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ANALYSIS OF SOCIAL SUSTAINABILITY SIMULATION OF RASHT'S CENTRAL PEDESTRIAN ZONE USING THE SPACE SYNTAX METHOD

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Abstract

In order to have the sufficient value and credibility, sustainability in city should involve social aspects as well. The concept of social sustainability is usually accompanied with qualitative aspects and is evaluated by concepts like human life and feeling of well-being. Social sustainability could eventually be considered as improvement of living conditions and the process by which societies reach the highest quality of social life. The main goal of this research is analyzing social sustainability of Rasht's central pedestrian zone using space syntax method, in order to study the city's configuration in terms of accessibility, security and readability. Space syntax includes using the variables obtained from the analysis of space configuration in understanding different geometrical elements patterns which have been created because of buildings and cities. The main purpose of space syntax is the relationship between human and the spaces in which he resides. This research is conducted using descriptive-analytical method and is based on data nature of the hybrid type. In the research's theoretical framework, studies gathering tools have been used in library form, utilizing documents and field operations including survey and direct observation, and analytical and quantitative method has been used in studying spaces.

INTRODUCTION

Despite incoherent hints which some thinkers have made in the past like Schumacher (2011), sustainable development is one of mankind's newest dreams that has been subject to countless arguments and controversies since its birth in 1977, yet these arguments are usually directed towards its executive aspects, indicators, procedures and mechanisms in different countries and few people have doubted its necessity principle. Sustainable development refers to the process which is the basis of improvement of situation and the destroyer of

environmental, social, economic and cultural shortcomings. The development which involves all of society equally, and meanwhile doesn't harm the environment. The mentioned process is based on right and effective utilization of natural, financial and human resources in order to fulfill today's generation's needs in such a way that the future generation wouldn't be in distress (VaezZade et al. 2015).

In the past two decades, the concept of social sustainability has become one of new models of development and has been combined with social, economic, environmental and political aspects of development. The social system's social sustainability means improvement of living quality, development of human resources and self-sufficiency of local societies in facing internal challenges and issues and reacting to external changes and managing and maintaining the values (Nastaran & H. Zargar, 2013), so that the European Union in Lisbon in 2000 defined social issues as an inseparable part of development models for the first time. (Samuelsson et al. 2004).

What is nowadays seen as sustainable or unsustainable development in societies is considered the result of the desire and will of different structures of power, economy and culture in society, therefore, it could be concluded that the effect of social factors in establishing sustainable development is very important and effective. Because of providing the basis of improvement in other fields of sustainable development, social sustainability studies are considered appropriate tools for the researchers and politicians for urban planning and policy making (Hugh, 2000).

The use of the space syntax method is basically for evaluating the ability of the suggested plans in fulfilling the plan's required items including creation, direction and prediction of movement throughout the city. Therefore, the movement pattern or distribution of applications in the city's status quo could be identified using this method and the intended patterns could be predicted in the suggested plans on this basis to ensure the efficiency of the suggested plans (Bafna & Shpuza, 2004, 2peponis). In order to predict the movement of the pedestrian, space syntax method could be used to identify the most accessible and most separated routes to direct and manage the pedestrian's movement efficiently (B.jiang, Claramunt & Batty, 1999, 2Aabubakar & Aina, 2006).

The main purpose of this research is the analysis of social sustainability of Rasht city's central pedestrian zone using the space syntax method, which has first dealt with gathering basic information regarding the keywords, and then, the vitality of the pedestrian zone will be analyzed using the Space Syntax software.

