable climatic conditions. Therefore, the creation and development of underground spaces with respect to the observance of climate comfort criteria is a

suitable solution for the development of the city and the preservation of the environment.

- **Creating a balance in density between public and private spaces and increasing coherence in the structure and texture of the city to save energy by creating desirable underground spaces (O2 S3)**

The density of the urban area helps in the optimal use of energy**.** But the increase in density leads to problems such as congestion, pollution, reduction of open spaces and reduce the viability of public spaces**.** Creating and developing desirable underground spaces can be a good way to balance urban density as well as increase the coherence between urban spaces, which leads to resource savings.

- **Using a large space of the city in locating to create public spaces and not affecting the natural and appearance of the city (O7 S6)**

It is impossible to use all the surface of land in a city to create public spaces**.** Therefore, this solution can be implemented by using related and continuous subsurface areas**.**

- **Increase urban security and encourage the presence of people to use the space and reduce noise and environmental pollution (S_7, O_5)**

Certainly, one of the reasons for the absence and attraction of citizens from urban areas is vehicles, insecurity, pollution, and so on.

The use of underground spaces can improve the vitality, safety and presence of citizens in public spaces by preventing the interference of rider movement with pedestrian movement and increasing the level of pedestrian access.

- **Defensive security of the city and protection of the environment through the development of the city in the underground spaces (S1, O6)**

Changes in the environment cause dangers due to human over-development of the environment. Utilizing underground spaces as public spaces will lead to resilience. Utilization of subsurface spaces as public spaces will lead to resilience. It will also have control over the microclimate.

6. Conclusion

Thematic and place concepts have different dimensions and there are numerous variables which affect the expected quality of the study subject. Different factors such as the large number of concepts, disagreement on their definitions, and uncertainty about the impact of quantities on qualities make it necessary to develop and evaluate a method based on the expert's ideas. As a model is required to be generalizable, and as there is published literature on the present study subjects including public livable spaces, subsurface spaces and appropriate forms in hot and dry climate, the researcher has used a unique method by integrating the existing methods to obtain the required results.

It has been tried to create a consistency between different phases of the research. First, the objectives of the research were determined. Then the research questions were developed and library studies with regard to the main concepts of the study were performed. However, questions and studies were revised several times so that the questions were made purposeful and more consistent with the objectives of the research. Reviewing the changes of urban spaces shows an evolution in the application of subsurface spaces, but still there are not codified models, checklists, and regulations for the developing subsurface spaces. As the setting of the research including subject, place and time were determined, the work was conducted on the area which seemed to be important and necessary. The findings revealed that subsurface spaces need to be immediately taken into consideration in researches. Nowadays, more and more cities are starting to use such spaces despite the fact that no comprehensive research has been conducted in this regard.

The main reason to select hot and dry climate for the study is that harsh climatic conditions justifies the use of subsurface spaces in such places. In such a climate, providing comfort in walled and controlled spaces is more feasible. The city of Zahedan was selected for the study because the researcher has an access to a group of experts, the city is growing fairly fast and there is a high congestion of population (95 individuals per hectare), the land has remarkably high value (the eighth expensive city with regard to estates), and the city suffers from shortage of public spaces (low service spaces per capita including green spaces which is less than one square meter). All these factors have made Zahedan an appropriate place to develop using subsurface spaces if the city is empowered economically and technically. However, the main objective of the research is to introduce a method to extract basic

necessities, and criteria, to study strong and weak points and threats, and to present models and strategies. The present method may also be applied on another city and depending on its conditions, different results may be obtained.

This was the researcher who made the decision on how to answer the questions; however, in all phases of the research, he benefited from a group of experts who analyzed and evaluated the subjects from different perspectives. By weighting different indexes of the questionnaire, SO strategy acquired the highest points which shows that the panelists evaluated the strong and positive points of subsurface spaces more than their weak points and threats. Therefore, the present study argues that livability in subsurface spaces is considered in order to develop public subsurface spaces. Moreover, in order to develop such spaces, it is necessary to consider these criteria and qualities. Meanwhile, different models have been designed to respond to these criteria so that only basic necessities of development are not the main factor to choose a strategy.

Summary of research findings states that if the living standards are met, public spaces created underground, in addition to providing public spaces needed by citizens in hot and dry climates such as Zahedan, can provide qualities such as climatic comfort, legibility, ease To be successful in transportation and environmental protection and lead to the optimization of urban land use performance through synergy due to increasing the density of public spaces and increasing the ratio of public spaces to other spaces.

