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Original Article

Determining Density in the Historical Region with Space Syntax Analysis, Erzurum City Center Example

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ABSTRACT

The phenomenon of the expansion of cities due to population growth contributes to the shaping of the spaces they host and, in this way, to the differentiation of the urban fabric. With the expanding new cities, the accessibility of the old city can be affected in this process. Historical city centers, which have an important place in the development of the city, can form a source for the planned urban area design later on, by forming physical integrity with the existing texture and determining the urban spatial analysis methods, and it provides an opportunity to compare the old and new texture. The focus of this research is to determine the change of the route of the historical places in Erzurum City Center by comparing the present and past accessibility and integration depending on the expansion of the city. As a result of the spatial analysis made within the scope of the study, the integration of Ayaz Paşa (integration value 1124.5) and Menderes Avenues (1165.1), located at the intersection of Rüstem Paşa covered bazaar, which is important in the historically built area of the city, was found to be high. It is seen that the place, which has been a valuable commercial structure in the past and today, still has not lost its feature. The integration value of the inner core city wall area in the old Erzurum city center was found to be quite low. This situation clearly revealed how isolated and sheltered the inner city walls are. Again, it has been clearly emphasized that today's axes with high integration such as Cumhuriyet Caddesi (1215.0) and Menderes Caddesi have high integration like the axes that existed in the same places in the past and that they are especially lines that connect the historical built environment. It has been shown that expansion in this way affects accessibility positively while changing the spatial structure within the old city.

Keywords: Erzurum city, heat map, historical buildings, space syntax analysis, urban landscape

Introduction

Globalization seen in the world is trying to shape the living spaces by interfering with the economic and socio-cultural lives of societies. The consequences of this rapidly increasing situation greatly affect the identities of cities, from our living spaces to our cultural spaces and architecture (Alkamali et al., 2017; Çetin et al., 2020; Dawes et al., 2021; Montello, 2017). Cities have emerged as a product of the settlement styles of civilizations since societies settled down. In other words, the phenomenon of the city is a form in which elements witnessing many historical and cultural activities, situations, and events come together. The identity and image perception of the city are concepts that are especially visually prominent in terms of architectural structures and include the natural environment and socio-cultural life principles (Aleksandrowicz, 2019; Hillier, 2005; Kubat, 2016; Wang, 2012).

In short, together with the physical environment of the city, the social, economic, and cultural components of the city also constitute the urban identity. These components give meaning to the city by influencing the urban environment with their unique character and identity structures in the historical process. The most important places of cities that add a temporal dimension to their living spaces and gain identity are their historical surroundings. Historical city centers form the core of the city's foundation by providing information about the historical development of the city (Bozhüyük, 2007). The historical core of the city, in addition to hosting important places, also represents the cultural structure, socio-economic situation, and artistic understanding of the period (Ahunbay, 1996). Being able to accurately read the social, cultural, and economic structure occurring in the historical city center and perceive the urban texture are important in planning the development

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of the city correctly. A systematic analysis of the spatial characteristics of the building should be made by developing a mathematical model without harming the traditional values of the historical centers of this planning process.

Considering the origins of the disciplines in planning research, it seems that many spatial sequence researchers try to identify historical themes or perspectives in their work. As in the studies of Hillier (1973) and Hanson (1998), a special spatial configuration method that enables the comparative analysis of buildings and settlements in both space and space is proof of a more clear reading of the architectural knowledge of the building (Ascensão et al., 2019; Griffiths, 2012). Thus, researchers contribute to urban history from an interdisciplinary perspective on a large scale.

Today, research on the spatial characteristics of historical regions in the fields of architecture, landscape architecture, and urban design is largely based on users' environmental cognition information obtained through interviews, questionnaires, cognitive maps, and factor analysis (Dalton, 2001; Morales et al., 2017). The choices made in planning studies are the result of experience and continuous work. As a tool that has been developed and studied over the years, space syntax provides an efficient way to assist the planning process. D'Autilia and Spada (2018) emphasize that space syntax should be perceived as three-dimensional (3D), not two-dimensional (2D). For this reason, it is important to add the third dimension in the perception of the space, that is, in the perception of its visibility in urban space/architecture/green areas.

People perform their activities in places and gain experience (Tümertekin & Özgüç, 2002). Random combinations of structural elements form the sequence (Hillier & Hanson, 1984). Space syntax is defined as a model used in the analysis of space. The concept of space syntax is based on the principle of emphasizing the importance of urban topology in urban studies, activities associated with the use of open spaces, and especially for the movement of pedestrians (Hillier & Hanson, 1984; Xu, 2020). Moreover, its reformulation in terms of line theory has opened up new theoretical and usage perspectives associated with propagation processes in binary graphs. Shifting urban space from Euclidean geometry to connectivity has shown that a city is a tool for connecting urban phenomena. A particular space, for example, the location of commercial activities, can have different effects when created in different connected spaces (Porta et al., 2011). Among the many variables that define the behavior of a city, space syntax has taken into account almost purely spatial ones. Axis lines or sightlines are the core element of the model, the topology of which are variables conditioned by the shape of the city. In the graph formulation, these lines are represented by graph nodes, while where they intersect determines the edges of the graph (Morais, 2018). Space syntax methodology provides tools to analyze the linguistic features of space, namely configuration, visibility, and accessibility, and their functional relationships with the physical, social, and spiritual environment (Turner, 2001). Kim and Sohn (2002) defined visibility as representing the size of a space that is visually perceived by people and can also be called isovist (Vision Graph Analysis). According to Palaiologou and Griffiths (2019), space syntax is based on spatial systems and open space patterns that are structured by building clusters. This includes traditional approaches to the historic built environment of stylistic periodization, preferred for understanding the role of spatial configuration in generating space-time events. The role of physical space in enabling social life is the main focus of space syntax, and numerous studies have questioned this issue in the context of cities (as well as buildings). Space syntax research uses mathematical modeling tools and metrics that provide topological-geometric (describing changes in path direction and orientation) and metric (based on unit distance) attributes of spatial systems designed as networks and analyzed as graphs (Hillier & Iida, 2005).

In recent years, space syntax has also been widely used in urban open and green spaces. It is thought that spatial configuration studies can encourage activities in urban parks. Since these configuration features form a structure to accommodate elements such as reinforcements, squares and semi-open spaces in the urban fabric, they need to be determined at the first stage of the design. Therefore, quantitative analysis of the spatial sequence can contribute to the development of landscape designs and the use of open and green spaces. The distance, together with the calculated spatial elements, increases the accessibility of the parks. In this context, the space syntax approach can be used in future research to investigate other spatial parameters, including tree heights, colors, texture, and shape (Zhai & Baran, 2013). Activity areas are designed to accommodate people and do activities, similar to buildings in an urban environment, and road circulation is designed to have a similar purpose to a city street (Sheng et al., 2021). Dursun (2007), in his study to determine the effect of space syntax contribution on design choices, concluded that assisting design choices through "evidence-based design" can be an efficient method. Li et al. (2009) studied the spatial array with the addition of Building Information Modeling (BIM), which shows that users can use it to improve the design while evaluating the consequences and consequences of each choice.