THEORETICAL FOUNDATIONS
Social Sustainability
Social sustainability discussions were first included in the sustainable development discussions framework in late 1990s, but was considered as an inseparable part of sustainable development models (Colantonio and Shiers, 2007) after Agenda 21 and the Lisbon Strategy in 2000 and was considered as

a special topic in sustainable development studies after the EU Summit in Guttenberg in 2001 (Samuelsson and Azar, 2004). The concept of social sustainability was formed in disagreement and criticism of some theorists and pundits regarding the modernism approach. These theories first started forming from philosophy and then entered urban planning and architecture in a gradual course. Rogers defines sustainable design as a type of design that satisfies today's needs without harming the future generations' resources. "In sustainable design, social and economic sustainability must be emphasized as much as energy consumption and buildings and cities' environmental effect (Rogers, 2005). In social sustainability's definition, John Lang points out people's desire to live in one place and emphasizes on the ability of continuing such procedure both now and in the future (Lang, 2004). Social sustainability combines political and social principles with issues related to participation, happiness, welfare, living quality, etc. Therefore, the concept of sustainability requires a physio-social network (Zarghami, 2008). Generally, social sustainability is evaluated with its main concept (stability and survival) which includes securing better living conditions in which balance, harmony, desirability and fair equality (or the settings required for living with health, security, peace, exhilaration, creativity and beauty) emerge.

Space Syntax Method

But what is space syntax? Space syntax includes utilizing the variables obtained from analyzing spatial configuration in understanding different geometrical elements patterns which are created because of buildings and cities (Abbas Zadegan, 66, 2002). These geometrical elements could be a line, a convex space or a point according to the analyzed space's type. In this regard, space syntax has been developed based on two presumptions. The first presumption is that space isn't regarded as a platform activity, rather as an inherent characteristic of it. Therefore, the movement occurs in a linear space and social interactions in a convex space and also the audience's visual range are defined according to his movement and change of viewing angle. Each of these geometric ideas have the ability of our activity in the space. The second presumption in this method is that space characteristics aren't as important individually in forming the audience's behavior as much as the way they're combined with other spaces present in the system. This relationship is the same as spatial configuration which has been thoroughly explained above. In the next stage, space syntax method analyzes the combination of these spaces and how they're related by converting them to a graph. A series of normal variables are obtained by analyzing the created graphs. These variables don't have value in and of themselves; rather it's by the relationship that's formed between these variables and the available social qualities in the intended platform that this analysis gains value and converts to a tool for understanding the spatial structure. The main variables created from this process are integration and separation levels which could be used in understanding spatial and social structures. Therefore, the distribution of integration and separation values in the researched platform could provide the possibility of statistical and quantitative comparison in different spaces from different cultures, or in other words, it provides the possibility of quantitative analysis of social patterns which are usually qualitative (Hillier & Vaughan, 2007, 3).

In summary, space syntax is a series of computer techniques for modeling buildings and cities so that the created model is created from a system including geometrical elements related to each other and analyzing this system to understand how its ingredients are related. When the research is about movement, these elements are linear, and they're convex spaces when the research is on social interactions, they're visible limits when the research is about complex behavioral patterns (Hiller, 2004, 46). The important point is that the space syntax method isn't just a simple modeling tool, rather it's a method for understanding the city's complexities, the logic of morphology and its development patterns and understanding their behavioral patterns (Hiller et al., 1993, 32). Space syntax is a method for understanding spatial configuration in such a way that the logic of their creating social factors is recognizable as well (Hiller & Vaughan, 2007, 2). Using this method results in different variables that are obtained from graphic analyses and multiple maps that show the distribution pattern of these variables throughout the city or building.

Connection

The most obvious analysis parameter is morphologic. In fact, the practical concept of connection is defined as a number of knots which are directly connected to each individual knot in the connection graph. Therefore, The above mathematical equation will be:

$$C_i = k \quad (1)$$

in which K is the number of knots which are directly connected (Asami et al., 2003, 2)

The connection parameter in the city's spatial analysis depends on the accessibility to the urban spaces.

Depth

The concept of "depth" could be a number of stages which is defined as a knot to all the other knots. In this case, it is said that the knot is deep if there are many stages to separate it from other knots. In contrast, it is said that the knot is shallow if few stages separate it from other knots. Depth isn't an independent parameter from spatial configuration, yet it is an important parameter for calculating the knot's integration. If i and j are in graph G, therefore the knot i's total depth is equal to the sum of distances. Therefore, according to its definition, the mean depth parameter (MD) is calculated as follows, where n is the total number of the graph's knots:

$$MD_i = \frac{\sum_{i=1}^{n} d_m}{n-1} \quad (2)$$

The increase of the total depth states significant physical progress of the city which is accompanied with the increase of neighborhood units at the sides. In fact, the increase of the total depth means the increase of the number of transitional spaces to reach the intended spaces. This fact can state that the city

has come out of the single core state and is transformed to the multi core city (Asami et al.).

