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The Effects of Spatial Connectivity on Pedestrian Movement and Space Usage in Waterfront Areas

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ABSTRACT

The existence and life of our cities are dependent on pedestrian flow. Spatial connectivity between public spaces makes pedestrian flow possible. There are many studies in the literature researching spatial connectivity using various methods. Many of them, only analysing physical connectivity, also focus on a determined urban area but not waterfront areas. The significance of this study is that it points to the potential of waterfront areas and focuses on both physical and visual connectivity analyses. Topographical features were also evaluated with 3D visual analyses. This study aims to ensure that waterfront areas can be more liveable and be a part of the urban structure through spatial connectivity. Five waterfront areas in Istanbul were selected from Tarabya and Kireçburnu which are on the European side of the Bosphorus. Spatial connectivity, pedestrian movement, and space usage were analysed in these areas. Spatial connectivity analyses which are metric reach, directional reach, two and three-dimensional visual analysis, were performed in Rhino Grasshopper. Pedestrian movement and space usage were analysed by twenty-minute systematic observations and the gate count method. Finally, all data were evaluated using Spearman correlation, cluster analysis and the Mann-Whitney U test. Study areas were divided into two groups based on their similarities related to spatial connectivity levels, the presence of green areas, the presence of urban equipment (play and sports areas), the visibility of the opposite shore, and the presence of site-specific functions. Mann-Whitney U tests were performed between these groups and pedestrian movement. As a result, while the correlation analyses did not yield significant results due to the limited number of areas studied, the observations revealed that spatial connectivity had a positive effect on pedestrian movement. However, spatial connectivity isn’t the only variable for increasing space usage. In addition to the connectivity of waterfront areas, it has been found that green areas and site-specific functions have a strong impact on pedestrian movement and space usage. So, what needs to be done to make waterfront areas an active part of the city is to strengthen the spatial connectivity and to increase the number and diversity of the facilities, especially the green areas.

KEYWORDS

Waterfront areas, spatial connectivity, pedestrian movement, space usage

1 INTRODUCTION

Supported by pedestrian movement, urban public spaces are freely accessible areas where each individual or groups can perform various activities, meet, and communicate, socialize, and thus participate in urban life (Carr et al., 1992). Pedestrian flow, which gives life to a city, must be provided between urban public spaces to ensure an enriched urban life. Providing flow in the city is only possible with the spatial connectivity established between urban public spaces. Connectivity as a characteristic that provides flow in urban public spaces (Ellin, 2006) enables these spaces to have stronger connections with their surroundings and makes the city more accessible. Thus, these areas don't turn into one of the unused, dead areas of the city. Many previous studies in the literature have tried different methods of measuring spatial connectivity such as pedestrian route directness ratio (Hess, 1997), the intersection density in an area (Frank et al., 2005), and metric and directional reach (Scoppa and Peponis, 2015).

Waterfront areas differ from other urban public spaces of the city by creating not only a border and an edge effect, but also by providing a transition between land and sea. With these features, waterfront areas have a great potential in the city. It's important to ensure that these areas are more liveable and a part of the urban structure and life. For this to occur, the spatial connectivity between the waterfront areas and the inner parts of the city must be strong. In today's cities, for various reasons, some waterfront areas have begun to lose their public character, their accessibility has become limited, and they have turned into idle areas that cannot be used very actively. Therefore, in this study, the effect of spatial connectivity on pedestrian movement and space usage in waterfront areas has been examined. With an increase in spatial connectivity, it's predicted that the accessibility of these areas will increase, and they can be used more actively. The research questions are presented as the following:

- How does spatial connectivity established in waterfront areas affect pedestrian movement?
- What is the effect of visual and physical connectivity on usage in waterfront areas?

Most of the studies in literature, which research spatial connectivity, were conducted on a designated area in the city (Aultman-Hall et al., 1997; Frank et al., 2005; Randall et al., 2001; Fasli and Pakdel, 2010; Hajrasouliha and Yin, 2015; Tang et al. Long, 2019). In some studies, more than one area with different street patterns was selected and the spatial connectivity variables in these areas were compared with each other (Hess, 1997; Özbil et al., 2015; Peponis et al., 2008; Saelens et al., 2003; Moura et al., 2017; Porta et al., 2006). Most of the studies focusing on spatial connectivity aim to measure physical connectivity. The number of studies that consider visual connectivity is comparatively less. For example, Hajrasouliha and Yin (2015) analysed both the physical and the visual connectivity in their study, but they made the visual connectivity analysis only in 2 dimensions. There are also studies in the literature that make 3 dimensional visual analyses (Bishop, 2003; Fisher-Gewirtzman & Wagner, 2003; Morello & Ratti, 2009; Van Bilsen & Poelman, 2009; Bartie et al., 2010; Othman et al., 2019; Van Nes, 2011).

Although there are many studies researching spatial connectivity through different parameters, not enough studies have been identified that specifically examine the physical and visual connectivity of waterfront areas with the inner parts of the city. This study attempts to fill this gap that exists in the current literature. This study points to the potential of waterfront areas and focuses on the analysis of both physical and visual connectivity in these areas. Visual connection analysis which was carried out in both two and three dimensions and thus considered the topographic characteristics of the areas makes this study different from existing preliminary studies.