Van Nes and Yamu (2021), in their study, made a detailed explanation about spatial elements by using the spatial arrangement method in the analysis of physical elements in urban areas. In addition, they revealed the differences between the internal and external features of urban spaces and clarified the typology concepts of the built form.

Mirmiran et al. (2021) aim to compare and analyze the spatial organization of modern houses in Roadstar, Iran, and to find their inefficiencies, thus eliminating location-behavior stresses by using a revision in the space syntax. For this reason, the empirical test method was used for the samples selected from the houses by using the UCL Depthmap software. Qualitative analysis on houses at three levels, namely the space-function, space-behavior, and space-form relationship, were examined. Then, three parameters, integration, connectivity, and depth, were used in quantitative analysis. The research findings show that the traditional house is built in harmony with the environment and the behavior system of the inhabitants, while the modern house has single-purpose spaces and it is not clear that it will meet different patterns of the modern space-behavior parameter.

Trif (2019) compared the urban incompatibilities between historical architecture and socialist architecture in Romanian cities with the space syntax method. In the study, the conservation strategies of historical and socialist spaces were discussed and an idea about urban ruptures was obtained. The article presented an advanced digital methodology for multi-criteria analysis to explore ways to identify and reconstruct urban cracks. In this way, the interventions that lead to the urban fragmentation of Romanian cities can be researched with computer-based methodology and solution proposals are developed.

In this study, Erzurum urban planning principles and historical place data were evaluated together, and the relationship between the

functional structuring features of the spaces that make up the historical texture of the city of Erzurum and the shaping features of the space was designed with the "space syntax" analysis method, which allows a comparative analysis between the spatial structuring features. This study aims to determine the broken relations between the parts of the city through the mathematical analysis of the results of human movements in the living spaces.

Material and Methods

Materials

Erzurum, which was founded in 4000 BC, is an old settlement. During the reign of Suleiman the Magnificent, one of the rulers of the Ottoman state, the city was reconstructed. (Anonymous, 2005). Located in the east of Turkey, this historical city has a surface area of 25,066 km^2 (URL-1, 2021) (Figure 1). According to 2020 TUIK (Turkish Statistical Institude) data, 348,156 people constitute the center of Erzurum (URL-2, 2021). The city shows continental climate characteristics (URL-1, 2021).

Erzurum, one of the most rooted cities of Anatolia, was established on a wide plain starting from the foot of Palandöken Mountain. The city has experienced important events in the economic, social, and political framework in the historical process and has come to the fore with its architectural structures. The settlement history of Erzurum, which is in a very important strategic position, dates back to ancient times. The social, political, and economic aspects of the city played an active role in the architectural structures built. Founded by the Byzantine Emperor Theodosios in the 5th century, the city has been the focal point of the Turkish-Islamic states, as it is located on trade routes. Finally, after the Battle of Manzikert, Erzurum was given to Ebu'l- Kasım Saltuk by Sultan Alp Arslan in 1071. After the collapse of the Anatolian Seljuk State, Erzurum remained under the rule of the Ilkhanids until 1336. The city later came under the rule of the Karakoyunlu, Akkoyunlu, and finally the Ottoman Empire. In the past, city squares were formed by the influence of population, socio-economic, human, and environmental factors as well as the points where roads meet. Especially, most of the historical buildings of Erzurum are gathered on the sides of the street in the east-west direction, which is now known as Cumhuriyet Caddesi. Erzurum Castle Masjid, Tepsi Minaret, Emir Saltuk Tomb, Üç Kümbetler and Ulu Mosque, built in Erzurum and located on Cumhuriyet Street, During the Saltuks Period, Double Minaret Madrasa, Yakutiye Madrasa, Cimcime Hatun Cupola, During the Ilkhanids, Lala Paşa Mosque, İbrahim Paşa Mosque, Caferiye Mosque, Rüstem Pasha Bazaar and Erzurum Castle were built during the Ottoman period (Çobanoğlu, 2001). Erzurum is one of the cities where a zoning plan was created with the proclamation of the republic. With the Lambert Plan in 1939, the historical city center of Erzurum was started to be placed in a formal structure. The change of the city in the historical process and the old zoning plans are important in understanding the spatial formation and planning approach of the city. The historical development of Erzurum city center is given in Figure 2.

Methods

Spatial sequencing theory is a graph-based theory developed by Bill Hillier and Jillian Hanson (1984). In this analysis, known as space syntax analysis, the most important concept is integration. Spatial syntax analysis is used to determine the numerical relationship of organization between spaces at the building or city scale. To perform the spatial syntax analysis in the study area, a spatial model of the city of Erzurum was created. The spatial integration value was calculated with the axis maps made. The integration value is a number obtained to reach the other transportation axis of the transportation axis, which is expressed with a straight line. The higher this number, the fewer connections the main axle needs to reach other axles. It is accepted that the accessibility of these axles within the system is higher than the other axles. The areas where the lines with high integration value are concentrated are expressed as the "integration core." The integration core can also be defined as the center of the system. These areas are suitable for hosting central uses due to their integrated structure. Integration values are numbers and can be automatically converted to a color graphical



Figure 1.
Working Area.