Integration

Integration is a value that shows a degree of a city's connection or separation from the overall system (total integration) or a part of the system (Asami et al., 2003, 2). It is told that a small scale space is more integrated if other spaces can access it after travelling through a few middle spaces. A space is less integrated if the number of required middle spaces increases. This idea is calculated by total integration. Integration can be calculated based on mean depth as well (Igbal, S., 2010, 13).

$$\frac{\left\{ k \left\{ \log_2 \left(\frac{k+2}{3} \right) - 1 \right\} + 1 \right\} \Big/ (k-1)}{MD - 1} \qquad (3)$$

Control Value

This value states the selection degree for the knots which are directly connected to it. The control value could be defined as the relative power of the axial line in potential absorption from its closest neighborhood (Asami et al., 2003, 2). In fact, control matches the variable surface which each knot provides for the knots to which a diameter is connected. Therefore, the knot i's control value is obtained as follows:

$$\mathrm{Ctrl} = \sum - \qquad (4)$$

Selectivity

It's the spaces with the highest collecting value. In fact, it dedicates space to a degree of selection in which many of the shortest communication paths are in that space ()Alitajer & Molavi Nojoumi, 2016; Jiang, Claramunt, & Klarqvist, 2000; Lima, 2001). In other words, it could be said that selection is defined as a dynamic universal scale from the flow inside a space. A space has a high selection value, when a large number of the shortest paths which connect all the spaces to all the spaces within a system pass through it (Klarqvist, 1993).

RESEARCH METHOD

In general, this research's method is descriptive-analytical, and is of hybrid type based on the data's nature. In the research's theoretical framework, studies gathering tools have been used in library form, utilizing documents and field operations including survey and direct observation, and analytical and quantitative method has been used in studying spaces. UCI Depthmap version 10.08.00 has been used in this paper. Having been developed by Turner (Igbal S., 2010, 20), this software has the ability to analyze in different scales whether a house or a city based on spatial parameters. According to Chart 1, only readability, security and accessibility have been studied among vitality indicators at the micro level.
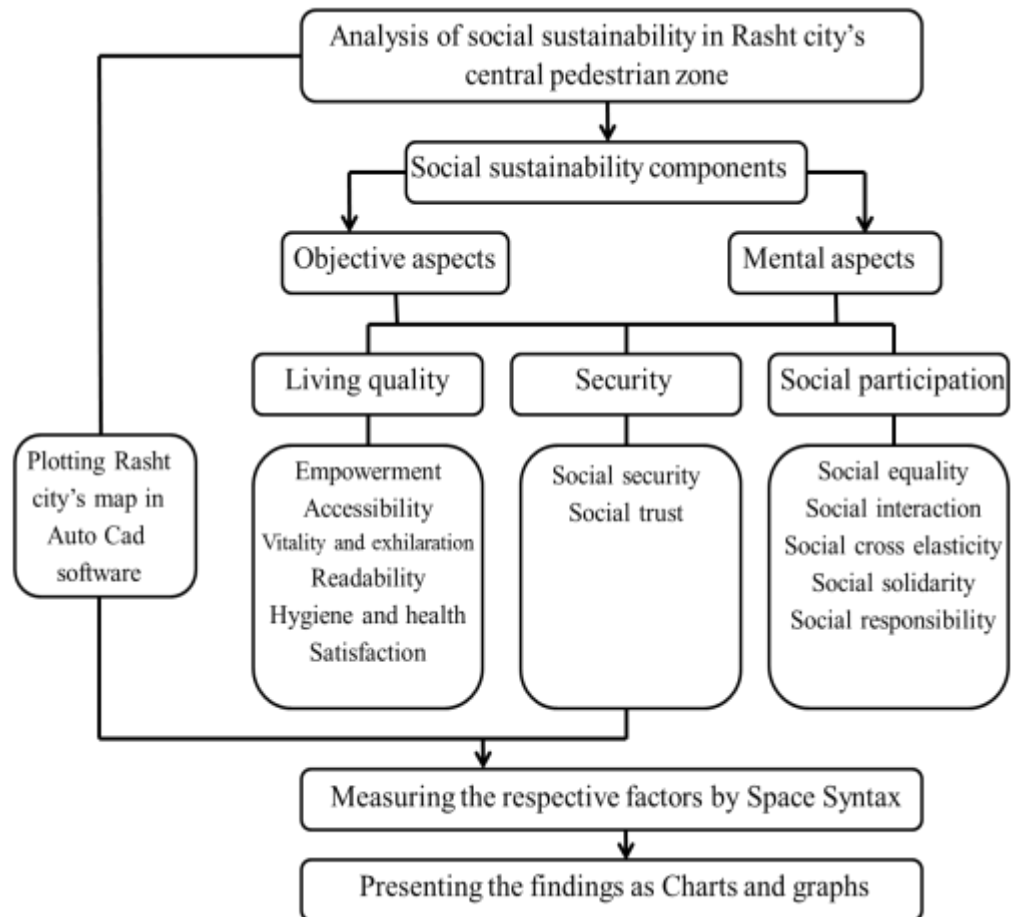
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│  Rasht city's central pedestrian zone     │
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         ┌──────────────────────────┐
         │ Social sustainability    │
         │      components          │
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Living quality	Security	Social participation
Empowerment Accessibility Vitality and exhilaration Readability Hygiene and health Satisfaction	Social security Social trust	Social equality Social interaction Social cross elasticity Social solidarity Social responsibility