This measure modifies the effect of natural and climatic conditions and decreases the severity of hot and dry climate in urban spaces. Moreover, transferring such spaces to the underground decreases energy consumption. It also decreases sound pollution and increases safety and defense security of Zahedan as every access to these spaces can be controlled.

Furthermore, subsurface public spaces do not have the limitations of uses of the spaces that surface spaces have. Subsurface spaces are free with regard to different uses, so public spaces can be transferred to under the ground.

Subsurface public spaces lead not only to the livability of urban spaces and climatic comfort, but also to the increase of urban tolerability since defense criteria develop.

Transferring public spaces to under the ground in Zahedan increases the livability of urban spaces particularly in hot seasons, improves the urban tolerability and security, improves the surface spaces use, decreases congestion on the surface, reduces the tendency to development on the surface, improves using urban spaces, etc.

Transferring spaces from the surface to the subsurface must be along with livability. In the present study, according to the introduced model, the criteria of livability of subsurface spaces in Zahedan are summarized in 5 criteria of functional, perceptional, environmental, physical and social. The functional criterion, itself, has six sub-criteria of flexibility, all-inclusiveness, efficiency and diversity, security and safety, walkability, and easy accessibility. The perceptional criterion has two sub-criteria of sensory richness and readability. The environmental criterion also has two sub-criteria of cleanliness and climate comfort. The physical criterion has three sub-criteria of human scale, continuity, and enclosure. The social criterion has four sub-criteria of vitality, place belonging, sociability, and considering human needs. As a result, while transferring the surface spaces to the subsurface, livability of the spaces must be particularly taken into consideration. In fact, applying the aforementioned criteria guaranties the livability of these spaces.

References

[1] Jianqiang. Cui, Wout. Broere, Dong. Lin. (2021). Underground space utilisation for urban renewal. *Tunnelling and Underground Space Technology incorporating Trenchless Technology Research*, 108 (2021) 103726. Available from: https://doi.org/10.1016/j.tust.2020.103726

[2] Broere, W. (2016). Urban underground space: Solving the problems of today's cities. *Tunn. Undergr. Space Technol*, 55, 245–248. Available from: https://doi.org/10.1016/j.tust.2015.11.012

[3] Jianqiang. Cui, Andrew. Allan, Dong. Linb. (2019). SWOT analysis and development strategies for underground pedestrian systems. *Tunnelling and Underground Space Technology*, 87, 127-133. Available from: https://doi.org/10.1016/j.tust.2018.12.023

[4] Yingqi. Cao, Fen. Li, Xuesong.Xi, Dani¨el Jacques Corn´e van Bilsen, Liyan. Xu. (2021). Urban livability: Agent-based simulation, assessment, and interpretation for the case of Futian District,

Shenzhen. *Journal of Cleaner Production*, 128662. Available from: 10.1016/j.jclepro.2021.128662

[5] Han Admiraal, Antonia Cornaro. (2019). Future cities, resilient cities – The role of underground space in achieving urban resilience. *Underground Space, in press*. Available from: https://doi.org/10.1016/j.undsp.2019.02.001

[6] Admiraal, H., & Cornaro, A. (2018). Future cities–resilient cities. In Underground Spaces Unveiled: Planning and creating the cities of the future. *s.l.: ICE Publishing*., 2018. pp. 115-127. Available from: https://doi.org/10.1680/usu.61453.115

[7] Sterling, R., Nelson, P. (2013). City resiliency and underground space use. In: Zhou, Y., Cai, J., Sterling, R. (Eds.). *Advances in Underground Space Development Research Publishing*, Singapore, 43–55. Available from: https://www.acuus.org/attachments/article/4/key6.pdf

[8] D.V.L. Hunt, L.O. Makana, I. JeffersonC.D.F. Rogers. (2016). Liveable cities and urban underground space. *Tunnelling and Underground Space Technology*, Volume 55, 8-20. Available from: https://doi.org/10.1016/j.tust.2015.11.015

[9] Bobylev, N. (2009). Mainstreaming sustainable development into a city's master plan: A case of urban underground space use. *Land Use Policy* (26 (4)), 1128–1137. Available from: 10.1016/j.landusepol.2009.02.003

[10] Jianqiang. Cui, Dong, Lin. (2016). Utilisation of underground pedestrian systems for urban sustainability. *Tunnelling and Underground Space Technology*, 55, 194-204. Available from: https://doi.org/10.1016/j.tust.2015.11.004