In a city like Istanbul, which is famous with the Bosphorus, the urban life of waterfront areas gains great importance. In this study, five study areas, Tarabya South Coast, Tarabya Square, Tarabya North Coast, Kireçburnu Park, and Kireçburnu Coast, with different levels of spatial connectivity and spatial qualities, were selected from the European side of the Istanbul coastline. The relationship between spatial connectivity, pedestrian movement and space usage in these selected areas was analysed. In addition to the spatial connectivity, the effects of green area, urban equipment (play, sports area), visibility of opposite shore and site-specific functions on pedestrian movements and space usage in the study areas were also analysed. The method of the study comprises space syntax-based analysis methods, gate counting and systematic observations. As a result of the study, all the data obtained were evaluated through statistical analysis methods comparatively and suggestions were made for further studies.

2 LITERATURE REVIEW

Human-built environmental relations are important in public spaces because people decide whether or not to use an area based on the characteristics of the built environment, and these features' effects on them. For this reason, the relationship between people (society) and their environment (space) and how physical environments affect human behaviour should be understood (Carmona et al., 2003). There are many studies in the literature researching the effect of the built environment on pedestrian movement or physical activity. Commonly defined characteristics in the studies are density, mixed land use, and connectivity (Frank and Engelke, 2001; Handy et al., 2002; Saelens et al., 2003; Frank et al., 2005; Oakes et al., 2007). According to these studies, the connections between streets in the urban network affect pedestrian movement. Hillier et al. (1993) mentions that pedestrian movement can be predicted by looking at the street layout, with the theory of natural movement, which is one of the space syntax theories. According to this theory, streets that are more accessible and more integrated attract more pedestrians. According to Hillier and Iida (2005), the structure of the street network affects movement flow, both geometrically and topologically. Therefore, street network can be expected to affect all life in the city. Connectivity is also a part of the street network and influences movement flow.

2.1 Spatial Qualities of Waterfront Areas

Waterfront areas, which are considered as the meeting place of land and water, create a favorable environment for many human activities. They have some spatial qualities that make them different from other urban public spaces within the city. The most important and unique feature that distinguishes waterfront areas from other public spaces in the city is that they separate and unite two different areas, land, and sea. So, while waterfront areas form a boundary in the city, they, at the same time, also connect these two areas. Thus, multifaceted areas with the potential to bring activities and people together, emerge.

Another important feature of waterfront areas is their permeability. Bentley (1985) associates permeability with accessibility; says that the only places that people have access can give them options. The increase in the accessibility of waterfront areas with the increase in connections with the inner parts of the city, also increases the permeability of the urban fabric. Bentley (1985) evaluates permeability not only physically but also visually. Bentley (1985) says that permeability depends on the number of alternative roads that reach from one point to another in the urban fabric, but these roads must be visible so that they can be used by everyone. Permeability between land and sea in waterfront areas is mostly visual. It's also possible to talk about physical permeability in waterfront areas that allow water-related activities. The visual or physical permeability between the waterfront area and the sea enriches the public space and establishes the relationship of the area with water. When accessibility is provided with permeability, flow is also provided. Ellin (2006) also mentions the concept of connectivity while describing the characteristics of spaces that provide flow. In this case, it's possible to define connectivity, not only as a characteristic of the built environment, but also as a characteristic of spaces that provide flow.

2.2 Spatial Connectivity

For urban public spaces to be used effectively, they must be interconnected. According to Lynch (1960), connectivity is one of the basic elements that defines the image of the city and is the lines on which users move or have the potential to move. Maki (1964) shows connectivity as the most important character of urban areas. According to Maki (1964), connectivity is the glue of the city, it is the action that unites all layers of activity in the city and the resulting physical form. When the connectivity is successful, the city becomes a recognizable and humanly understandable entity. Kostof (1999) emphasizes the importance of flow in the city and says that by connecting the public spaces, flow and spatial continuity will be ensured between the spaces. Saelens et al.

(2003) defines connectivity as the linearity and ease of travel between two points. On the other hand, Peponis, Bafna, and Zhang (2008) define connectivity as being related in its most general sense and consider it as the power source of urban potential. The concept of connectivity, which is one of the characteristics of both the flow and the built environment, can be evaluated through two basic components, physical and visual connectivity.

The spatial connectivity mentioned in the study is the one established between the waterfront areas and the inner parts of the city. Pedestrian connectivity is an indicator of how accessible a neighborhood is to its residents when it comes to walking (Randall & Baetz, 2001). Therefore, when examining the concept of spatial connectivity, the reach and distance between two determined points gain importance. Various spatial connectivity measures have been used in the literature. While these indicators are mostly used to measure physical connectivity, some can also be used to measure visual connectivity. Dill (2004) examined these indicators one by one. Özbil, Peponis, and Stone (2011) analysed these indicators by dividing them into groups. In Table 1, the indicators defined in both studies were classified according to the groups created by Özbil, Peponis, and Stone (2011). Accordingly, the indicators are divided into four groups.

The first group deals with typological distinctions. In this group, intersection density, cul-de-sac density, connected-node ratio, and percent four-way intersections are calculated. The second group considers connectivity as a factor affecting accessibility and walkability. In this group, as in the first group, intersection density, cul-de-sac density, connected-node ratio, and percent four-way intersections are calculated. In addition, block length, block size, block density, intersection-cul-de-sac ratio, street density, link-node ratio, percent grid, grid dummy variables and mean distance between intersections are included in this group. The third group works on a particular region of special importance in a network, such as an important destination or assembly area. In this group, pedestrian route directness, walking distance and effective walking area are calculated.

