

UTILIZATION OF PLACE-MAKING APPROACH IN URBAN SPACES USING HISTORIC MANSIONS ATTRACTIONS

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Abstract

Rapid changes, especially modern ones, in historic cities have led to losing meaning in many urban spaces with identities and have made them useless. It has also made these urban spaces not only lack their past identity but also lose their functions for satisfying people's need. This research has scrutinized problems of the case study and tried to propose solutions for making a place regarding potentials of a historic urban context. The study aims to investigate the place-making approach in an urban space with cultural and historical aspects. The research method is descriptive-analytic. Descriptive method is used to present definitions and concepts of the subject in its theoretical base by investigating library resources especially lately written articles. Analytic method is accomplished by the analysis of the acquired information through Cronbach's Alpha method. It is considered to be a measure of scale reliability by SPSS. Findings predicate that people are more interested in places that are adaptable to their social and cultural needs and the historical and climatic features of their hometown. Trying to provide cultural and recreational functions that meet contemporary needs of various ages would make this urban space more popular.

Keywords: Sense of place, place-making, genius loci.

1. INTRODUCTION

With the expansion of social networks, city dwellers today are more and more interested in communal spaces, a place to meet, talk, and share some simple activities such as walking, sitting, and watching. If such spaces had historical and cultural identity, they would be more welcome due to the sense of belonging, a feeling that forms in a successful urban space after years and causes public interest to the space. Not only should such places be considered as a trophy, but also their possible defects must be

detected and resolved. The place-making approach can be effective in this regard. This approach tries to formulate strategies for the improvement and development of a space by discovering the needs and desires of the people who use the space. In fact, place-making takes shaping the public arena into consideration in order to maximize the common values.

The aim of this research was to investigate the place-making approach in a space with historical and cultural identity. In the next steps, how to use this potential to improve quality of a space and create a proper place for people to connect with would be discussed. The research question is to search the reason of the charm of an existing urban space due to its historical and cultural features. Thus, reasons such as greenery and freshness, peace and quiet, good access, communication with surrounding context, and feeling safe are examined; activities that give quality improvement to the existing urban space, are also searched.

It was said that the first step is to discover the needs and desires of people. This, in addition to a detailed observation of the environment, mandates questioning people who use the space and recognizing the way they use it. This will be reviewed in the methodology section..

2. LITERATURE REVIEW

Among experts, David Canter has written a book called *Space Psychology* (1977), which is considered one of the most important resources in this field. In his book he has mentioned:

The sense of place not only creates coordination and proper functioning of the human and architectural environment but also provides a sense of security, fun, and emotional awareness for the individuals. It is certainly a sense of place to help the identity and belonging sense of people to place (Canter, 1971).

From Christian Norberg-Schultz, the famous phenomenologist who has studied the topic of *genius loci*, the *Space in Western Architecture* (1975), and from the Canadian geographer, Edward Relph, the *Place and Placelessness* (2008) have been used. In addition to these classics, in the topics of space and *genius loci*, articles from Shamay, Simon, Tuan, and Falahat have been considered.

Some definitions in other papers have been explained as follows:

When certain place meanings appear to be more prevalent toward an individual, the conception that a person has toward a place will eventually shape their emotions, behaviors, and attachment to that place. In the context of urban research, numerous studies examine and discuss the role of place attachment and sense of place in understanding the value of place to people (Zakaria, et al., 2015).

The meaning of places derives from both physical and experiential attributes. Saar and Palang (2009) found several factors that can make places to become meaningful, such as through the experience and relationships that people have with other people. Some places hold past memories for people to recollect and reconnect with their histories. There are also places that acquire their meaning through certain activities that people do or engage. The spatial and experiential attributes that shape the meaning also create memories. Mowla (2004) suggested that 'memories have a context and place form, while place acts as a structure to reinforce or aid the recollection of memories'. However, when these qualities start to disconnect with the individual and places become less familiar through change, memories might also diminish (Sumaiyah, et al., 2013). One of the challenges of dealing with historic spaces is the 'lack of positive response' between the historic site to its context and surroundings (Heath, et al., 2013).

Ali Madanipur (2000) knows place as a part of the space with a sense of value and meaning. Place has some features such as sense. The landscape reflects the sense of any place. It is the view that reflects the conditions of the location and shows the human values, activities, and objectives (Mahmoodi Nejad, 2008).

place is where the events flow. The events that are going on in order to live; and as having a close relation with the existence and life, it is also life-giving. Place is where we have a perfect understanding of the existence and life (Habibi, 2008).