Plotting Rasht city's map in Auto Cad software

Measuring the respective factors by Space Syntax

Presenting the findings as Charts and graphs

Illustration of Chart 1 – Social Sustainability Conceptual Chart

First, after field surveys, the intended have been plotted maps using Auto Cad software, so that they've become the three kilometer radius of the city for the central pedestrian zone. Then, some of the required indicators which include the ability of connection, integration, selection, depth and control value have been studied and analyzed using the Depth Map software. The basis of this theory is the calculation of the city's structural model using the graph theory. Space syntax analysis is based on the axial map which usually reveal the urban streets' network and includes few of the long and short axes (Hiller & Vaughan, 2007).

Case Study Introduction
Rasht is located in 49° and 36' by east, 37° and 16' by north and 300 kilometers from Tehran. Also, with a 180 square kilometers area, Rasht is sitting on a plain field at an average altitude of 5 meters above sea level. The Alborz mountain range is located south of Rasht city. The closest city to Rasht is Sowme'eh Sara, which is 26 kilometers away from it. Rasht is surrounded by the Caspian Sea and Anzali Lagoon from north, Pasikhan River, Sowme'eh Sara and Fuman from west, Sangar District and Rudbar County from south and Kuchesfahan and Astaneh-ye Ashrafieh from east. Rasht City has five municipal districts, each of which are divided to three zones. 8.3 kilometers long, Rasht City's central pedestrian zone includes the main Shohadaye Zahab (Municipality) square, A'lam-ol Hoda street and parts of Imam Khomeini and Sa'di streets.
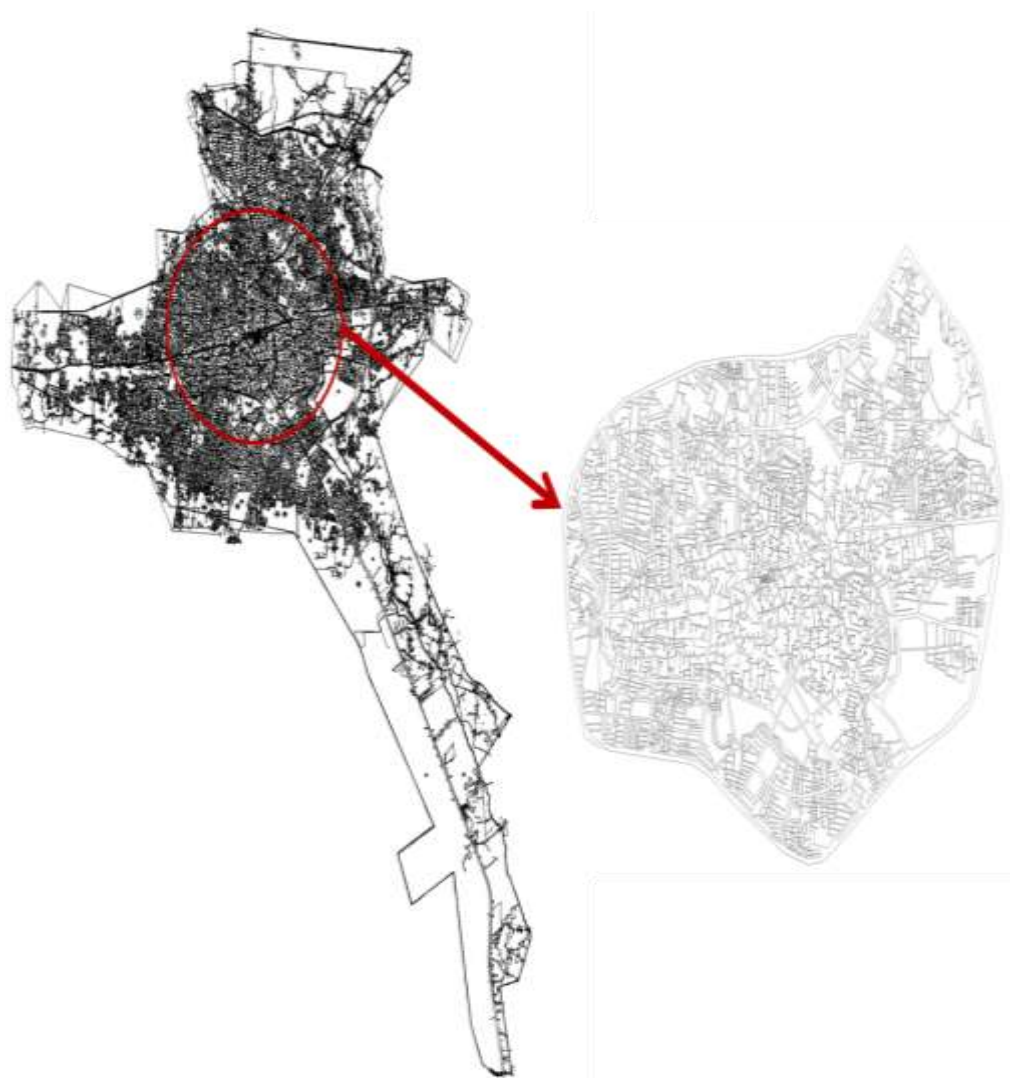
