Int. J. Urban Manage Energy Sustainability, 5(4): 171-183, 2024

Journal of Urban Management and Energy Sustainability (JUMES)

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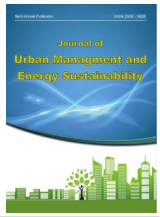

CASE STUDY RESEARCH PAPER

Evaluation of green roof design Indicators Based on the visual-perceptual component (Case Study: Shiraz City)

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ARTICLE INFO

Article History:
Received 2023-07-20
Revised 2023-10-02
Accepted 2023-11-29

Keywords:
Green roof, landscape organization, sustainable urban development, Shiraz city, visual-perceptional components

ABSTRACT

The green roof is one of the new approaches of architecture and urban planning and is based on the concepts of sustainable development, which can be used to increase the number of green spaces per capita, improve the quality of the environment and sustainable urban development. The current research is analytical-descriptive and has a practical purpose. The method of data collection is both documentary and libraries, and survey method has been used. The main aim of this method is to create a set of perceptual data in the landscape organization of Shiraz city in order to examine the quality of perception and understanding of different people with the property evaluation level in relation to urban green spaces as one of the main indicators of urban landscape sustainability. After determining the average score of the case samples, taking into account the SAW weighting method and the TOPSIS ranking method, as well as the weighted feedback of each index in the Delphi method, qualitative ranking is done. Findings show the scale of the green roof and the function of the building can be considered effective in influencing the conceptual model in the urban landscape, but it cannot be concluded that the larger the scale and area of the green roof, the more effective it is in improving the quality of the urban landscape. The results show visual-perceptional component quality is related to aesthetic preference, and in future researches, the relationship between the indexes can be evaluated.

DOI: 10.22034/ijumes.2024.2036181.1237

Running Title: Green roof design Indicators Based on the visual-perceptual component

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
22	02	10

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INTRODUCTION

A landscape is a part of the environment that can be paid attention to in a specific place and is related to its background in the environment (Bell, 2016). Landscape comes from the root of "opinion", which in Dehkhoda culture means looking at something in contemplation, anticipating the presence of something, insight, thought and opinion (Polat, 2004). The urban landscape is all the available information from the space that can be received by the senses and processed in the process of perception. Information such as form, function and meaning of space (Pakzad, 2016). One of the main characteristics of the concept of urban landscape is that it is presented as an "objective-mental", "human-physical" phenomenon and a "social-spatial" structure. The main types of urban landscape include a wide view, internal view, Cityscapes are also visual corridors (Nishimura, 2015). According to Cullen's definition (1961), the landscape of every city is a response to human behavior, weather conditions, safety factors and skillful interventions in the framework of increasing the capabilities of the environment (Watmann et al., 2015). The urban landscape is the result of the level of contact between man and the city, and in this regard, humans not only influence the urban landscape through their activities in the structure of the visual landscape of the city, but also the behavior and mental understanding of citizens are affected through contact with the urban landscape (Khakzand et al., 2013). Cullen define the urban landscape as the art of providing visual and structural integration to the set of buildings, streets and places that make up the city environment, and considers it the art of how to establish connections between the various components of the city body (Eiter, 2010). Cullen's view of the urban landscape includes most of the physical dimensions of the urban landscape. His emphasis is more on the visual and objective aspects of the urban landscape. Kevin Lynch considers the three perceptual, physical and functional factors important in the urban landscape (Reza Zadeh, 2006). By confirming Cullen's ideas, he adds the perceptual aspect to the dimensions of the urban landscape. In "Dictionary of Urban Design Concepts", Behzad Far places the components of the urban landscape in three parts: physical, non-physical factors and human activities (Bishop et al., 2001). He defines the landscape as a transmitter that transmits different information to humans and divides its components into two categories: physical and human (Cassatella, 2011). Golkar introduces the landscape as the manifested and tangible part of the form, where the visual, functional and semantic crystallization of the things that shape the space can be seen (Golkar, 2007). It has also been stated that the urban landscape is the citizens' understanding of the city, which takes place through the perception of its symbols (the physical dimensions of the city) and the association of meanings related to them (the mental dimensions and memories). The three objectives of the urban landscape are: aesthetic, cultural-identity and functional (Mansoori, 2014). The goal of aesthetics considers the tangible dimension of the space that creates a pleasant reaction in the user. Paying attention to the physical aspect of the space, the type of volumes and their composition, color, materials, contiguity, dark and light, rhythms, contrasts, milestones and indicators, vegetation, the presence of natural elements and other characteristics that form tangible dimensions. is placed in this category. The aesthetics used at this stage are a function of climatic, historical, artistic, religious, traditional and cultural elements. The functional goals of the urban landscape create a context for the design of various topics, which are selected according to the project topic and its functions. Goals such as making the environment legible and calming it down are included in this group. The purpose of the identity aspect of the urban landscape is to create a sense of happiness, comfort, peace and security (Moghadisi and Haqit Bin, 2014; Ode Sang et al., 2008; Sakieh et al., 2016). The sensitivity of the urban