3. DEFINITIONS AND CONCEPTS

3.1. *Concept of Place*

Based on the phenomenology view, place is something more than an abstract location; it is a collection of elements that define the character of the environment, which is in fact the essence of the place (Norberg-Schulz, 1993). An essence is based on awareness and understanding, and defines places as profound centers of human existence. (Relph, 2008). Critical perspective emphasizes dynamic and ongoing social interaction and communication as well as a combination of the inside and outside, and acknowledges features such as globalization of economy, culture, relationships, and social connections and so on, which are constantly being reproduced in places, as reasons for uniqueness of them (Messy, 1994). On the other hand, positivist's view point considers the difference among people's assessment of places due to the difference among human beings and regard it as the core of people's "conceptual systems" associated with a specific location (Canter, 1977). Thus, places are linked to humans and are the result of the interaction among three components: human behavior, concepts, and physical

characteristic (Parsaee, et al., 2015). With an emphasis on each of the mentioned factors, that specific place accepts different conceptual systems for different people. Another major issue regarding place is the mechanical structure and the dialectic of inside and outside, which is the main factor of human's way of presence in place and its experience (Kalali & Modiri, 2012). place is a space which is invested understandings of behavioral appropriateness; social meaning and cultural expectation. (mohammad, et al., 2013).

3.2. The Meaning of the Sense of a Place

Tuan (1977) argued that places were essentially "centers of meaning constructed out of lived experience" that through time would be perceived as significant to the lives of the people (Ujang & Zakariya, 2015).

In phenomenology view, sense of a place means the reality and identity of it, which is an indicator of the importance of messages and concepts existing in a place. Messages and puzzles people understand and decode are based on roles, expectations, motivations, and other factors (Rappoport, 1990). Based on this view, perception and judgment that take shape based on decoding the meanings set forth in the mind, will help create a sense of place (Relph, 2008). In fact, phenomenologists, taking into account three components of form, function, and meaning in the form of the components of place-identity, consider sense of place as an aspect or another dimension of identity that acts in relation to the three mentioned components. From the phenomenological perspective, sense of place means to connect with places by understanding the meaning of symbols and everyday activities. This sense could be formed in the living place, deepened through time, and extended later. Individual and social values impact sense of a place and the sense of a place affect values, attitudes, and especially individual and social behavior in places. People usually participate in social activities based on their sense of place (Canter, 1977). Sense of place is not only the cause of coordination between architectural space and human but also the reason for feeling safe, enjoyment, and people's perception. It contributes to the sense of belonging to the place as well. From phenomenological point of view, the most important concepts to express sense of place are place-loving words, place experience, and its character.

Sense of place means the immaterial characteristics or personality of the place that are semantically close to the spirit of a space, which in terms of the history used to be utilized for holding religious ceremonies in the place, where visitors had to pay close attention to the movements of the worships in the event. Its rules were vital awareness of the environment, a traditional and religious repetition, and a sense of camaraderie and friendship (Brinckerhoff Jackson, 1994). As Steele (1994) believed, spirit of a place is a combination of features that gives a specific character to a location.

The character of a place is also among the most important factors of sense of place. In Simon's idea, a place not only indicates a geographical location but also shows the main character of a site, which makes it stand out from other locations. Thus, in a place, different dimensions of landscape come together to create a distinguishable and unique sense of place (Seamon, 1982). But from Norberg Schulz's point of view, place is something more than an abstract location. It is a wholeness actually made of things and materials and has shape, context, and color; the set of these factors define environmental character (Norberg-Schulz, 1993), which is in fact considered place-identity.

Place-loving is also a term used by phenomenological geographers, equivalent to sense of place. Tuan has used this term instead of sense of place and considers it a loving and effective link between people and places or camps (Tuan, 2001).

Place-loving is expressed from various aspects including aesthetic, sensory, or emotional. In fact, sense of belonging to a place is a higher level of sense of place and leads to the formation of a link between the individual and the place when the individual considers himself a part of the place and imagines a special character for the place based on his own symbols, signs, concepts, and operations of the place. This character is unique to this individual, so the place becomes important and respectable in his mind (Falahat, 2006).

Setha Low believes place-belonging is among aspects of identity and psychological interpretation. In psychology, place-belonging is a cognitive relationship with a place in a particular space or environment and is defined, in terms of identity, as the spatial relationship of the individual to the social environment in which that person lives. Thus, place attachment is a base for the individual's and the group's comprehension of the environment and often happens in cultural places (Altman & Low, 1992).