<table>
<tr><th colspan="4">The Indicators of Spatial Connectivity</th></tr>
<tr><th>1.Typological Distinctions</th><th colspan="2">2.Accessibility and Walkability</th><th>3.A Particular Region of Special Importance</th></tr>
<tr><td>Intersection density
Cervero and Radisch(1995),Cervero and Kockelman (1997), Handy et.al(2002), Reilly and Landis (2002), Frank et.al(2005), Lee and Moudon (2006), Kerr et.al(2007), Peponis et.al (2008)</td><td>Intersection density
Cervero and Radisch(1995), Cervero and Kockelman (1997), Handy et.al(2002), Reilly and Landis (2002), Frank et.al(2005), Lee and Moudon (2006), Kerr et.al(2007), Peponis et.al (2008)</td><td>Intersection-cul-de-sac ratio
Song and Knaap (2004)</td><td>Pedestrian route directness
Hess (1997), Frank and Engelke(2001), Randall and Baetz (2001), Handy et.al (2002), Handy et.al(2003), Lee and Moudon (2006)</td></tr>
<tr><td>Cul-de-sac density
Handy (1996)</td><td>Cul-de-sac density
Handy (1996)</td><td>Street density
Handy(1996), Matley, Goldman and Fineman (2001)</td><td>Walking distance
Aultman-Hall et.al (1997)</td></tr>
<tr><td>Connected node ratio
Dill (2004)</td><td>Connected node ratio
Dill (2004)</td><td>Link-node ratio
Ewing (1996)</td><td>Effective walking area
Dill (2004)</td></tr>
<tr><td rowspan="5">Percent four-way intersections
Cervero and Kockelman (1997), Boarnet and Sarmiento (1998), Greenwald and Boarnet (2001), Parks and Schofer (2006)</td><td rowspan="2">Percent four-way intersections
Cervero and Kockelman (1997), Boarnet and Sarmiento (1998), Greenwald and Boarnet (2001), Parks and Schofer (2006)</td><td rowspan="2">Percent grid
Boarnet and Crane (2001), Greenwald and Boarnet (2001)</td><th>4.Space Syntax-Based</th></tr>
<tr><td rowspan="2">Integration and choice
Hillier and Iida (2005), Hillier, Yang and Turner (2012), Özbil (2014), Özbil et.al (2015), Hajrasouliha and Yin (2015)</td></tr>
<tr><td>Block length
Cervero and Kockelman (1997), Handy et.al (2002)</td><td>Grid dummy variables
Crane and Crepeau (1998), Messenger and Ewing (1996)</td></tr>
<tr><td>Block size
Hess et.al(1999), Krizek (2000), Reilly and Landis (2002), Song(2003), Oakes et.al (2007), Peponis et.al (2008)</td><td rowspan="2">Mean distance between intersections
Handy et.al (2003), Rodriguez et.al (2006)</td><td rowspan="2">Metric and directional reach
Peponis et.al (2008), Özbil, Peponis and Stone (2011), Scoppa and Peponis (2015), Özbil et.al (2015), Hajrasouliha and Yin (2015)</td></tr>
<tr><td>Block density
Cervero and Radisch (1995), Cervero and Kockelman (1997), Frank et.al (2000)</td></tr>
</table>

Table 1: The indicators of spatial connectivity in the literature (Özbil, Peponis, & Stone, 2011; Dill, 2004).

The fourth group is about space syntax. Hillier and Hanson (1984) developed the space syntax method, which considers space as a dimension of social life and social life as a dimension of space. With these analyses, the spatial organizations of a built environment, a building or a street network are analysed and their relationship with pedestrian movements is examined. For the analysis made in a street network, the accessibility of all street axes that make up the network is measured and the distribution of pedestrian movements according to the spatial structure of the streets is analysed. The aim is to provide a general definition of spatial structure and connection hierarchy (Özbil, Yeşiltepe, & Argın, 2015). According to Özbil (2014), space syntax-based analyses can be divided into two groups. The first group is segment-based analysis. Integration and choice, as well as metric and directional reach, are in this group. The second group is visibility graph analysis.

In the first group, integration is the accessibility of each street in a network from all parts of the network, depending on the number of direction changes. Choice is the number of routes with the shortest length or the least change of direction between all possible origin and destination points in a network. While metric reach defines the total street length that can be accessed within a specified walking distance from the midpoint of each street segment in a street network, directional reach defines the total street length that can be accessed from the midpoint of each street segment with a specified number of direction changes. It has been observed that the streets that can be accessed with less direction changes and that are more connected can be accessed more easily and pedestrian movement is more intense in these areas (Hillier et al., 1987; Peponis et al., 1989; Conroy Dalton, 2003).

Visibility graph analysis, which is the second group, measures the visible volume of the space from a point determined in the space. Turner et al. (2001) developed visibility graph analysis as a method that provides a holistic analysis of more than one location in an environment. Analyses can be applied in the urban fabric or in a building. It can be applied to the whole or a specific area of the urban fabric. According to Özbil (2014), these analyses are positively related to pedestrian movement, activity and interaction. According to Desyllas (2001), there is an important relationship between visibility graph analysis and pedestrian movement in outdoor areas. It's possible to make these analyses two and three-dimensional.

3 METHODOLOGY AND STUDY AREAS

3.1 Methodology

Spatial connectivity, pedestrian movement and space usage in waterfront areas were analysed in the study (Figure 1). The data obtained as a result of these analyses were evaluated using statistical analysis methods. The analysis of spatial connectivity was made in two steps as physical and visual connectivity. Space syntax-based analysis methods were used for both connectivity variables. In the physical connectivity analysis, metric and directional reach are analysed. While analysing metric reach, the distance threshold was determined as 400 m according to the average walking distance determined by Aultman-Hall et al. (1997). While analysing directional reach, the angle threshold and the number of direction changes were determined by considering the studies in the literature. The angle threshold was taken as 20° considering the linearity of the roads in the study areas and the number of direction changes was taken as 2.