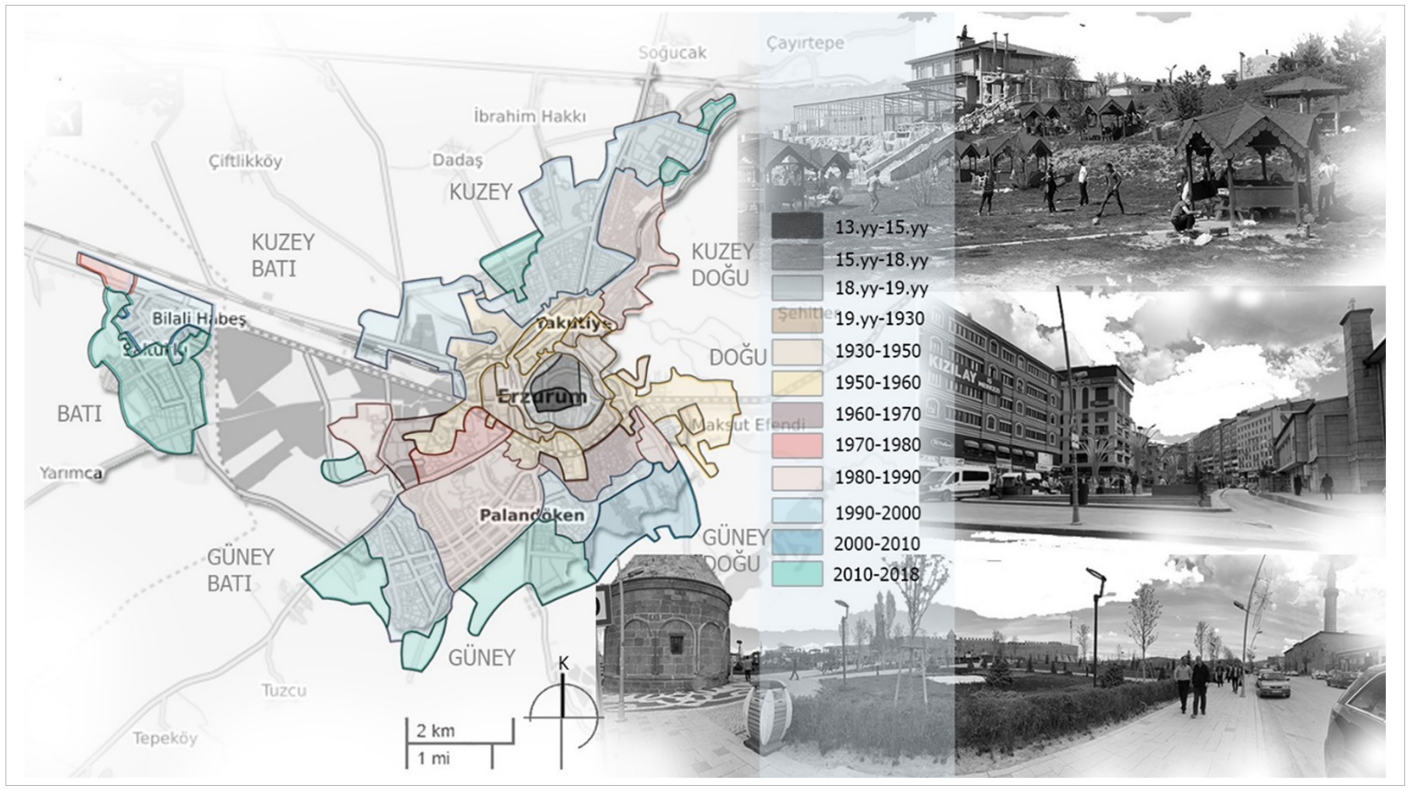


Figure 2.
Historical Development of the City of Erzurum.

representation on the computer. Integration is a comparative value and has no unit (Kubat et al., 2003).

The natural movements seen in the structuring in a city are the rate of pedestrian movement defined by the shaping feature of the area. This natural movement is the most dominant movement type in urban areas. The longer line can direct attention to a building facade from an open angle and the shorter line to pay attention to the building from the right angle. It is seen that there are quite large differences in the connection properties of existing lines to other lines. It is these differences that govern the effect of space in movement within the system. The more movement that is less "deep" into the other, the less movement that is more "deep" attracts. This depth gives the value of "integration," which is the most important shaping parameter for the whole. The spaces that are passed through a lot are called "integrated" and those that are passed less are called "segregated."

Integrated spaces have the potential to bring together all the people who live in a place or are there for any reason. The most integrated spaces, on the other hand, are the spaces that have the possibility to pass through even to go to another place, and these areas are called "integrated core" (Hillier, 2001).

The most basic concept of the space syntax method is "integration." This method is formed by superimposing the smallest and largest potential motion lines of the system, which turn into a grid in the city's building blocks system. By calculating the integration (integrity) of each of these lines to the local and the whole system, the analysis of urban grid systems can be made and the movement flow can be estimated in this direction. Two basic analysis methods of integration are relative or relative asymmetry (RA) and the other is real relative asymmetry (RRA). In 1984, Hillier and Hanson introduced the RA measure to express integration. Relative asymmetry compares the depth of an axial map from a given line to the depth and shallowness it could theoretically have. Any line seen on the map is equal to the time it intersects all other lines of the axis map. The occurs when axis map from a given line looks like a single linear array away from that line, each additional line of the map adds another level of depth. (Teklenburg et al., 1993).

Real relative asymmetry and integration equations can be found on any piecewise map. Therefore, there is the ability to calculate localized (radius-like) measures within segmental systems without some revisions to existing relativization equations (Dalton & Dalton, 2007; Teklenburg et al., 1993).

Global selection is a measure of "through motion" based on assigning a value of 1 to each field in the spatial network (whatever it is represented in). The shared values for each area are then aggregated to provide a metric for the importance of that street within the spatial network. Selection, as in this study, measures how far an area can be passed than anyone else. The shortest routes from all areas to all other areas in the entire system or within a predetermined distance (radius) from each segment (Hillier, 2003).

The study consists of three stages, first of all, a detailed literature review was made on the spatial sequence. Then, Erzurum city center maps were digitized in the Autocad program. To calculate the numerical data, the integration distribution was tried to be determined by using depth MapX 0.8.0 program in Erzurum city center and the historical city

core,which forms the basis of the study, and spatial integration values were calculated according to the global selection in analysis.

Results

As a result of the analysis made in the first settlement area of Erzurum city, an axial integration map was created. The analyses clearly show that the integration is concentrated in the outer fortification area. Urban structures, which were generally considered to be defensive in ancient settlements, also came to the fore in Erzurum. The integration value of the inner corefortification area located in the old Erzurum city center was quite low. This situation revealed how isolated and sheltered the inner city wall is (Figure 3).

The highest integration value of Erzurum city is Çiğdemli Bridge (3241.8), which connects the E80 and D100 highways. Considering the city center, Fatih Sultan Mehmet Boulevard (3227.5) provides the Kars-Ağrı connection in the east and E-80 Erzurum-Erzincan Highway (3234.2) in the west have the highest integration value. This road, which is used most intensively in the east-west direction, supports the analysis result. The integration value is high on the D100 Kars-Erzincan (3137.5) ring road, which is also in the east-west direction. Integration value is also quite high in the D950 Erzurum-Tortum (3190,0) highway, which provides a connection to Erzurum's North-South direction and especially to the northern districts and the Black Sea region. High integration was also detected on the Erzurum-Airport (3149.5) road in the north-south direction coming from Erzurum Airport and connecting to Erzurum Technical University. Terminal (3181.4), 50. Yıl (3163.3) and Çaykara (3162.9) streets in Yakutiye district, where our study area is located, also have high integration values. While Çaykara and 50. Yıl streets have a commercial and residential texture, Terminal street is surrounded by places where recreational activities can be performed. The integration value is also high on Cemal Gürsel Street (3144.9), located between Atatürk University junction and Havuşbaşı town square. Again in the region, Cumhuriyet Street (3036.0), which is known as an important axis among Historical Buildings and constitutes the important commercial corridor of the city, has a high integration value. The integration value of the line that connects the area designed as Atatürk University West campus to the D100 highway is quite high. In general, the integration, which is concentrated in the city core, decreases in a balanced way as it spreads to the outer borders of the city. The city of Erzurum, located on the historical silk road node, still reflects the commercial potential it gained from the past in the north-south and east-west directions (Table 1) (Figure 4).