In a lot of places, the relation between the individual and space doesn't happen through experience. Place-belonging toward mythical places unexperienced by human can be formed as previous social concepts and therefore perceived political ones (Richardson, 1963).

On the other hand, positivism and critical approaches emphasize how social, cultural, and gender differences impact humans in the formation of sense of place (Messy, 1994). This represents the interaction between the individual and social values, attitude, and sense of place (Falahat, 2006). Sense of place is a sense that one makes as a result of an event or tradition and holds it within himself with a sense of recovery and re-reading the events (Jackson, 1994).

In today's interpretations, the sense of place is something that people create in a particular time period and thereby create custom and repetitive events where feelings describe the environment. Some places

have such a sense of attraction that give the individual an indescribable feeling and make him eager and willing to go back, which is called sense of place (Falahat, 2006).

3.4. Different Levels of Sense of Place

Shamai (1991) determines seven levels for the three steps of sense of belonging to a place, attachment to a place, and obligation to a place. These levels of sense of place indicate the application of the sense of place process that include indifference to the place, awareness of the place, attachment to the place, becoming as one with the targets of the place, and a sense of dedication to the place.

3.5. Place-making

Place-making is a people-centered approach to planning, design, and management of public spaces. In simpler words, it includes watching and looking to the environment and questioning people who live, work, or play in a particular space, with the goal of discovering their requests and needs. Then, this information is used to create a shared vision for the site. Outlook can help evolve strategies for public spaces and the people who use them (Seamon, 1996).

4. METHODOLOGY

The method of this research is descriptive-analytical and the required information was gathered using library studies and documents researched concerning the topic. Data was collected through a questionnaire. The research was conducted in spring and late May. The study population referred to all citizens of the city of Sanandaj, including both genders, visiting Jeloabad (forecourt) of Khosroabad. Required sample of the population was 100 people who were mostly between 18-35 years of age, but the ages over 60 years and even 90 years have been among the respondents with a low percentage. The study consisted of three phases of gathering information, data processing (data entry to SPSS), and data analysis using SPSS software and Cronbach's Alpha. It should be noted that the technique used was survey and the data has been collected by a questionnaire. Survey technique helps researchers to collect very extensive data about the beliefs, values, attitudes, and actions and contribute to the progress of research through descriptions, definition, and exploration of the phenomena.

5. FINDINGS

5.1. Case Study

The current urban context of Sanandaj goes back to the Safavid reign of Suleiman Khan Ardalan (1046 AH) in Kurdistan, Iran. Sanandaj is a mountainous city and has been expanded among hills. After street plumbing in the Reza Shah era and development of urbanization in the 1960s and 1970s, many buildings and urban spaces such as markets, governmental citadel, residential buildings, and even mosques lost their primary structure (Ghasri, 2009). Among these was the Khosroabad mansion, which is one of the largest and oldest Iranian gardens, placed in the suburbs of Sanandaj, between Mount Abidar and Qtarchyan neighborhood

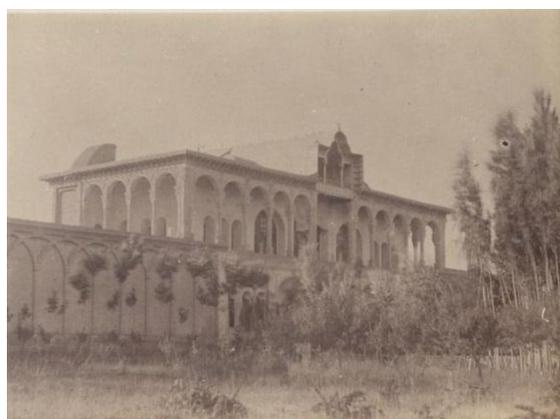


FIGURE 1 - FORECOURT SPACE OF THE KHOSROABAD MANSION-1883(SOURCE:GHASRI)