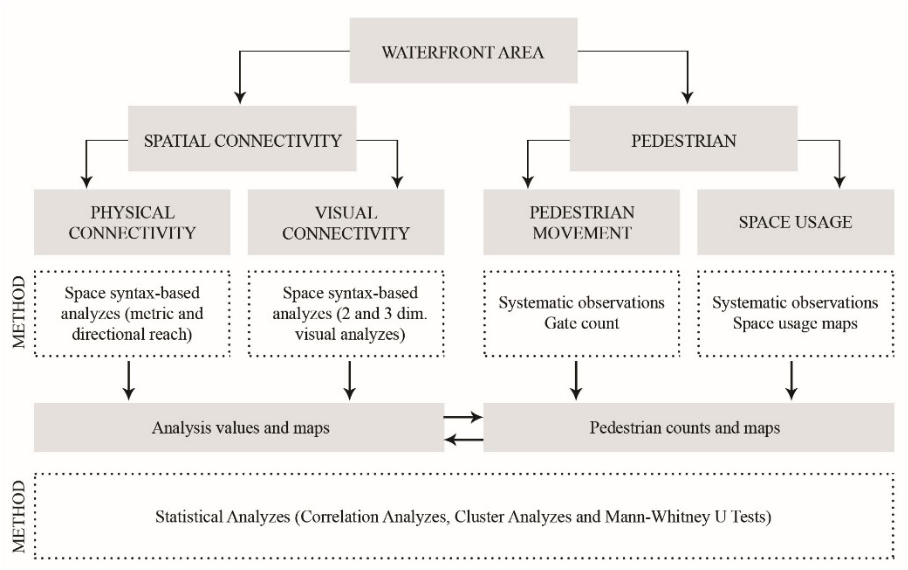


Figure 1: The variables and methods used in the study.

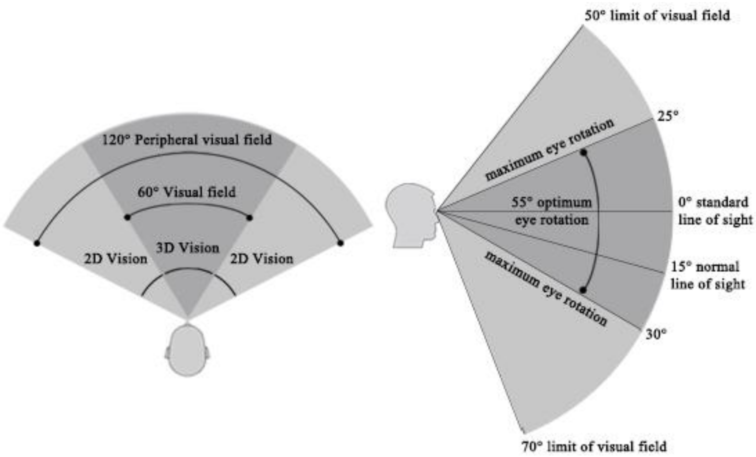


Figure 2: Horizontal and vertical visual fields.

In the visual connectivity analysis, visibility graph analysis was used. These analyses show which part has the greatest visual integrity in a street network. In this study, both two- and three-dimensional analyses were performed separately for each area. For both analyses, the radius was determined as 400 m, based on the threshold distance determined in the physical connectivity analysis. In the two-dimensional analysis, the two-dimensional angle of view of the human eye was taken for the horizontal angle of view. This value is determined as 120°. In the three-dimensional analysis, the three-dimensional vision values of the human eye were taken as a basis. Accordingly, the height was taken as 170 cm, the horizontal angle of view was taken as 60°, and the vertical angle of view was taken as 55° (URL-1, 2, 3) (Figure 2).

Spatial connectivity analyses were performed using the Grasshopper plugin of the Rhino. In all areas, the focal point was chosen as the midpoint of the study area. As a result of the analysis, connectivity values, maps showing accessible connections, visibility maps and images were obtained. Then, pedestrian movement and space usage were determined by twenty-minute systematic observations and pedestrian counts in the study areas. All the observations were made in the same weather conditions during the summer season. These observations were made for three days in total, two days during the week and one day at the weekend, across four different time periods: morning, afternoon, evening, and night. In one day, 80 minutes of systematic observation, 20 minutes in each time period, were made. In three days, 240 minutes of systematic observation were made in total. In addition, pedestrians passing through the area were counted using the gate count method. These counts were performed in the midpoint of each study area as in the spatial connectivity analysis and took five minutes at each time period of the day. Then, the number of people using the area was determined and the spatial uses in the area were evaluated. These counts and observations took fifteen minutes in each time period. Accordingly, space usage maps were created. At the same time, the number of people using the area and the activities undertaken were also determined. Finally, all data obtained were evaluated comparatively using Spearman correlation analysis, cluster analysis and Mann-Whitney U test as statistical analysis methods. In correlations, while metric reach, directional reach, two and three-dimensional visual connectivity are independent variables, pedestrian count and space usage are dependent variables.