landscape when it focuses on the concept of sustainability should be hidden in all the components of the city's body form, one of the main cells of which can be the roofs that somehow contain nature and a corner of the environment.

The green roof is not actually a new invention, grass roofs, rooftop gardening, living roofs, bio roofs or garden roofs are a conventional and traditional building technique in many parts of the world with an ancient background, which can be He pointed to the first examples of it, the Hanging Gardens of Babylon in 500 BC. The idea of creating a garden on the roof and cultivating on it was used by Iranians 2500 years ago and on the roofs of ziggurats. The hanging gardens of Babylon were actually not gardens that were suspended in the air, but green spaces that were located on the roofs and skylights of several buildings. This conventional and traditional technique in the form of a living ecosystem, with its many advantages, which we will discuss further, is a positive and effective step towards improving the quality of the urban landscape, the ability to create a favorable environment in urban environments, refining and improving air quality and establishing Thermal balance will reduce the effects of thermal Islands. Green roofs in terms of quality in recent years with the goals of environmental protection, promotion of socio-cultural interactions and improvement of economic conditions, improvement of the current state of energy consumption, low per capita green space in the country, the possibility of optimal utilization of urban lands, proper management of sewage Surfaces and attention to aesthetic issues Have grown significantly and made this issue even more important, but by studying and examining the existing examples in the country, still in terms of performance in reducing energy consumption, design, implementation and maintenance, He was not responsive They lack effective efficiency and have major problems that will require providing a suitable design model. Despite the fact that green roofs are beautiful in appearance and create a fun and pleasant environment for work, life and social interactions, and compared to traditional roofs, they help to return the initial investment during the life of the building, there are many other advantages in the environment. Such as: 1) compensating for existing pollution, 2) reducing the effects of heat islands, 3) improving the management of sewage control, so that the sewage created in buildings can be used for irrigation of green roofs with re-treatment, 4) reducing drainage. , 5) Saving energy consumption, 6) Increasing the durability and lifespan of roof coverings, 7) Adjusting the climate, reducing the winter cold, maintaining and ecological balance of the city, 8) Reducing noise pollution and insulation against noise, 9)) will increase per capita green space and improve the quality of the environment, vitality and dynamism of the city. Currently, the green roofs in the country, in practice, due to the existence of research gaps and the lack of a design model and the following main reasons: 1) lack of attention to the qualitative aspects of the urban environment in the country's urban planning system, 2) lack of provision of sufficient water resources, materials (suitable soil) etc., 3) lack of proper use of gray wastewater and control of floods and runoff and proper management of rainwater, 4) lack of coordination of the type and vegetation suitable for the region's climate and their cultivation and maintenance, 5) Create and impose Extra load and heavy weight on the roof and structure, 6) Expensiveness of current methods and lack of complete and professional systems for Maintenance, not only has not been useful and responsive and has not benefited from its positive and effective aspects. Rather, the effects and destructive consequences and its negative aspects are more visible in the examples implemented in the country, to the point where the implementation of the green roof has been neglected in most of the country's buildings. Therefore, in large cities and towns, contemporary urban landscapes, due to the influence of various factors on how their texture is formed

and the speed of its changes, on the other hand, the repetition of similar urban landscapes, do not represent the characteristics of their natural, cultural and historical background (Gerber and Hess, 2017). Obviously, the green roofs of architectural buildings in the middle scales can help to better understand the audience from an urban point of view.