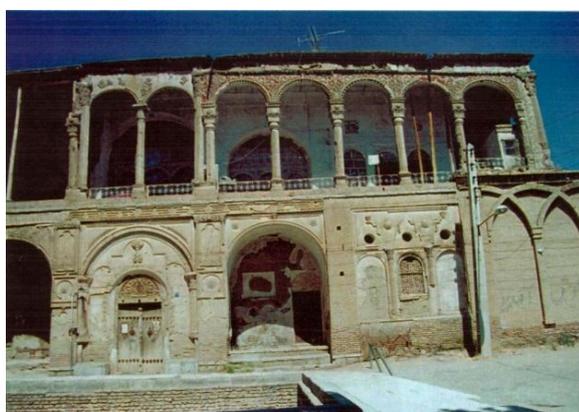


FIGURE 2 - FORECOURT SPACE OF THE KHOSROABAD MANSION AND WEAR MANSION-DAMAGED GARDEN AND OUTWEAR OF SURROUNDING AREA (SOURCE: GHASRI)

The Chaharbagh of Khosroabad turned into the residential neighborhood of Khosroabad which's most inhabitants were educated and cultured people. In recent decades, plans for the restoration of cultural

heritage, which is owned by the National Heritage, have been performed and recorded in this location. The presence of elements such as a historic old building, old trees, a pond, and the river in the Forecourt space contributes to the vitality of the place. In addition, sitting spaces in old-settlement form, porches, stairs, and platforms, as well as lawns and ancient trees' shadows cause people to turn to this place. With the unfinished and incomplete repairs, this place has been converted from a local space into an urban promenade.

The research findings were in form of observations and field work and are presented in two ways:

1. Field observations in the studied site
2. Questionnaires handed to those visiting the place

5.2. Field observations in the studied site

The observations which cover the last three years, indicate that through time renovating the building, flowing water in the waterways and the pond in the mansion's Forecourt, refurbishing the floor, and organizing the green space of the Forecourt, has practically created hangouts for people in different ages and has increased the presence of passengers in the place as well. This space has turned into a place for fun and spending time throughout a year and especially in spring and summer afternoons, when people from all parts of the city come to visit it. By observing the behavior of visitors and their answers to the questionnaire, people's sense to this place can be felt. This sense of belonging is rooted in the identity and history of this site and citizens' presence in this place may be regarded as a search for identity.



FIGURE 4 - PEOPLE WELCOMING THE SPACE (SOURCE: AUTHOR)



FIGURE 5-PEOPLE WELCOMING THE SPACE (SOURCE: AUTHOR)

5.3. Questionnaires handed to those visiting the place

The second part of the research findings was derived from questionnaires handed to people visiting the place. In this questionnaire, it has been tried to identify the features and elements that made people want to be present in this place. In this regard, the questionnaires were given to diverse individuals including men and women of all ages with different professions and education to ensure an appropriate sample was tested.

The questionnaires were analyzed with the SPSS software and the final results are shown in the tables.

5.3.1. Questions

1. What do you think has made this place attractive?
2. 2.Which of the following activities is usually the reason for you to be present in this place?
3. Do you feel safe in this place? Which of the following factors is a cause of security?
4. Which of the following activities do you welcome in this place?

TABLE1 - RESULTS OF FIRST QUESTION

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Historic and old buildings	37	32.1	32.1	96.2
	Green spaces and old trees	23	31.0	31.0	31.0
	Water element (as the pond and stream...)	26	23.0	23.0	92.7
	Space for sitting, such as platforms, ladders, old-settlement... ,	8	3.0	3.0	32.0
	Neighborhood and surrounding space context	6	12.0	12.0	100.0
	Total	100	100.0	100.0	

TABLE 2 - RESULTS OF SECOND QUESTION

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Spending time and enjoying the atmosphere of this place	23	38.1	38.1	19.5
	A place to hang out with friends	29	32.2	32.2	46.3
	Resting	35	16.1	16.1	80.5
	Visiting old and historic buildings	23	15.3	15.3	100.0

TABLE3 - RESULTS OF THIRD QUESTION

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Context and neighborhood	24	21.2	21.2	24.2
	movements of local people throughout the day	21	17.2	17.2	46.3
	Lighting of the place	25	15.3	15.3	73.2
	Residential buildings around the place	19	25.4	25.4	92.7
	kind of people visiting the place	11	22.1	22.1	100.0
	Total	100	100.0	100.0	

TABLE 4- RESULTS OF FORTH QUESTION

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Convention and meeting space (communication)	17	42.3	42.3	82.3
	Sports space	13	6.2	6.2	29.3
	Ritual and cultural space	18	18.4	18.4	46.3
	Children's playing area	32	8.5	8.5	28.8
	Artistic space	20	26.4	26.4	100.0
	Total	100	100.0	100.0	

5.3.1. Visitors' motivations for visiting this place:

The surveys demonstrate that features such as history, trees, the vital element of water, and peace and quiet in this place are the most important ones to attract people. Spending time, enjoying the atmosphere, and meeting friends construct the main activities of this place for people (table 1 &2).