The number of observed areas remained few for correlation analysis. For this reason, although the correlation coefficients were high and above, very few of them were significant. In case the number of samples is enlarged, the coefficients expressing the high and above level of relationship are expected to be significant. But due to pandemic conditions, observations couldn't be made in more areas. Therefore, other analysis methods were used. The study areas were divided into groups according to their similarities based on spatial connectivity levels, presence of green areas, presence of equipment (play, sports area), visibility of the opposite shore and site-specific functions with cluster analysis. The aim of this analysis was to examine the relationship between the groups obtained for each variable and the pedestrian movement and space usage data separately. For this, Mann-Whitney U tests were performed between these groups and pedestrian movement and space usage data obtained by cluster analysis for each variable.

The variables that are divided into groups by cluster analysis are independent, and the variables of pedestrian movement and space usage are dependent variables. In the Mann-Whitney U test results, it was determined whether there was a significant difference between the means of the pedestrian count and space usage and the groups determined in cluster analysis. Thus, it was observed whether the independent variables have an effect on pedestrian movement and space usage.

3.2 Selection and Introduction of the Study Areas

The Bosphorus is a natural border that separates the two sides of Istanbul. Carmona et al. (2003) states that many cities have clearly defined edges and cites Istanbul as an example. He mentions that the image of the city is determined by the Bosphorus, which forms a border for both the European and the Anatolian sides. Both visual and physical connections established between the waterfront areas and the inner parts of the city are important. These connections ensure the integration of the waterfront area with the inner parts of the city and make that area more accessible.

Five areas on the coastline of the Bosphorus were selected as the study area. Waterfront areas open to public use on the Anatolian Side are limited compared to the European Side. For this reason, the study areas were selected from the European Side. The coastline of the European side of the Bosphorus is divided into 1 km pieces. For each part, the number of connections reaching the coast from the inner parts of the city were determined. The two areas with the highest number of connections were İstinye (10) and Tarabya (7). In order to compare these two areas, connectivity and integration analyzes of both areas were made using the Depthmap program (Figure 3). As a result of the analysis, Tarabya's average connectivity and integration values were higher.

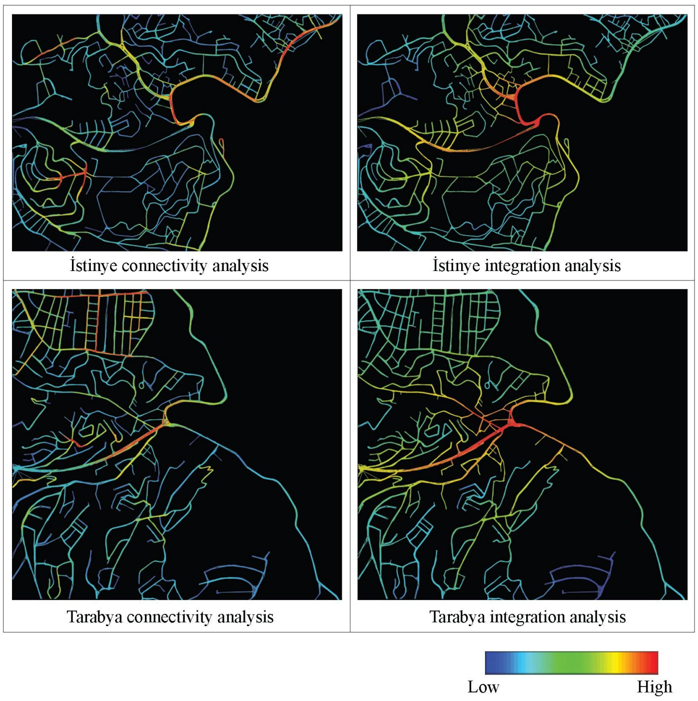


Figure 3: Comparison of the connectivity and integration analysis of İstinye and Tarabya.

In addition, the waterfront area in Tarabya offers more options to users compared to other areas. For this reason, Dr. Ahmet Sadık Park, which is located in Tarabya, was chosen as the study area with the most connections. In the study, this area will be mentioned as Tarabya Square. In addition to this area, other areas with few or no connections were also selected. Whether these areas have different functions and green areas was also taken into account.

The first of these is at the south of Tarabya Square. The number of connections and the variety of functions is low in this area and there is no green area. In the study, this area will be mentioned as Tarabya South Coast. The third area is at the north of Tarabya Square. There is no direct connection with the urban fabric here and the area is far from the connection points. The diversity of functions in this area is low and there is no green area. In the study, this area will be mentioned as Tarabya North Coast. The fourth and fifth areas are the Haydar Aliyev Park which is at the north of Tarabya Square and the waterfront area near this park (Figure 4). The number of connections in the park is few, but the variety of functions is high. In the waterfront area, there is no direct connection with the urban fabric, but the area is close to the connection points. The diversity of functions in this area is low, but there is a green area. In the study, these areas will be mentioned as Kireçburnu Park and Kireçburnu Coast. The number of connections, function and presence of green areas vary in the selected study areas (Figure 5). Thus, different situations like spatial connectivity, presence of green area, presence of urban equipment (play, sports area), visibility of opposite shore and presence of site-specific functions can be compared.