In fact, the green roof is the use of unused spaces of urban buildings to create green spots. In addition to the aesthetic aspects of the city, this causes air conditioning in the microclimate scale and reduces air pollution and ultimately improves the environment of the city's residents. Of course, paying attention to this issue with any approach is not specific to recent decades, therefore it has been considered throughout history. The green roof is one of the new approaches of architecture and urban planning and is based on the concepts of sustainable development, which can be used to increase the number of green spaces per capita, improve the quality of the environment and sustainable urban development. The practical use of roofs can be considered as the possibility of optimal use of urban land (Förster et al., 2019). The need to study green roofs with regard to environmental issues in architecture and urban planning is of special importance in order to improve the quality of the environment and sustainable urban development. Based on the policies of reducing the adverse effects of urbanization on the environment, by guiding these activities through raising awareness, it is possible to be effective in improving the environment; Also, the different costs of installing green roofs based on the type, materials and environment compared to normal roofs, not including green roofs as a part of a sustainable green system along with other planning policies and designing urban spaces, the cheapness of energy in Iran. And consumers' unwillingness to reduce energy costs, lack of legal framework to encourage investment in this sector, and lack of informing officials and experts and middle managers of municipalities about the benefits of green roofs, lead us to this directs. When the issue of green roof is examined as a micro scale, it may not show macro needs, but when the urban landscape as a whole has cells like green roof, the necessity of looking at it can be understood.

In the review of the background of the research on the topic of sustainable urban landscape architecture in the field of urban green roofs which is discussed in micro-scale architecture, so far, no research has been observed that has independently investigated the research methods and approaches comprehensively. Also, a precise way of evaluating the urban landscape with a sustainable approach in the green roof area has not been defined as a comprehensive method. But in the dimension of landscape architecture, urban landscape and centering on the concept of ecology as one of the understandable examples of the city system and also green roofs as a phenomenon, a combined method to evaluate and achieve the research goals can be considered as a kind of He proposed innovation. Also, the expansion of the concepts of sustainable urban landscape and green roof in terms of explaining the structural model of the research, which will lead to the formulation of the proposed indicators, is also considered a new aspect of this research. In addition to that, creating a practical and executive relationship between the green roof design model and the quality of sustainable urban landscape for the first time in the city of Shiraz, as well as presenting the green roof design model and promoting it in future constructions as an influential principle in the city's detailed plan. Also, the mental landscape in the direction of improving the urban environment and improving the quality of the urban landscape can be expressed as the innovation of the current research. Based on this, the dimensions and indicators of explaining the urban landscape quality mechanism based on the green roof concept can be presented as follows: (Tab. 1)

Table 1: Research framework of the research (Source: Hamzavi et al., 2023)

The dimensions, components and indexes in explaining the urban landscape quality mechanism based on the green roof concept					
Dimensions	Components	Index	Type	Measurement method	Minimum spatial scale of measurement
Urban landscape	Visual-perceptual	Visual scale	Quantitative	Visual preference	Urban district
		Visual clarity	Quantitative		
		Formal feature	Quantitative		
	Environmental	Greenery	Qualitative	Questionnaire	
	Functional	Aesthetics	Quantitative	Questionnaire	Urban district
	Aesthetics	Readability	Qualitative	Questionnaire	Urban area
		Texture and materials	Qualitative		
		Size	Qualitative		
		Proportions	Qualitative		
Green roof	Ecology	Environmental comfort	Qualitative	Questionnaire H.S.E	Urban area
	Socio-economic	Sense of place	Qualitative	Questionnaire	Urban district
		Identity	Qualitative		
	Environmental	Mental health	Qualitative		