Figure 2 Rasht Map and Study Range

According to the role of the pedestrian in the study range and analyzing the pedestrians' vitality, first, this theory's spatial parameters are calculated in each period according to the space syntax method, and then they're compared to each other. These parameters must be evaluated in terms of urban space configuration in general and local scales. Based on this, the three kilometer radius from the pedestrian zone was taken and analyzed.

RESULTS AND DISCUSSION
Results using Simulation by Space Syntax Software
One of the vital issues in this research is using the city map for accuracy in understanding the urban spatial structure and creating urban spatial structure. With this goal, first import the city map to Depth Map software, and then, linear maps for analyzing Rasht City's structure are obtained using related techniques.

Figure 3 The Analysis of Accessibility

Figure 4 Analysis of Rasht's Pedestrian Zone's Accessibility

To study accessibility after the analysis related to this variable, accessibility maps with different color spectra are obtained, such that dark red is the highest and dark blue is the lowest accessibility. Now, according to figure 3, it can be said that Imam Khomeini, Shariati and A'lam-ol Hoda streets have the red color spectrum, which could be said that they're on the first color spectrum, and also part of streets with the highest accessibility. Lakani street which is located left of Sabzeh Meydan has orange color spectrum which indicates accessibility. At top of the pedestrian zone, there's Sa'di street with orange color spectrum. Generally, it's safe to say that in this zone, according to the colors with red and yellow and orange color spectra, accessibility is relatively high.