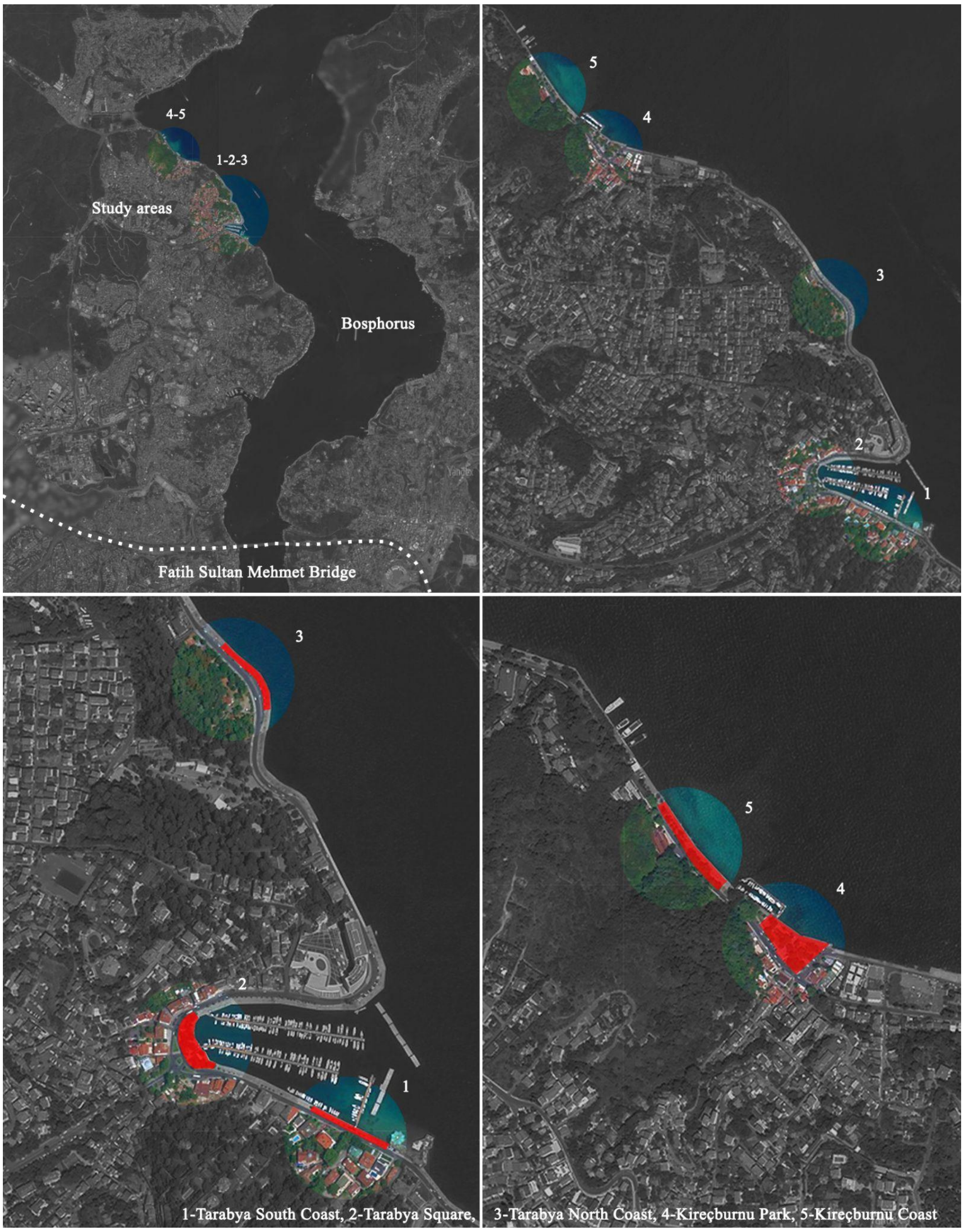


Figure 4: The location of the study areas.

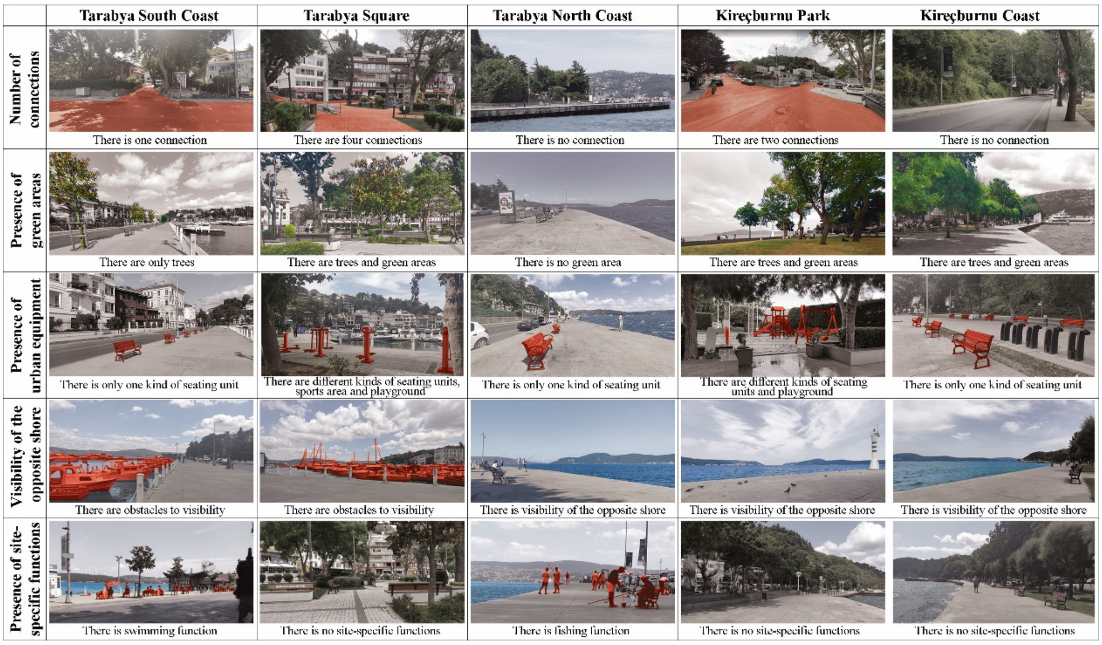


Figure 5: Comparison of spatial qualities of study areas.