The integration value of the route of the Great Mosque, Double Minaret Madrasa, Yakutiye Madrasa, and Lala Pasha Mosque (213,8) located in the Erzurum castle and its surroundings, which is included in our study area, which is located in the old historical city texture of Erzurum 1904, was found to be high (Aslanapa, 1989; Konyalı, 1960). At the same time, this route coincides with today's Cumhuriyet Street. The integration value of the road leading to Rüstempaşa Bedesteni (218.0) in the north-south direction between Lala Paşa and Caferiye Mosques is the highest. It is located in a similar direction and position with Menderes Street, which has a high integration value today. However, it has been determined that the integration level of the housing cluster (197.4) located in the north-south direction is high. In the commercial zone (163.4), located in the north of the area and at the bottom of the city wall, the integration level is lower than the historical building density and residential area. The value on the road (128.1), which is interconnected with the Eski Ambarlar and İbrahim Paşa Mosque, located

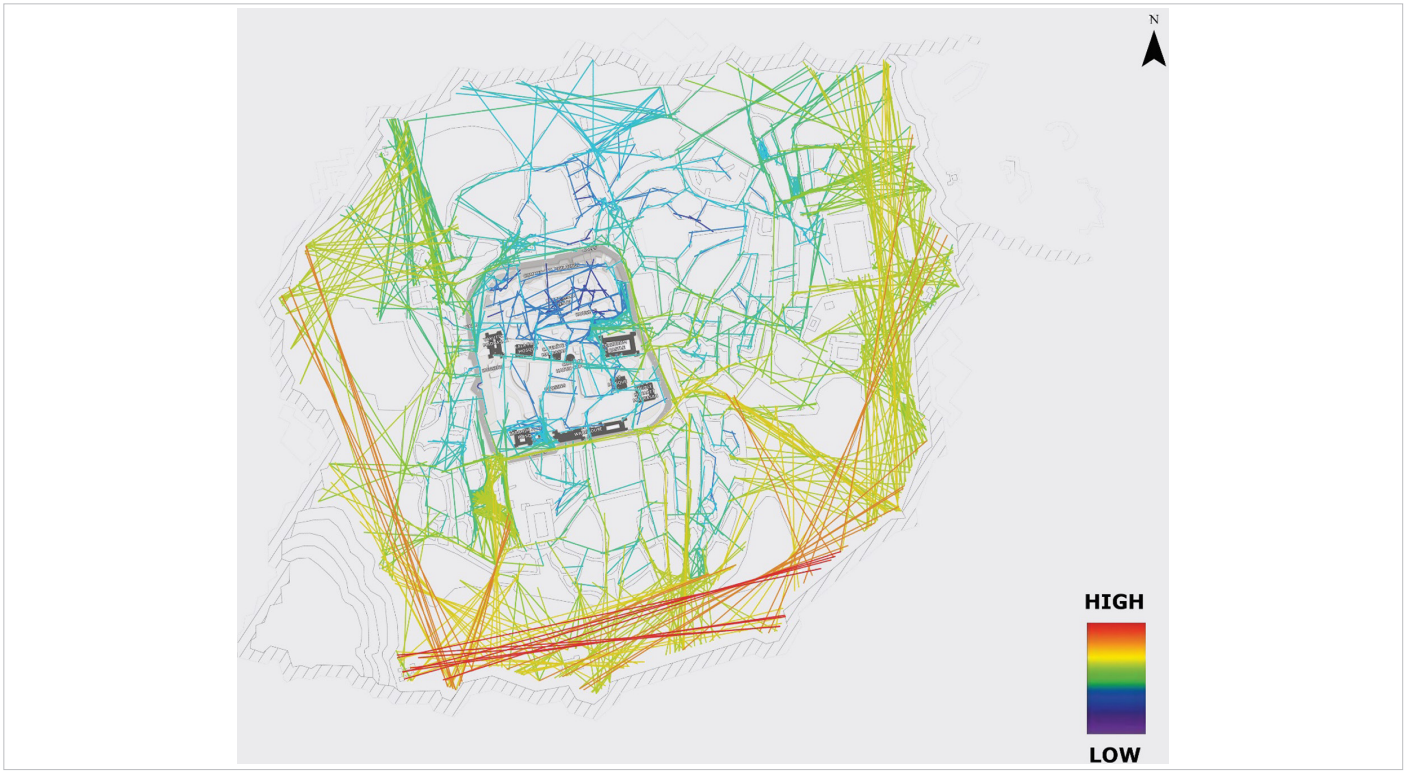


Figure 3.
Axial Integration Analysis of the Old Erzurum City Center.

Table 1.
Erzurum City Center Average Integration Values

Name	Segment Number	Average Integration
Çiğdemli Bridge	2	3241.75025
Erzincan-Erzurum Way	183	3234.205997
Ilıca Bridge	2	3232.10485
Fatih Sultan Mehmet Boulevard	86	3227.541606
Erzurum Erzincan Way	42	3197.303038
Tortum Way	30	3190.006343
Karasu Bridge	4	3182.289175
Terminal Road	18	3181.425983
50. Yıl Road	51	3163.348618
Çaykara Road	29	3162.898631
Erzurum-Tortum Way	100	3161.699965
Cahar Dudayev Road	10	3150.69162
Erzurum Havaalanı Way	41	3149.477363
Cemal Gürsel Road	9	3144.933678
Somunoğlu Road	9	3138.954667
Kars-Erzincan Way	87	3137.49154
Aziziye Bridge	2	3137.3014
Saray Bosna Road	24	3136.413404
Barış Street	6	3134.8372
Ömer Nasuhi Bilmen Road	12	3131.528292
Erzurum-Ağrı Way	41	3130.885278
Meteoroloji Lodging Street	2	3129.07755
İpekyolu Intersection	6	3127.38325
Dr. Refik Saydam Road	16	3126.974713
İstasyon Road	6	3123.115417
Ali Ravi Road	44	3122.153773
2. Kurtderesi Street	1	3115.8657
3. Kurtderesi Street	2	3113.71365
Erzurum Kars Way	14	3107.313557
Fuar Way Road	15	3103.329573
DSİ Lodging	9	3102.774556
Atatürk Boulevard	31	3100.381748
Orhan Şerifsoy Road	13	3100.346738
Menderes Road	23	3099.032587
Aziziye Road	20	3097.76448
Atatürk Üniversitesi	26	3088.339496
Sultan Alparslan Road	22	3086.0013
Refik Saydam Road	20	3085.094
Hizmet İçi Eğitim Enstitüsü	2	3083.27135
Erzurum PazarWay	4	3082.31035
Organized Industry Way	3	3081.1687
Central Management Road	6	3078.000717
Organized Industry Way -1	5	3077.7498

(*Continued*)

Table 1.
Erzurum City Center Average Integration Values (*Continued*)