MATERIALS AND METHODS

Methodology

The current research is analytical-descriptive and has a practical purpose. The method of data collection is both documentary and libraries, and a case-by-case sample of the field method has been used. In the following, using quantitative and qualitative combined methods, each of the indicators has been evaluated, which can be referred to visual preference methods and Simon Bell's landscape evaluation method, as well as Philip Thiel's environmental qualitative evaluation. In these three mentioned methods, the beginning of the research is done with the visual preference method. In this method, visual preference perception has been used to collect environmental and landscape data. The main aim of this method is to create a set of perceptual data in the landscape organization of Shiraz city in order to examine the quality of perception and understanding of different people with the property evaluation level in relation to urban green spaces as one of the main indicators of urban landscape sustainability. Gave. In order to better understand the environmental perceptions and environmental effects of the respondents in their evaluation, the images of green roofs of buildings in the urban areas of Shiraz are used. The examined criteria were measured and evaluated through a questionnaire including selected photos from 24 photos by experts with the help of the achievement matrix, and at the end, the most important criteria affecting the beauty of these images were identified. According to the results of the table below, it can be concluded that how many of the 24 images surveyed by the experts have the highest average scores, in other words, the selected image has the highest visual quality. In the final stage, after determining the average score of the case samples, taking into account the SAW weighting method and the TOPSIS ranking method, as well as the weighted feedback of each index in the Delphi method, qualitative ranking is done.

DISCUSSION AND FINDINGS

In this part, according to the mentioned research method and also the presented research framework, each of the three indicators including visual scale, visual clarity, form characteristic of the "visual-perceptual" component are evaluated and analyzed. It is necessary to explain that in each of the indicators, the sub-index has been taken into consideration in an implicit way according to the type of investigation. The findings are finally evaluated and ranked according to the selected case samples.

Evaluation of visual scale, index, visual clarity and form characteristic

In the visual analysis that is done with the photos, it is important that the researchers record all the conditions at the time of photography in such a way that it is possible to repeat the photography with the same conditions as before. For this reason, things such as the position of the photographer and the angle of the camera, time, and distance must be clear in the analysis of urban views (John Way, 2013). Accordingly, in this research, several photos have been taken of every building and green roof on it, from a fixed position and in the same time frame. Study samples were photographed with different lenses, angles and distances. Finally, the best angle of view to show the real scene, the position of the photographer and the appropriate lens were selected by experts and researchers. All the photos taken and selected from the study site were taken using a Sony N50 digital camera with a 35 mm lens at the viewing level of a standing observer. In the end, after removing a number of photos, 24 photos were finally selected. So that each of the photos show the various features of the landscape on the green roof of the building. In the table below, the number of 8 selected photos for classification of the three buildings in question was briefly displayed. Also, in this section, it has been tried so that certain visual effects are not effective in photography. The pictures also show the same be the sights that the observer observes with his own eyes.

Identifying the selected image of the green roof using the visual quality classification method of experts

In this section, in order to identify selected images and prioritize effective criteria in visual quality, including 3 main sub-indices from the point of view of people, a group of 20 people consisting of three levels of bachelor's, master's and doctorate was considered. In the first stage of measurement, 24 selected photos of the green roof of the three main buildings were provided to the people in the form of a pictorial questionnaire and they were asked to give each photo a score between five numerical values (very beautiful 2 +, beautiful +1, normal 0, ugly 1- and very ugly 2-). In the present method, it has been used as much as possible according to the respondents. Also, people's opinion about each photo has been investigated separately (Fairclough et al., 2018). The highest average score of each photo shows the desirability and high quality of the view of the green roof in the desired building. By using the visual quality classification method at this stage of the research, photos with high quality of view are selected to check the measured criteria and other photos are excluded from the next research cycle. In order to calculate and summarize the score and average score of each photo, equation 1 is used:

$$N = \sum_{i}^{5} = 1 n_i^{(3-i)}$$

Equation 1: The average score of each photo Source: Razavi and Vaezi Heer, 2016

N: the set of points of each photo

n1: the number of people choosing a photo with very nice quality

n2: the number of people choosing a photo with good quality

n3: the number of people choosing photos with normal quality

n4: the number of people choosing photos with bad quality

n5: The number of people choosing photos with very ugly quality

Measuring the criteria of visual quality of images with the matrix of access to measures