5.3.2. Factors affecting the sense of security:

Security in public space is considered as a vital criteria and necessary for people to have sense of place. Based on table 4, residential buildings around the place, were realized as the most important factor that provide sense of security as it has been mentioned by 25.4 % of the people. 22.1% have stated feeling secure relies on the kind of people who visits there; 21.2% have considered "The context of the neighborhood" as the main factor affecting the security; and only 17.2% and 15.3% of surveys related it to the movements of local people throughout the day and lighting at night respectively.

5.3.3. Deficiencies that make people reluctant to be present in the place:

The most important defects of this place were lack of urban furniture, landscaping, and suitable space for sitting. The lack of proper tourist facilities such as small business units and catering units are also among those mentioned. Furthermore, convention and meeting spaces, artistic and ritual ones, and cultural spaces in order of significance are spaces where their existence is so vital for the satisfaction of the sense of place from people's view point. Some people complained about lack of decorative and artistic elements in historic places with original architectural value. It seems that lack of these spaces and their related features caused a real damage to the sense of place for this mansion. This view states a need to improve the quality of the location for the users.

5.3.4. The comparison of people's apprehension from the feeling of place in two famous spaces of Sanandaj with different specifics:

A part of the questionnaire was to compare the vitality of two different areas, the Khosroabad mansion, placed in the city with a direct relation to the people's daily life space, and the Abidar Forest Park. Common features of both of these places are being popular among people as well as being identity-based in the minds of the people of the town. But this place is quite different from the Khosroabad mansion in terms of physical and identity structure in many ways. For this reason, different behavior patterns of people visiting the places can be seen.

In studying people's answer to the comparing questions, more than half of them (%58) have had a pleasant experience in Khosroabad and have felt far more peace and quiet in this space comparing to the Abidar park. %12 of people stated the Abidar Park was more desirable in terms of the sense of space due to its natural features. But %17 of people have considered the two places completely different because of different behavioral patterns, and mentioned that both were desirable to fulfill a part of spiritual and physical needs. Factors such as cultured residential neighborhood was among factors of safety for passengers of the Forecourt of Khosroabad. People visiting this place welcomed its change to a place of communication and gathering in the form of an artistic place.

6. CONCLUSIONS AND RECOMMENDATIONS

At the beginning of the study the researchers were in search of the cause of attraction of an urban space considering its various features. It was found that in the Khosroabad Forecourt nothing but elements such as waterways and ponds, green spaces, and peace and prosperity attract people. If we omit the historical-cultural features of this space, it can be recreated by water and green space and

generally landscape design anywhere in the city. But what distinguish the Khosroabad Forecourt from the designed urban spaces, are its cultural-historical features rooted in the mental imagery of people, the sense of belonging to this place, and the sense of place. However, the need to improve the quality of this place can be felt.

Installing urban furniture, landscaping, and defining some complementary activities in the areas are factors that contribute to the matter. The number of such spaces with potential to turn into an urban space with identity is not few in Iran and they only need to be identified; their deficiencies to be detected and resolved.

The study indicated that to create a place, factors that distinguish it from other places should be emphasized and different aspects of a landscape in one place should be realized and consolidated.

According to the study's progress, these distinctions in the Khosroabad Forecourt include peace and quiet, greenness and freshness, and the nice feeling of seeing the water and hearing its sound, which become more impactful due to the history of the mansion and its surrounding context.

By the existence of this mansion in the downtown, the feeling of security indicated by people/survey would be provided. Furthermore, the chance of creating a place would be available for the people routine life in the city. The result of the survey on the comparison of the Khosroabad mansion as an urban place and the Abider Park as an outer natural landscape would definitely accept this issue.

Meanwhile, an effort to fix the defects of this place leads to solutions such as creating the space applications required by the various visitors of different ages. Applications such as museums of documents and historic objects in Sanandaj in the Khosroabad mansion (after full restoration), galleries for display and sale of art objects, catering units and sanitation, along with furniture and urban equipment, suitable landscaping, and creating path improve the quality of space and will cause the Khosroabad Forecourt to become a unique urban space in Sanandaj.