Name	Segment Number	Average Integration
Ensar Street	8	3076.989438
Private Şeker Student Dormitory	1	3076.8525
Çiğdemli Overpass	6	3075.57455
Gölbaşı Road	10	3068.89053
3. Sanayi Road	10	3068.01199
Erzurum Artvin Way	18	3067.750894
Taşkent Street	11	3065.753982
AÜ Faculty of Agriculture Sheep Breeding Branch	20	3064.257675
Araplar Düzü Road	4	3063.01555
Dadaşkent Way	7	3062.529457
2. Fetfacıoğlu Street	1	3062.3767
Industry Road	3	3061.895767
Yalçın houses Street	1	3060.0833
1. Street	6	3059.5628
Keresteciler 7. Street	8	3059.4422
Hastane Street	3	3057.722967
Eastern Anatolia Research Institute	3	3057.607267
Erzurum Ağrı Way	18	3057.424556
Leyla Street	6	3055.733617
Şıh Köyü Road	9	3055.374878
Behind Combined Cluster Houses	1	3055.0764
Ahmet Aslan Street	4	3055.014875
24 Temmuz Road	4	3053.91815
Kılıç Street	3	3053.018233
Yenişehir Road	14	3053.017514
Hal Street	1	3052.3242
İstanbul Kapı Road	25	3051.353292
Hastaneler Road	7	3050.9865
Dört Yol Road	7	3049.809371
Sabunhane Street	7	3049.628343
Kıbrıs Road	1	3048.126
İpek Street	9	3047.490833
Orhan Street	3	3046.0187
Fabrikaönü Street	12	3045.759108
Milli Egemenlik Road	41	3045.497871
Gasoline Station	2	3045.1664
Kardelen Site	1	3044.864
Evren Paşa Street	5	3044.81596
Erzurum Airport Enterence	1	3044.7327
Köşk Road	3	3044.163233
Erzurum Airport	5	3043.89028
Mehter Street	3	3043.742933
Erzurumspor Football Club	1	3042.3633
2. Konak Street	1	3040.3259

(*Continued*)

Table 1.
Erzurum City Center Average Integration Values (*Continued*)

Name	Segment Number	Average Integration
Malazgirt Road	4	3039.614875
Emir Şeyh Road	13	3039.551477
Y. Selim Street	3	3039.236167
Özel İdare Social Facility	1	3039.0164
Şehit Polis Ercan Yılmaz Street	2	3038.90035
Yavuz Selim Road	12	3038.56715
Samsun Road	11	3037.351836
TCK 12. Regional Management	4	3036.74305
Kombina Road	13	3036.460715
Cumhuriyet Road	26	3036.049608
Necip Fazıl Kısakürek Road	11	3035.553327
Yakut Street	3	3035.375833
Osmanbey Street	2	3034.8776
Yönetim Road	17	3034.361341
Dr. İspirlioğlu Street	3	3033.631167
Fetvacıoğlu Street	3	3032.930267
Sağlık Bakanlığı Facility	6	3031.98295
Ahmet Yesevi Road	14	3031.001157
Bentdibi Street	1	3030.7356
Kavakkapı Road	4	3030.29015
Cengiz Topel Road	4	3030.185275
2. Street	2	3030.08725
Çat Way Road	11	3029.621382
Evliya Çelebi Road	5	3029.46172
Ministry of Public Works and Settlement Lodging	1	3027.9446
İsmail Gürcan Road	2	3027.4868
Demirciler Road	4	3027.27275
Prof. Dr. İhsan Doğramacı Boulevard	16	3026.684812
Sugar Factory	4	3026.54645
Mosque Street	2	3024.6421
2. Mosque Street	2	3024.16795
Şevket Arı Road	4	3023.772125
Atatürk High School Street	2	3023.41455
Water tank Road	5	3022.99958
Sigorta Street	2	3022.964
Lale Street	2	3022.0133
Yavuz Sultan Selim Boulevard	24	3020.779196
Umut Street	1	3020.3708
Palandöken Road	8	3018.828825
Erzurum DDY overpass 2 Bridge	1	3018.7939
Aziziye Highway Industrial Site	2	3018.447
Kara Veli Street	2	3017.1487
Nene Hatun Road	1	3016.7144
Usuğ Street	6	3015.779117

(*Continued*)

Table 1.
Erzurum City Center Average Integration Values (*Continued*)

Name	Segment Number	Average Integration
Yonca Street	7	3015.664086
Köy Hizmetleri	6	3015.558017
Marangozlar Street	5	3014.27456
2. Çimen Street	4	3013.790325
Zakirbey Road	3	3012.529233
Erzurum-Yenişehir Way	5	3012.52254
Piri Reis Street	4	3012.43485
Fuar Way Arkası Street	2	3011.2533
Kolordu Street	4	3011.168575
Millet Bahçe Road	1	3009.6648
AÜ Süleyman Demirel Medical Faculty Hospital	4	3009.52815
Kurtderesi Street	1	3009.4619
Kars Kapı Road	2	3008.4513
2. Manolya Street	2	3008.45095
Menderes Street	3	3008.264967
Yenikapı Road	9	3007.625078
Türbe Way Road	5	3005.8895
Küçükevler Road	4	3005.87835
Inside Ata Park Botanical Garden Park Way	1	3005.8042
Fındık Street	1	3005.4084
Gasoline beside Street	2	3005.00355
6. Konak Street	1	3003.9036
Kemer Street	2	3003.80545
Etem Baba Road	1	3003.6821
Kazım Karabekir Road	2	3001.51255
Boydak Street	1	3001.2595
Nafiz Ergün Street	1	3000.6716
Dere Road	3	3000.472833

on the border of the southern city wall and oriented in the east-west direction, was low (Table 2). This proves that in the past, storage areas in Erzurum city core were built in more sheltered areas for security purposes. (Figure 5).

Considering today's core region, the integration value of the avenue is since many important historical buildings such as Erzurum castle, Ulu Mosque, double minaret madrasah, Yakutiye madrasa, and Lala Pasha mosque are located in this region along the Cumhuriyet street (1215.0) located in the east-west direction (Beygu, 1936; Yurttaş, 2001). is the highest. Again, commercial buildings in the region are one of the important factors affecting the integration. Integration value was also high in Menderes Street, which is located along the north-south direction. The fact that important historical and commercial fabric is located along Menderes street (1165.1) supports its integration value. In this direction, Rüstempaşa covered the bazaar, Yakutiye Municipality building, and Ali Ravi Street (1127.1), where the old stone warehouses are located, have a high integration value. Mumcu street (1094.5) is a street connected to Yakutiye Madrasa and is a dense area in terms of trade and historical places (Table 3) Yenikapı street (1015.0) is also dense in terms of commercial and socio-cultural spaces Integration of the pedestrian zone of stone shops, which is one of the important tourism destinations, is moderate (Taflan, 2008). The built environment of Erzurum castle, which is a square and located in the study area, and Yakutiye square have a medium level of integration value (Figure 6).