Security is also one of urban vitality's important subsets. To study security, we use the Selectivity variable.
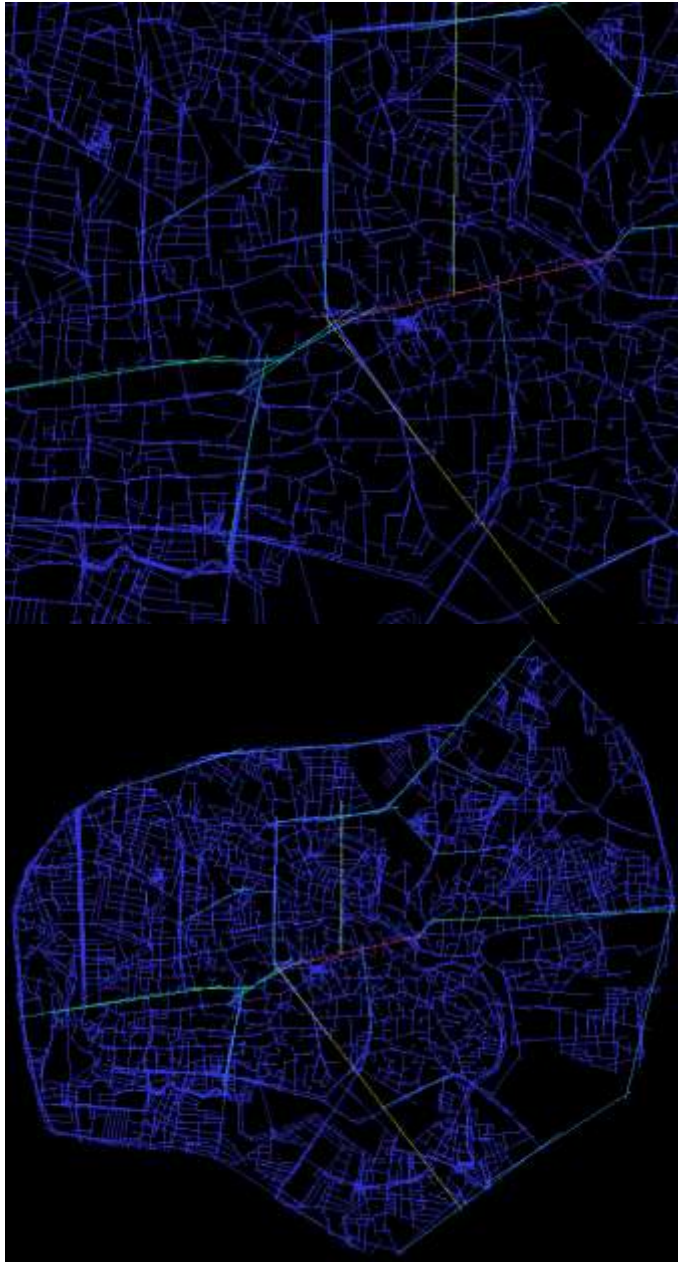

Figure 5 The Analysis Related to Selectivity in Rasht City's Central Pedestrian Zone

According to the analysis related to Selectivity, it could be found out that Shariati street has the highest selectivity and after that, Sa'di and Imam Khomeini have the highest selectivity, respectively relative to other parts of the city. As a result, according to figure 4, it could be said that this zone is located at an important part of the city.