Renovating the building and its historic neighborhood, landscaping, and installing furniture and equipment around the city to create an atmosphere of communication and meeting, as well as preventing the entry of private cars in the area, are of the necessary measures in the people's opinion. Also organizing local movements and imposing restrictions for residents and tourists in the neighborhood are the other proposals. According to some experts, preventing the creation of non-historical spaces and expanding the atmosphere of communication both in the physical dimensions of space and the functional ones are necessary.

It should be noted that this strategy must not make this historic site to lose its identity. Therefore, elimination of deficiencies and creating the required applications must be deliberate and conscious. The prevention of environmental and sound pollution is in fact maintaining the sense of place. Tourist reception management, promoting its historical and cultural identity and saving its peace and quiet, will prevent its degeneration to a typical bustling downtown resort.

REFERENCES

- Altman, L., & Low, S. (1992). *Place attachment(Human Behavior and Environment)*. New York: Springer US.
- Canter, D. (1977). *The psychology of place*. London: Architectural Press.
- Falahat, M. (2006). The concept of the sense of place and the factors forming it. *Honar-ha-ye-Ziba (Architecture and urbanism)*, 26, 57-67.
- Ghasri, M. (2008). *Emra Ardala*. Office of Municipal Studies of Sanandaj. Sanandaj: Chapavol.
- Habibi, R. (2008). Mental images and sense of place. *Honar-ha-ye-Ziba*, 35, 39-50.
- Heath, T., Oc, T., & Tiesdell, S. (2013). *Revitalising historic urban quarters*. New York: Routledge.
- Hummon, D. M. (1992). *Community attachment*. In *Place attachment*. New York: Springer US.
- Jackson, J. B. (1994). *A sense of place, a sense of time*. New Haven:Yale University Press.
- Kalali, P., & Modiri, A. (2012). Explaining the role of concept in the process of formation of the sense of place. *Honar-ha-ye-Ziba (Architecture and urbanism)*, 50, 43-53.
- Mahmudi Nejad, H., & Bemanian, M. (2008). *Phenomenology of place, to the promotion of space in the urban area*. Tehran: Municipalities and Organizations Publications.
- Massey, D. (1994). *Place, space and gender*. Minneapolis: University of Minnesota.
- Mohammad, N. M. N., Saruwono, M., Said, S. Y., & Hariri, W. A. H. W. (2013). A sense of place within the landscape in cultural settings. *Procedia-Social and Behavioral Sciences*, 105, 506-512.
- Mowla, Q. A. (2004). Memory association in place making: understanding an urban space. *Memory*. 9, 52-54.
- Norberg-Schulz, C. (1974). *Meaning in western architecture*. Santa Barbara, CA: Praeger Publishers.
- Othman, S., Nishimura, Y., & Kubota, A. (2013). Memory association in place making: a review. *Procedia-Social and Behavioral Sciences*, 85, 554-563.
- Parsaee, M., Parva, M., & Karimi, B. (2015). Space and place concepts analysis based on semiology approach in residential architecture: The case study of traditional city of Bushehr, Iran. *HBRC Journal*, 11 (3), 368-383.
- Rapoport, A. (1982). *The meaning of the built environment: A nonverbal communication approach*. Tucson: University of Arizona Press.
- Rolph, E. (2008). *Place and placelessness*. London: SAGE.

- Richardson, W. J. (2013). *Heidegger: Through phenomenology to thought*. Rotterdam: Springer Netherlands.
- Saar, M., & Palang, H. (2009). The dimensions of place meanings. *Living reviews in landscape research*, 3(3), 5-24.
- Seamon, D. (1982). The phenomenological contribution to environmental psychology. *Journal of environmental psychology*, 2(2), 119-140.
- Seamon, D. (1996). A singular impact: Edward Relph's place and placelessness. *Environmental & Architectural Phenomenology Newsletter*, 7(3), 5-8.
- Shamai, S. (1991). Sense of place: An empirical measurement. *Geoforum*, 22(3), 347-358.
- Steele, F. (1981). *The sense of place*. Boston, Mass: CBI Publishing Company, Inc.
- Tuan, Y. F. (1977). *Space and place: The perspective of experience*. Minneapolis: University of Minnesota Press.
- Ujang, N., & Zakariya, K. (2015). The notion of place, place meaning and identity in urban regeneration. *Procedia-Social and Behavioral Sciences*, 170, 709-717.
- Zakariya, K., Harun, N. Z., & Mansor, M. (2015). Place Meaning of the Historic Square as Tourism Attraction and Community Leisure Space. *Procedia-Social and Behavioral Sciences*, 202, 477-486.