The heat map of today's city center, historical touristic places, and commercial structures was made according to the spatial distribution. Then, this map was overlapped with the integration map and the relationship between the building settlement and integration was investigated. Rüstempaşa Bedestenin, which is one of the historical touristic buildings and today's commercial buildings, has a high density in the historical and commercial heat map. This building, located at the intersection of Menderes and Ayazpaşa Streets, where the integration value is high, supports the analysis. Considering the heat map showing the distribution of the commercial area, although the integration values of the Taş stores pedestrian zone and the Old Bat market street are moderate, the heat density value is high. It is known that these axes are among the important commercial axes of the city. Apart from the Erzurum city core, which constitutes the study area, another region with high

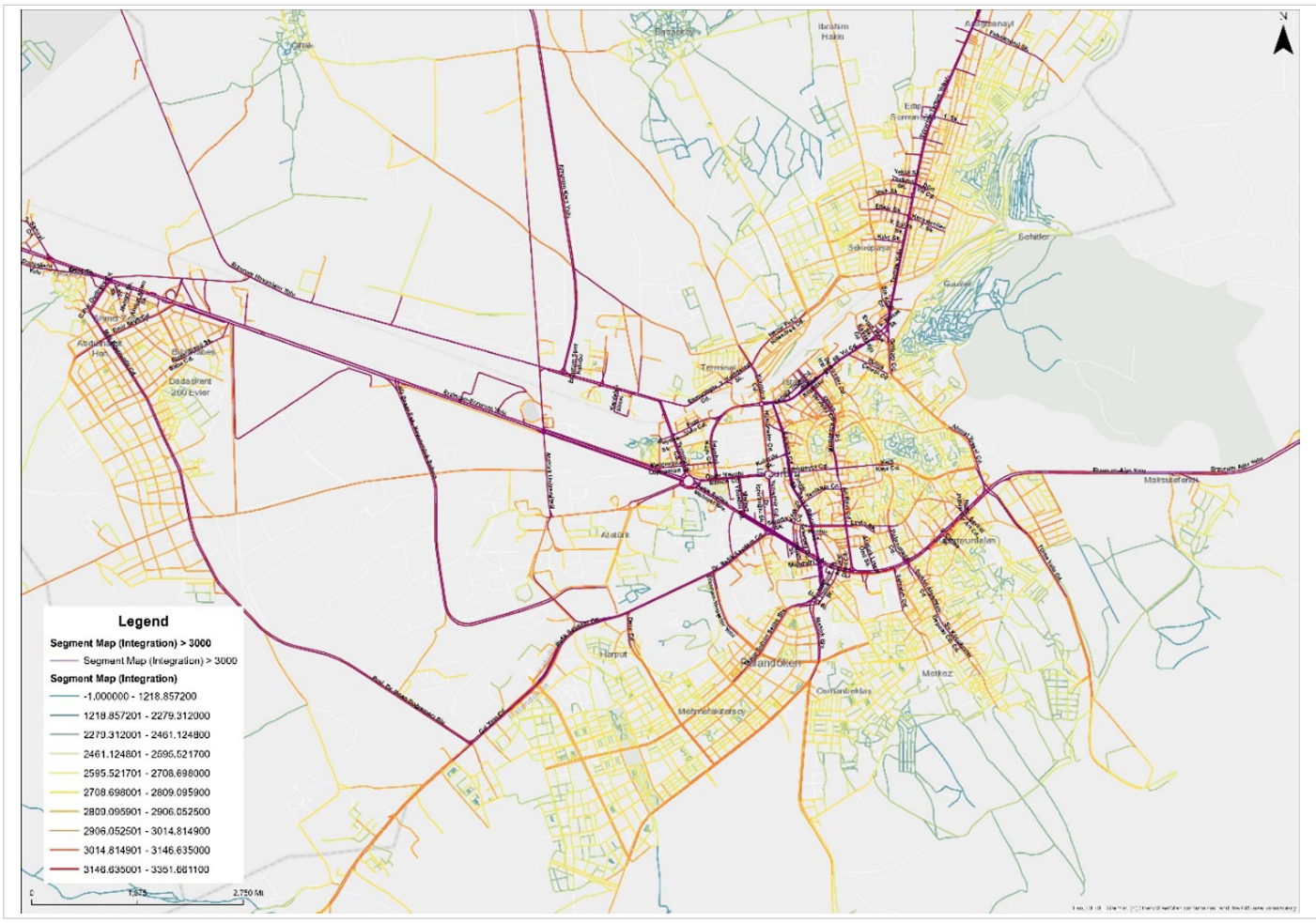


Figure 4.
Erzurum City Center Segment Integration Analysis.

commercial density is the section along the Cumhuriyet street axis up to the Havuzbaşı city square. In this region, the part with the highest heat density is Palerium AVM. It is one of the important trade centers today.

In the historical and touristic areas, especially in the city core, the heat map is evenly distributed. The busiest area is where the Rüstem Pasha bedesten is located. Apart from this, the heat density is highest in the area around the city core where the Murat Paşa Mosque, the new Hamam, and Murat Paşa Mansion are located (Figure 7).

Discussion, Conclusion and Recommendations

Supporting and improving the urban space syntax of urban historical heritage sites and surrounding open spaces requires a multidisciplinary network of relationships. Overall, one of the most important contributions of the space syntax method to heritage urbanism is to properly address the historical role of space in the formation of current and future spatial cultures that are sustainable, comprehensive and flexible.Difficulties may arise from time to time in the application of the space syntax method and in the more systematic use of its optimum potential. In order to minimize these disruptions, analytical methods adapted to date-heritage and spatial sequence relationships should be determined. In the study, the historical texture of Erzurum City and its changes in transportation axes over the years, its functions in the city and the spatial integration of street accesses were examined with space syntax analysis. It has been determined that the integration of the street axes that provide access to the historical buildings in today's city center is intense, as in the old Erzurum historical route.

Table 2.
Erzurum Old City Core Average Integration Values

Name	Old Menderes Street	Old Cumhuriyet Street	Buildings	Commerical Buildings	Old Stone Warehouse Street
Segment Number	8	16	10	2	4
Average İntegration	218.0	213.8	197.4	163.4	128.1

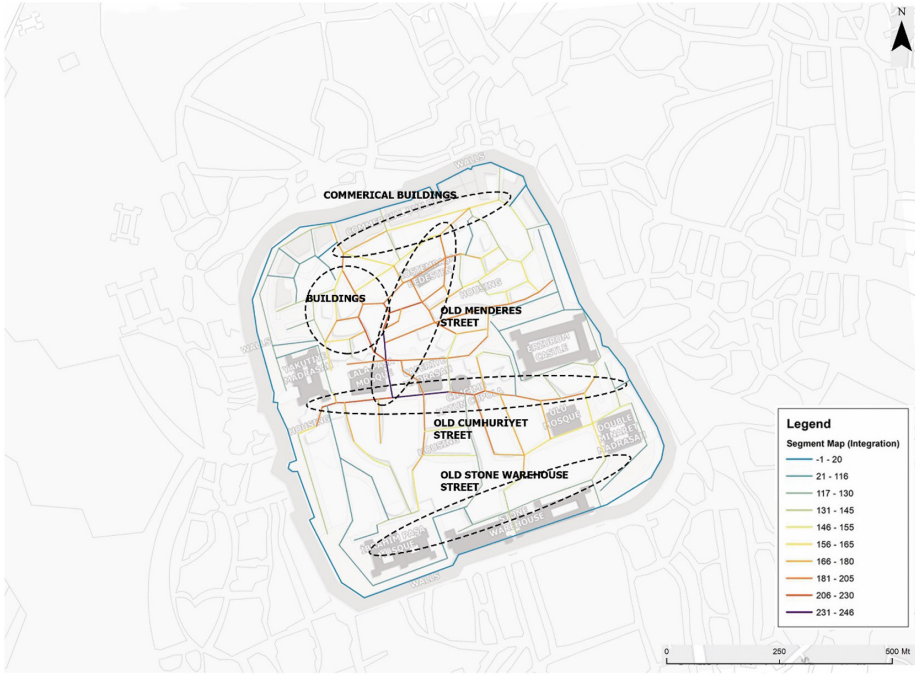


Figure 5.
Segment Integration Analysis of the Old Erzurum City Core.