Tarabya's coastal road was opened in the 1950s. Before the coastal road opened, the connection to the waterfront settlements was provided from the sea, due to the topography of the Bosphorus forcing transportation (Erkök, 2001). Although the coastal road provides a connection with the city center, it has also created a disconnection between the inner parts of the district and the waterfront area. Erkök (2001) states that the connectivity between the urban area and the waterfront area is completely cut off by making uninterrupted roads to all waterfront areas. This disconnection has diminished over time, because of the increase in connections starting inland and reaching the coastal road. In 1959, the historical road going down from the Tarabya hills to the coast was widened and the Tarabya-Hacıosman highway was opened. This new road comes to the front of Tarabya Park, where it connects to the coastal road. After the 1980s, construction in and around Tarabya increased rapidly and started to destroy the green areas (Kaya, 2019). This situation continues today. The yacht marina project planned for Tarabya Bay was completed in September 2012. Due to this project, the visibility of the opposite shore in this district has been interrupted.

4 EVALUATION OF FINDINGS AND RESULTS

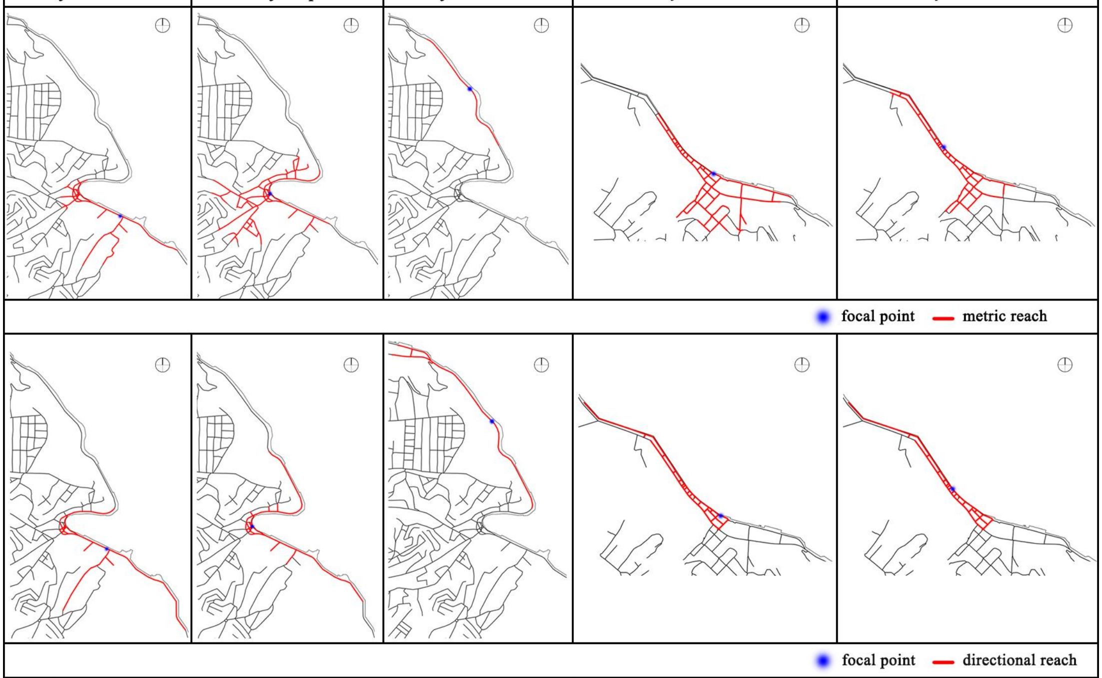
The findings obtained as a result of space syntax-based analyses, pedestrian movement and space usage in the selected study areas were analysed and interpreted separately, and then their relations were examined.

4.1 Evaluation of Space Syntax-Based Analysis

Spatial connection in all study areas was analysed as physical and visual connection as stated in the literature review. In all analyses, the focal points of the study areas were taken as the starting point and the focal points were chosen as the midpoint of each study area.

Physical Connectivity Analysis

Physical connectivity was measured by metric reach (distance threshold 400 m) and directional reach analyses (angle threshold 20°, number of direction changes 2). In both analyses, maps that scan the connections that can be reached with the determined threshold values were obtained. As a result of the analysis, the metric and directional reach values of each area were also calculated (Figure 6).



	Tarabya South Coast	Tarabya Square	Tarabya North Coast	Kireçburnu Park	Kireçburnu Coast
M.R.	2464.38	4344.35	800.00	3560.13	2725.07
D.R.	2379.65	2319.39	1670.96	1918.67	1918.67

M.R.:Metric Reach, D.R.:Directional Reach

Figure 6: Metric and directional reach values of study areas.