In order to measure the beauty criteria in the selected photos obtained by the Q-Sort method, in the first stage, the Hill evaluation method or the goal achievement degree matrix was used. The following table briefly shows 8 photos out of 24 selected photos and the results of the Q-Sort method. This method was proposed by Morris Hill in 1966. (Opdum et al., 2018) This matrix has a wide range of uses in the planning process and, like other techniques of this group, it helps to make rational decisions for appropriate actions in the exploitation of scarce resources, in order to achieve the expected goals as much as possible. (Manso et al., 2021) This method is used in contrast to cost-benefit analysis and planning balance sheet, in cases where their goals are not completely clear and there are relative and not quantitative values to measure them (Gray, 2017). Also, the method of achieving the goals in order to overcome the lack of resources has been proposed for the comprehensive, which can be used to examine the qualitative goals and compare the achievement of goals such as economic, aesthetic and environmental (De Oliveira and Bonvicino, 2020). The beauty of the photo on a three-spectrum scale:

- Full realization (desirable) +1
- Relative fulfillment (relatively unfavorable) 2+
- Unfulfilled (unfavorable) 3+

Specify Before completing the questionnaire, a brief explanation was given about the criteria and how to score the photos. The criteria examined through a questionnaire including selected photos from 24 photos were measured and evaluated by experts with the help of the achievement matrix and at the end the most important criteria affecting the beauty of these photos were identified by the people and then using Analytical software in SPSS (16) obtained the following table. The positive and negative average score of each photo indicates the desirability and quality of the photo, and its negative indicates the lack of photo quality. According to the results of the table below, it can be concluded that 8 of the 24 photos surveyed by the experts has the highest average scores, in other words, the selected photos have the highest visual quality. (Tab. 2-4) (Fig. 1)

Table 2: How the selected people rate the 24 photos of the three selected buildings

Image	Photo selectors (n=50)						
	n1	n2	n3	n4	n5	N	Average
1	0	5	28	17	2	-14	-0/28
2	0	3	27	22	0	-16	-0/32
3	2	12	34	4	0	8	0/16
4	0	20	22	10	0	9	0/18
5	3	20	22	7	0	18	0/36
6	1	26	25	0	0	26	0/52
7	0	2	16	26	8	-39	-0/78
8	0	10	19	21	2	-14	-0/28
9	0	2	21	26	3	-28	-0/56
10	5	27	13	7	0	28	0/56
11	3	24	20	5	0	22	0/44
12	0	2	19	22	5	-20	-0/50
13	0	0	11	32	9	-48	-0/96
14	0	1	23	24	4	30-	-0/6
15	0	0	27	23	2	27-	-0/54
16	2	25	16	9	0	19	0/38
17	0	0	22	24	6	34-	-0/68
18	3	36	12	1	0	41	0/82
19	0	3	11	27	11	44-	-0/88
20	0	1	25	19	5	32-	-0/80
21	0	2	19	25	6	33-	-0/66
22	0	1	25	21	5	30-	-0/6
23	0	3	10	26	10	40-	-0/82
24	0	2	21	22	5	22-	-0/52

Table 3: Measurement of visual quality criteria in selected images

Image Chosen	Measuring visual quality criteria in selected images (n=50)							
	Green roof functional connection space	Continuity of facade and green roof	Connecting the visual space to the outside view	The spatial hierarchy of the green roof	The central line of the green roof	Elements and details	Continuous view of the green roof	Green roof visual connectivity scale
1	1	1	1-	1-	0	1-	1-	1-
2	0	1	1-	1-	0	1-	1-	1-
3	1-	1	1	1	1	1	1	0
4	1-	0	1	0	1	1	0	0
5	1	1-	1-	1	1	0	1	1-
6	1	0	0	1	0	0	1-	0
7	0	0	1	1	0	1-	1-	1
8	1	1-	0	1	1-	1-	1	1
Number of points - 1	2	2	3	2	1	4	4	3
Number of points 0	2	3	2	1	4	2	1	3
Number of points 1	4	3	3	5	4	2	3	2
The percentage of complete fulfillment of the criteria	56	48	9/48	75	66	8/51	7/41	2/45