In this study, the last variable related to social sustainability is readability. To study readability, the relationship between connectivity and integration must be studied.
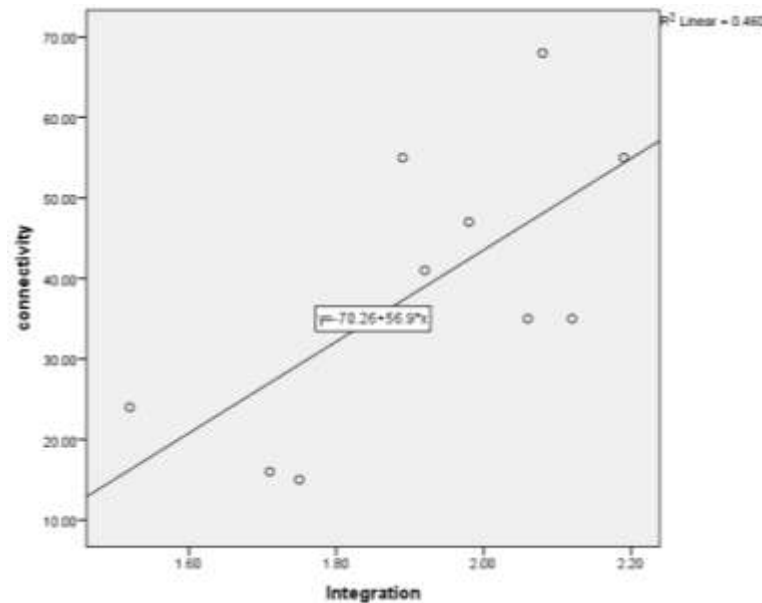
Figure 6 Connectivity and Integration Scatterplot

As it is seen at figure 6, and according to the R2 number which is 0.460, it could be concluded that this relationship isn't very strong and therefore, there's no significant readability in this zone.

All of the numbers related to the intended variables could be seen and studied at table 1. As you can see, Shariati street, Sa'di street, A'lam-ol Hoda street and Imam Khomeini street have the highest accessibility (integration). Also, Shariati, Imam Khomeini, Takhti and Lakani streets have the highest connectivity and selectivity.

Table 1 The Characteristics of the Streets Located in Rasht's Central Pedestrian Zone

Number	Street name	Connectivity	Integration (HH)	Integration (R2)	Integration (R3)	Selectivity
1	Shariati	55	2.19	6.95	4.41	5745770
2	Sa'di street	35	2.06	6.00	4.06	802294
3	Imam Khomeini street	68	2.08	7.34	4.63	3510880
4	A'lam-ol Hoda street	35	2.12	5.51	4.09	1872470
5	Lakani street	55	1.89	7.04	4.36	508860
6	Bistoon street	41	1.92	6.42	4.17	2411830
7	Haji Abad street	15	1.75	4.98	3.61	84590
8	Takhti street	47	1.98	6.69	4.20	3008400
9	Motahhari street	24	1.52	5.39	3.69	641031
10	Moallem street	16	1.71	4.78	3.30	756287

Results Using Gate Observation at Rasht's Central Pedestrian Zone and comparing it to the Simulation Method

Calculating pedestrian density at the central pedestrian zone was studied in one week and on the two days of Saturday and Thursday and at the same times, and then this density was compared to the simulation of the pedestrian zone.

Figure 7 The Locations of the Gates to Detect the Density of Pedestrians at Rasht's Central Pedestrian Zone