Kim and Sohn (2002) analyzed the urban street configurations of two areas with different urban street configurations using the Space Syntax theory to investigate the relationship between the urban street configuration of office buildings and the land use density.The analysis concludes that there is a fundamental difference in spatial configuration between the two domains in terms of their local structure and global context. It has been revealed that urban configuration affects the physical formation of cities. This result shows that the land use density is significantly affected by the street configuration.When the spatial characteristics of the historical elements in Erzurum city center are examined, in parallel with the concentration of the functional structuring in the area around commercial, religious and residential structures, both the old settlement plan and the new planning studies that highlight this plan; , goal and inside goal lines were determined and the integration value was high.

These lines form the main backbone of the city and are the route where most activities are seen. Accordingly, it is seen that the study area, which is located on the historical axis in the city center, has not lost its spatial feature in the past and today as a valuable commercial structure. In the article, the past and present general integration of the historical texture in the city and the related density relationship, differences and similarities are evaluated in terms of functionality (Durmuş & Kubat, 2015). Alkamali et al. (2017) investigated how the expansion of Muscat affected access to the old city in their study in Muscat province and former Greater Mutrah city in Oman. This city was chosen for its inherent value in history, economy and tourism in the country and region, and they used axis maps to understand how accessibility in this area is affected in terms of space syntax theory and related methodology. Integration radius for the old city before and after the expansion of Muscat using DepthMapX software in the analysis It was calculated as 3 and the data were analyzed statistically, showing that the enlargement positively affected the accessibility of the old city and changed the spatial structure in the region.

In recent years, the tourism value of the cities has increased with the transformation studies carried out in accordance with the socio-cultural, physical and ecological structures of the cities. With the urban transformation works carried out in Erzurum city center and its historical surroundings, the architectural structures along the historical Cumhuriyet street route were rearranged, thus increasing the number of local and foreign visitors, and the tourism attractiveness of these places came to the fore. Mansouri and Ujang (2017) used the space syntax method to determine tourist mobility in the historical region of Kuala Lumpur, Malaysia. In the study, they evaluated the accessibility of pedestrian tourists to the transportation networks in the historical region, the connectivity of the roads on the historical route and the integration. As a result of the study, it was revealed that integration with

Table 3.
Erzurum City Core Average Integration Values

Name	Cumhuriyet Street	Menderes Street	Ali Ravi Street	Ayazpaşa Street	Mumcu Street
Segment Number	17	23	14	14	12
Average İntegration	1215.0	1165.1	1127.1	1124.5	1094.5

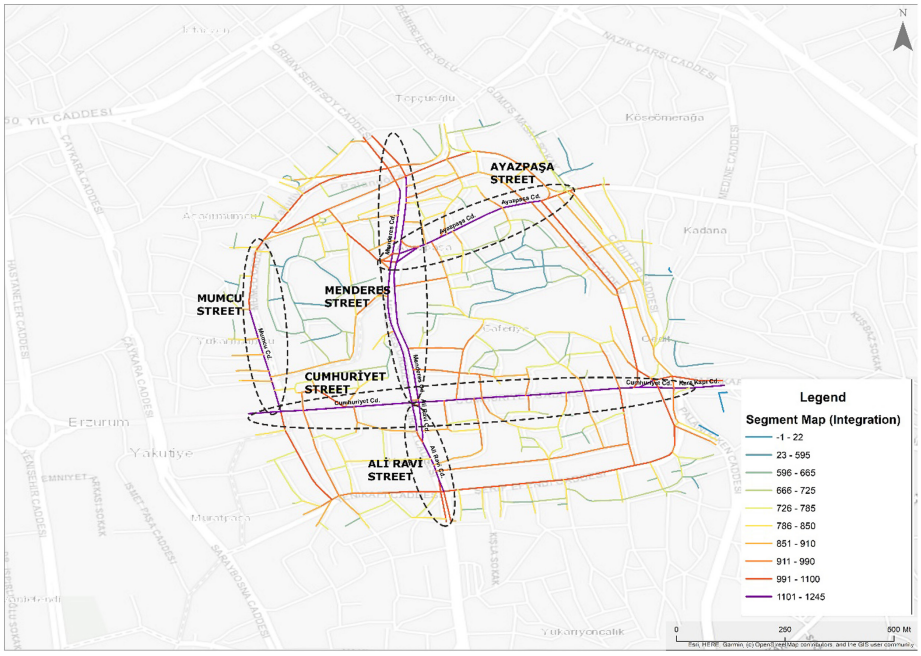


Figure 6.
Today's Erzurum Urban Core Segment Integration Analysis.

pedestrian movements could be increased with pedestrian-oriented activities along the road rather than the connections of walking paths. Therefore, it has been suggested that urban designs that will provide walkability in these places will be more beneficial in order to increase the attractiveness of historical city centers.

Apart from the physical environment of a city, its social, cultural, economic, and political components also give different dimensions to the urban identity (Atakara & Allahmoradi, 2021). Each component has its unique visual character and identity, and these components, which contribute to the formation of the city, affect the urban environments in the historical process and give the city an identity. The natural and cultural values that cities have accumulated from past to present have an impact on identity. In this sense, the most important component that gives identity and temporal dimension to the living spaces of cities is historical environments.

In line with the data obtained within the scope of the study, the historical transformation of urban textures, urban functions, and spatial integration of street networks was examined by space syntax analysis. Although the first findings on the Erzurum city map show the Byzantine period, today's studies indicate that it belongs to the Turkish-Islamic period. In this direction, Erzurum's map of 1904 and today's current city center situation has been analyzed in general with the spatial syntax method on a global scale. In addition, the inner city wall region, which constitutes the city center and has an important