Table 4: Classification of images based on the criteria of the active matrix

Image number	Image type	Visual scale			Visual clarity			Form			Number of elements
		Micro	Middle	Macro	Specific	semi-specific	Ambiguous	Linear	Central	Combined	
1	Green roof functional connection space	×	-	-	-	×	-	×	-	-	5
2	Continuity of facade and green roof		×		×	-	-	-	-	×	4
3	Connecting the visual space to the outside view	×	-	-	-	-	×	×	-	-	5
4	The spatial hierarchy of the green roof	×	-	-	-	×	-	×	-	-	4
5	The central line of the green roof		×	-	-	×	-	-	-	×	3
6	Elements and details	×	-	-	×	-	-	-	×	-	4
7	Continuous view of the green roof	-	-	×	×	-	-	-	-	×	4
8	Green roof visual connectivity scale	-	-	×	-	-	×	-	-	×	3

RESULT AND CONCLUSION

Recognitive classification of studied samples

Based on this, the following table can be explained as a classification of samples by cognitive criteria: (Tab. 5) (Fig. 2)

Close to ideal

At this stage, the results obtained from the evaluation of the research criteria, the weight points assigned to each criterion on each sample using the TOPSIS method and the order of the decision matrix, without linear scaling, and also applying the coefficient assigned in the final stage of the Delphi method as the influence coefficient, taking into account the positive and negative levels, the Closest and most distant sample to the ideal level is specified and introduced. Also, the most effective criteria are introduced and identified using the Shannon entropy method. (Tab. 6-10)