Generally, 22 gates were selected to study this area according to the pedestrian zone's main arteries. Pedestrian traffic at each gate was measured in a 3 minute period from 11 to 13. Based on the average number of people measured, the heaviest traffic occurred at gates 1 and 2 in Imam street and gates 9 and 10 located in Shariati street. Presence of the city's old bazaar which is located in this area is among the causes of the heavy traffic at these gates. Imam Khomeini Street and Shariati Street are the most important streets located in the pedestrian zone. The diagram related to the changes in pedestrian traffic at the beginning and end of the week are illustrated in figure 8.
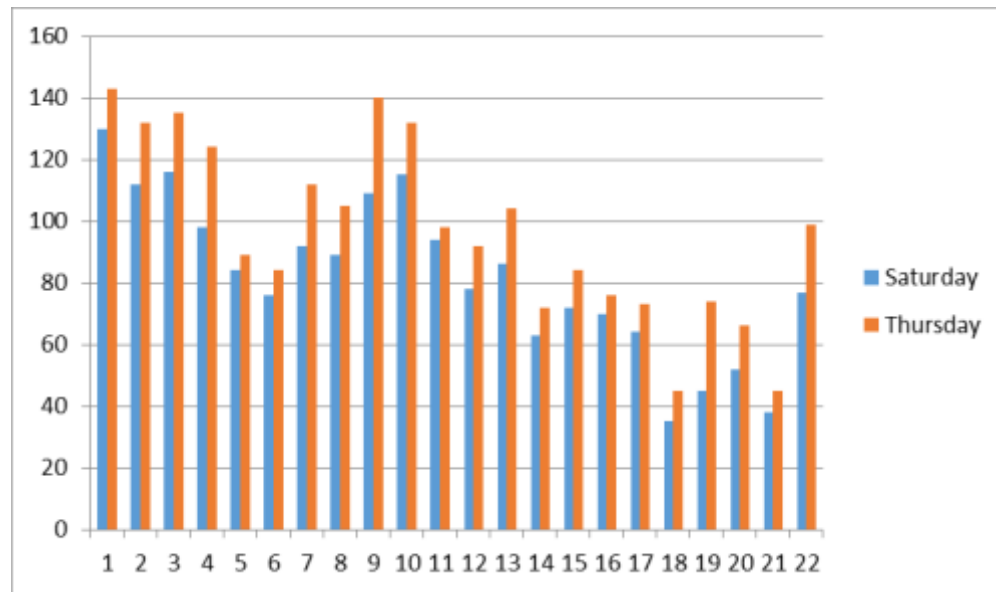
Figure 8 Comparison of the Pedestrians' Density Level at the Central Pedestrian Zone on the First and Last Days of the Week

According to figure 8, it could be concluded that the pedestrians' density level has been higher on the weekend than the beginning of the week.

Based on the simulated data and the axial analysis of this area (figures 3 and 4) and table 1, and the field observations, it could be concluded that Imam Khomeini Street at the south, Shariati Street at the east, Sa'di Street at the north, and also Bistoon and Lakani Streets have a very good accessibility. These reports show that these paths have the required potential for proper access towards the central pedestrian zone, and they could be considered as the main paths for accessing the pedestrian zone.

CONCLUSION

As it was stated before, social sustainability has a close relationship with every aspect of sustainability, and therefore, every aspect of urban sustainability including natural sustainability, physical sustainability, economic sustainability and political sustainability must be considered in studying social sustainability. It's obvious that no major has the ability, knowledge and skill to create such phenomenon on its own, but each major must contribute to the participation process. Therefore, social sustainability factors should be considered in designing urban spaces, so that people are encouraged to use these spaces with more desire. The goal of this study is to study the use of space syntax to analyze urban design, to be able to study the city's configuration in terms of accessibility, security and readability based on it. Therefore, the intended area was simulated using the Depth Map software. In this analysis, the axial lines or in other words the streets and alleys have a specific number which is specified with Ref. Number, and each of these lines has separate characteristics in terms of connectivity, general integration, local integration and selectivity (Figures 3, 4 and 5). All the numbers related to the simulation of Rasht City's central pedestrian zone are gathered in table 1. By analyzing and comparing the conducted simulation and gate observations, the hypothesis issued in this research could be answered, that this area, as an

economic and historic fabric as the major urban center helps the density of pedestrians in this area alongside multiple other factors including social and cultural factors.

According to the simulation studies (table 1) and field studies, it could be concluded that the central pedestrian zone has a high connectivity and connection to other streets are made through this zone, and it could be considered as the city's beating heart. In terms of accessibility, this zone can also be named as an artery which has a high accessibility and density. 2 and 3 integrations refer to this point, and due to selectivity, it could be emphasized that it has a high selectivity, which indicates security in this area. This study shows the architects and planners that sustainability and social components could be analyzed with simulation the right use of space syntax method. Also, local observations of environment affect the understanding of human behavior and are effective in deciding to improve the urban space.

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