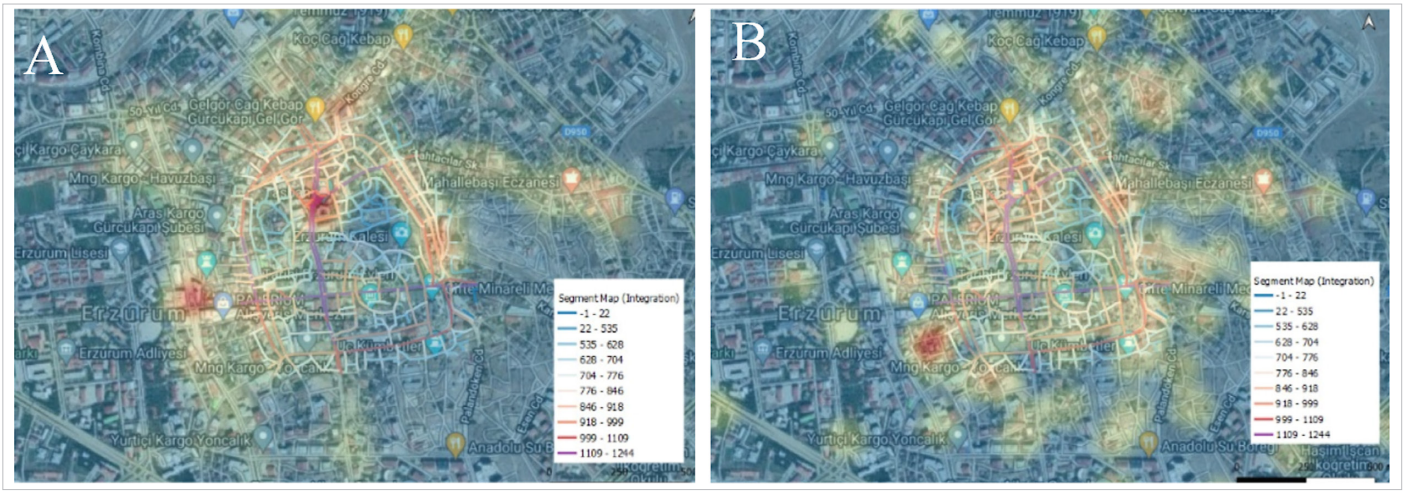


Figure 7.
Erzurum City Center A-Commercial Area, B- Heat Distribution Map According to Historical Touristic Place settlement.

location in terms of historical-cultural heritage, has been examined and interpreted on a local scale. The relationship between the general integration of the historical texture, which has been preserved from the past to the present, and the user density, and the differences in terms of urban function between two different periods were evaluated. In all segment and axial integration analyses, connectivity weighting has been made.

These historical buildings, both inside and outside the historical city walls, have been very effective in the urban planning of Erzurum today. Especially the architectural works located around Cumhuriyet Street have been made more visible and contributed to the regular city planning with the effect of the landscaping works carried out in recent years. Considering the other irregular areas of Erzurum city center, it is seen that it is a correct decision to live together with history in terms of architecture. In addition, these inferences prove that the architectural structure and street texture built in the past periods were revealed by taking into account the location and population density of the city. The architectural structures in this densely populated center are places where many needs can be met today, as in the past. Being able to accurately read the social, cultural, and economic structure occurring in the historical city center and perceiving the urban texture is important in planning the development of the city correctly. It is important to make a systematic analysis of the spatial characteristics of the building by developing a mathematical model without harming the traditional values of the historical centers of this planning process. Today, research on the spatial characteristics of historical regions are carried out in the fields of architecture, landscape architecture, and urban design.

These places, where large masses of people gather in the city, are the determining factors in the formation of the settlement area (Eravşar, 2002). Here, the transportation network is shaped according to architectural structures and the density of social, administrative, and economic vitality is striking. It can be said that Erzurum Castle was effective in the distribution of central settlements and that the castle city model applied in other cities of Anatolia was applied.

Based on Griffiths' (2012) account of the study of history in space syntax, space syntax provides a starting point for the integration of history and heritage studies. Accordingly, three main areas of future research activities were identified as conservation areas, street scales, and spatial cultures. In general, the contribution of the space syntax field to heritage urbanism is to identify the historical role of space in the formation of current and future spatial cultures and to create long-term sustainable, inclusive, and durable plans.

Li et al. (2016) applied space syntax analysis to understand the relationship between street network integration and urban fabric in Gulangyu Island, China, in the historical and touristic areas of the city. According to the data obtained through analysis, it has been determined that Gulangyu has a good spatial structure. In the newly developed tourist center in Gulangyu, a high value of global integration has been detected, which is convenient and beneficial for tourists in areas with a relatively higher average value (761) compared to the global average. Accordingly, tourist preferences in these centers on Gulangyu Island show a high correlation depending on the street network integration. recommendations have been made.

Yang et al. (2021) applied two behavioral simulation methods AnyLogic and Depthmap in space syntax to examine the accessibility of the street system and property plot to urban texture levels in the North Bund area of Shanghai, to explore their advantages and disadvantages in terms of simulation principle, placement precision, and computation of results. As a result, behavior simulation, pedestrian flow, walking time, etc. It was able to visually reflect the usage status of certain areas through micro-behavior data such as However, it has been determined that the sensitivity of fit between the output and the real situation is lower than the behavior simulation, and the capacity and service level of the urban space cannot be directly evaluated.

Battistin (2021), in his research, presented the results obtained from the application of Space Syntax to the street network of the Roman town of Falerii Novi and documented it largely through extensive magnetometric research. Working with a combination of source data, predominantly geophysical, it evaluated multiple scenarios of the city's incomplete urban layout. Three different space syntax analyses (axial analysis, segment analysis, and visibility graph analysis) focusing on connectivity, integration, and selection parameters were applied to each proposed scenario. It has provided a useful tool that can increase knowledge of its structure and roads.

Cities and buildings are places where a network of "unidentified relations" is given place to the real world, in contrast to social environments, from material to culture (Hillier, 2003). A spatial order can reveal certain social patterns that enable us to maintain things about ourselves and our cultures by constructing them in space and make them inevitable and natural. space syntax analysis techniques were introduced with the aim of making the "unidentifiable" "identifiable." This technique, which we can also call the "unidentified orders technique," proposes a geometric network model based on the formation features of the space in the unity of relations in an urban space. The space syntax method uses point, line, space, and area elements to create layered symbols of the built environment and urban open and green spaces. To mathematically measure the spatial configuration relationship of these spaces, space syntax analysis can measure matrices of symbols using topological line theory.

In short, space syntax is best described as a research program that explores the relationship between human societies and space from the perspective of a general theory of spatial structure in all its different forms (Bafna, 2003).

These historical buildings, located in the middle of Erzurum city center, have been largely restored and preserved in line with their past usage purposes. Urban transformation played an important role in the rearrangement of architectural structures on both sides of Cumhuriyet Street, which passes through the center of the city, and in the increase in the number of visitors. In this transformation, the elimination of shanty houses and shops located around or very close to historical buildings has positively affected the city silhouette. When we look at the areas where these historical buildings are built, it is observed that they are the most active places in terms of commercial, cultural, and administrative aspects. Today, this region, which is frequented by the majority of the people of the city, serves the same purposes. However, successful works on the restoration of historical buildings and landscaping, which constitute our subject, played an important role in the increase in population density.

Restoration and consolidation work in these architectural structures were carried out in historically important sections such as the Double Minaret Madrasa, Yakutiye Madrasa, Erzurum Castle, Lalapaşa Mosque, Caferiye Mosque, Rüstem Paşa Caravansaries. These are also places that make great contributions to the socio-cultural, religious, and economy of the city.

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