[11] D.V.L.Hunt, D.NashC.D.F.Rogers. (2014). Sustainable utility placement via Multi-Utility Tunnels. *Tunnelling and Underground Space Technology*, 39, 15-26. Available from: https://doi.org/10.1016/j.tust.2012.02.001

[12] Hend H. Yassin. (2019). Livable city: An approach to pedestrianization through tactical urbanism. *Alexandria Engineering Journal*, 58(1), 251-259. Available from: https://doi.org/10.1016/j.aej.2019.02.005

[13] Jian Penga, Fang-Le Penga, Nobuyoshi Yabukib, Tomohiro Fukudab. (2019). Factors in the development of urban underground space surrounding metro stations: A case study of Osaka, Japan. *Tunneling and Underground Space Technology*, 91, 103009. Available from: https://doi.org/10.1016/j.tust.2019.103009

[14] Loretta. von der Tann, Stefan Ritter, Sarah Hale, Jenny Langford, Sean Salazar. (2021). From urban underground space (UUS) to sustainable underground urbanism (SUU): Shifting the focus in urban underground scholarship. *Land Use Policy*, 109, 105650. Available from: https://doi.org/10.1016/j.landusepol.2021.105650

[15] Sassano, G., Graziadei, A., Amato, F., Murgante, B., (2017). Involving citizens in the reuse and regeneration of urban peripheral spaces. In: Silva, C.N., Bucek, J. (Eds.), *Local Government and Urban Governance in Europe*. Springer, Cham, Switzerland, Local Government and Urban Governance in Europe, 193-206. Available from: 10.1007/978-3-319-43979-2_10

[16] Bobylev, N. (2011). Comparative analysis of environmental impacts of selected underground construction technologies using the analytic network process. *Automation in construction* (20(8)), 1030-1040. Available from: 10.1016/j.autcon.2011.04.004

[17] Mao-sheng Zhang, Mao-shengZhang1Hua-qiWang, Ying Dong. (2020). Evaluation of urban underground space resources using a negative list method: Taking Xi'an City as an example in China. *China Geology*, 3(1), 124-136. Available from: 10.31035/cg2020006

[18] Litman, T. (2011). Well measured: Developing indicators for sustainable and livable transport planning. *Retrieved from Retrieved from* http://www.vtpi.org/wellmeas.pdf

[19] Sanford, E. L. (2011). What is the difference between livability and sustainability? Retrieved from: http://www.camsys.com/kb_experts_livability.htm

[20] Geller, A. L. (2003). Smart growth: A prescription for livable cities. *American Journal of Public Health* (93(9)), 1410–1415. Available from: 10.2105/ajph.93.9.1410

[21] Rue, H., Rooney, K., Dock, S., Ange, K., Twaddell, H., & Poncy, A. (2011). The role of FHWA programs in livability. Retrieved from https://www.fhwa.dot.gov/livability/state_of_the_practice_summary/research2011.pdf

[22] Kochera, A., Straight, A., & Guterbock, T. (2005). Beyond 50.05: A report to the nation on livable communities: Creating environmental for successful aging. Retrieved from http:// assets.aarp.org/rgcenter/il/beyond_50_communities.pdf, Accessed date: 28 Se

[23] Leccese, M., & McCormick, K. (2000). Charter of the new urbanism. In: Congress for the new urbanism. *McGraw-Hill*.

[24] X. Li, J. Liu. (2003). Preliminary research of the fussy comprehensive appraisal to environment climate of the urban human settlements. *Econ. Geogr*, 23 (2003), 656-660. Available from: https://doi.org/10.1016/j.accre.2021.07.006

[25] D. Scott, M. Rutty, B. Amelung, et al. (2016). An inter-comparison of the holiday climate index (HCI) and the tourism climate index (TCI) in Europe, Atmosphere, 7. 80. Available from: https://doi.org/10.3390/atmos7060080

[26] Evans. (2002). Livable Cities? Urban Struggles for Livelihood and Sustainability. *University of California Press, Berkeley*. Retrieved from https://www.ucpress.edu/book/9780520230255/livable-cities

[27] M. Douglass. (2002). from global intercity competition to cooperation for livable cities and economic resilience in Pacific Asia. *Environment and Urbanization*, 14(1):53-68. Available from: https://doi.org/10.1177/095624780201400105