Figure 1- 8: selected images

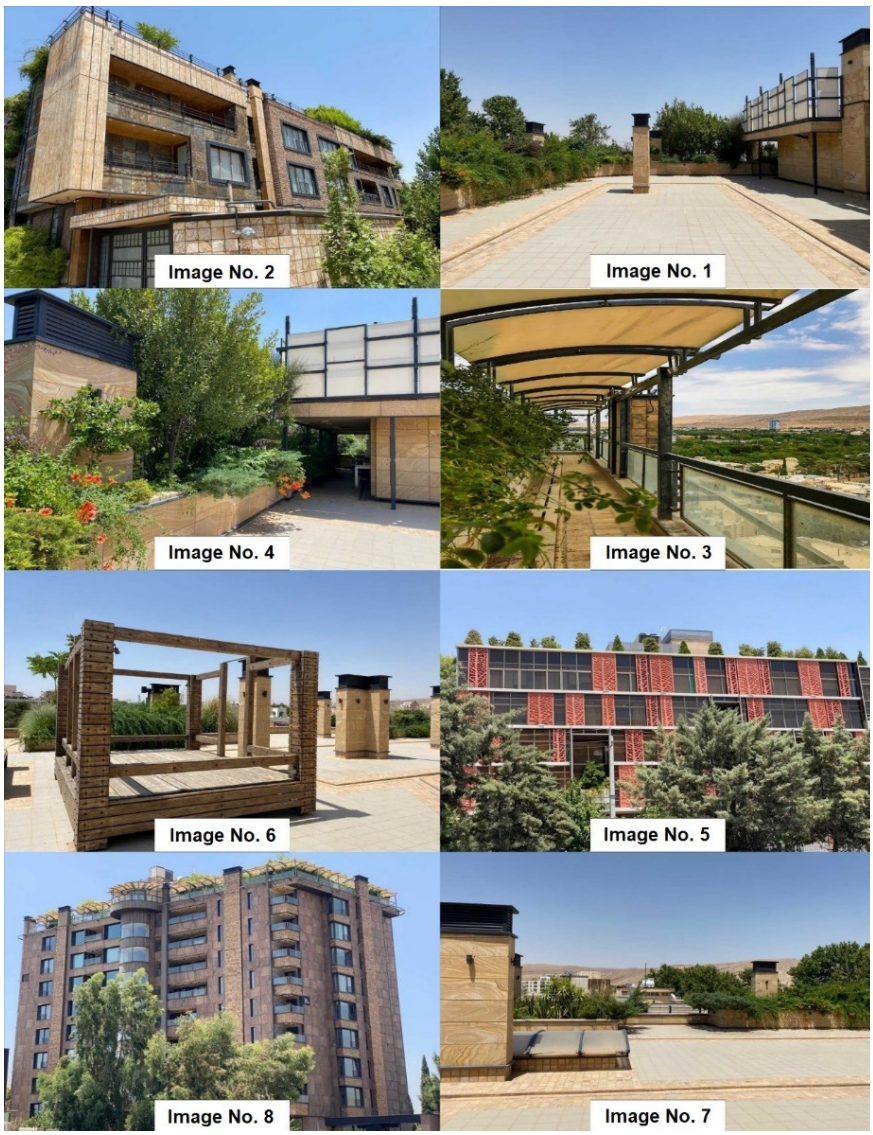

Table 5: cognitive classification of case examples

Building	Function	The approximate area of the green roof (square meters)	Type of building	Green roof scale	Green roof type
Khaan House	Residential	1000	High-rise apartment	Micro	Modern
Tabiaat	Commercial-administrative	2000	High-rise apartment	Middle	Modern
Khane-bagh	Residential	750	apartment	Micro	Modern

Figure 2: Location of selected cases in Shiraz city

Table 6: Primary decision matrix

Initial decision matrix	
	Scale and visual clarity, Form feature
Khaan House	75.00
Tabiaat	57.67
Khane-bagh	70.33
SUM Pig	358.00

Table 7: Linear scaleless matrix

Linear scale-free	
	scale and visual clarity, Form feature
Khaan House	0.2095
Tabiaat	0.1611
Khane-bagh	0.1965

Table 8: Linear scaling with influence coefficient

Linear scaling with influence factor	
	4.22
	scale and visual clarity, Form feature
Khaan House	0.8840
Tabiaat	0.6797
Khane-bagh	0.8290

Table 9: Distance from positive and negative ideal

The distance from the positive and negative ideal		
	scale and visual clarity, Form feature	
	Negative	Positive
Khaan House	0.125055	0
Tabiaat	0.022294	0.041747
Khane-bagh	0.089175	0.003026

Obviously, the scale of the green roof and the function of the building can be considered effective in influencing the conceptual model in the urban landscape, but it cannot be concluded that the larger the scale and area of the green roof, the more effective it is in improving the quality of the urban landscape. The amount of density when it is concentrated in one point actually has more darkness contrast at a closer scale, but when it is looked at further away, it covers less space. In fact, creating a building with a higher scale and at the same time a green roof with high greenery and more area in its function in urban landscape is much weaker than creating several buildings with greenery and less area because in the visual dimension and visual component, the concept of landscape It can be understood in a gestalt. Based on the obtained results, it can be considered that future studies can also examine the internal relationships of the variables, and based on this, by using the coding method and creating conceptual load in the fundamental concepts, research hypotheses about the relevance and significance of the internal relationships. also examine

Table 10: The positive and negative levels of the samples and the proximity to the ideal

	di+	di-	cl	Rank
Khaan House	0.156957	1.237369	0.887431	1
Tabiaat	0.561665	0.792943	0.585367	2
Khane-bagh	0.784	0.865994	0.524847	3

	m	8	K=	0.4809					
Entropy of each index	Ej	0.8528	0.8531	0.8532	0.8455	0.8433	0.8700	0.8516	
Degree of deviation	dj	0.1472	0.1469	0.1468	0.1545	0.1567	0.1300	0.1484	1.2037
Normalized weight	Wj	0.1224	0.1220	0.1219	0.1284	0.1302	0.1080	0.1233	1.0000
	RANK	3	5	6	2	1	7	4	
		scale and visual clarity, Form feature							
	DM Ws	0.11909							
	λjWj	0.0146							
	W'j	0.1166							
	RANK	6							

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HOW TO CITE THIS ARTICLE

Hamzavi, H., Karimi, B., & Keshmiri, H. (2024). Evaluation of green roof design Indicators Based on the visual-perceptual component (Case Study: Shiraz City). International Journal of Urban Management and Energy Sustainability, (), -.
DOI: 10.22034/ijumes.2024.2036181.1237