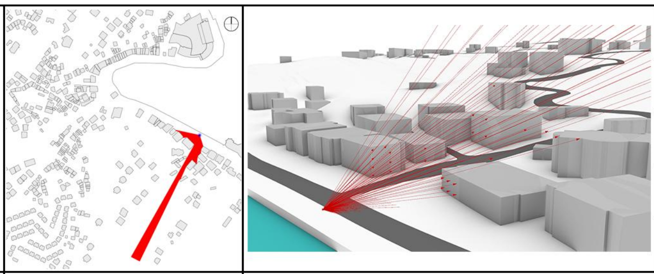
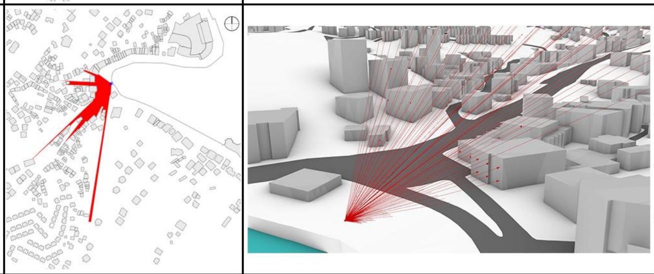
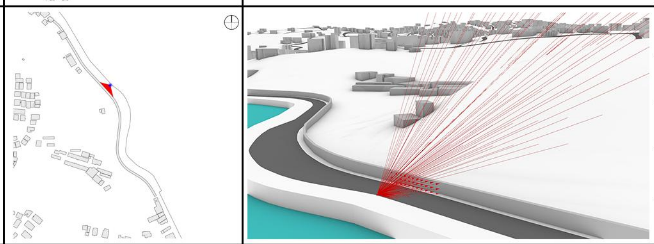
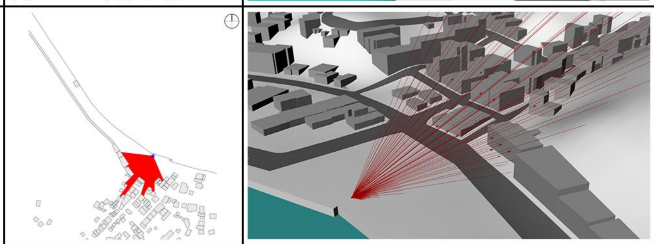
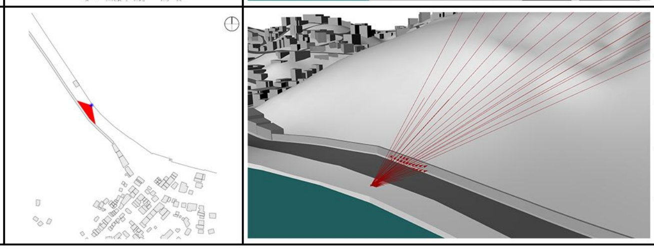
As a result of the metric reach analysis, the areas are ranked from the highest value to the lowest as follows: 1. Tarabya Square (4344.35), 2. Kireçburnu Park (3560.13), 3. Kireçburnu Coast (2725.07), 4. Tarabya South Coast (2464.38) and 5. Tarabya North Coast (800.00). Tarabya Square, which has the highest metric reach value, also has the highest number of connections. Kireçburnu Park ranks second in metric reach as well as in the number of connections. The metric reach value of Kireçburnu Coast, which is not connected with the urban fabric, is higher than Tarabya South Coast, which has only one connection. This is because the area is close to the connection points. The area with the lowest metric reach value is Tarabya North Coast, which is not connected to the urban fabric and is far from the connection points.

As a result of the directional reach analysis, the areas are ranked from the highest value to the lowest as follows: 1. Tarabya South Coast (2379.65), 2. Tarabya Square (2319.39), 3. Kireçburnu Park and Kireçburnu Coast (1918.67) and 4. Tarabya North Coast (1670.96). Tarabya South Coast, which has the highest directional reach value, has only one connection. While this area ranks fourth in metric reach, it has the highest value in directional reach. The reason for the high directional reach value of the area is that it has more linear paths than other areas. Thus, more areas were scanned until 20° turns for the third time, and the directional reach value became high. Although Tarabya Square has the highest number of connections, it ranks second in directional reach, yet its directional access value is very close to Tarabya South Beach. The value of Kireçburnu Coast, which has no connection with the urban fabric, is the same as Kireçburnu Park, which has two connections. The fact that the two areas are close to each other may have been effective in this case. The area with the lowest directional reach value is Tarabya North Coast, which also has the lowest metric reach value, isn't connected to the urban fabric and is far from the connection points.

As a result, physical connectivity values were also high in the study areas which have the highest number of connections. Tarabya Square has the highest value in metric reach and one of the highest values in directional reach. The physical connectivity values of the study areas were also low in the areas which are far from the connection points and that do not have a connection. Tarabya North Coast has the lowest value in both measures. Accordingly, metric and directional reach are consistent with each other and the number of connections.

Visual Connectivity Analysis

Visual connectivity was measured by two and three-dimensional visual connectivity analysis. In both analyses, maps and images scanning the area that can be seen with a radius of 400m and specified viewing angles were obtained. As a result of the analysis, two and three-dimensional visual connectivity values of each area were also calculated. In the three-dimensional visual connectivity, the arrow numbers and ratios that go to the sky, hit any physical obstructions and the ground are determined for each area. Since the arrows hitting the obstructions define the area we see, those arrow ratios were taken as the three-dimensional visual connectivity value (Figure 7).

Tarabya South Coast		Sky	30%
		Obstacle	***46%***
		Ground	24%
		2 Dimensional	8825.62
		3 Dimensional	0.46
Tarabya Square		Sky	39%
		Obstacle	***50%***
		Ground	11%
		2 Dimensional	9399.58
		3 Dimensional	0.50
Tarabya North Coast		Sky	44%
		Obstacle	***30%***
		Ground	26%
		2 Dimensional	363.09
		3 Dimensional	0.30
Kireçburnu Park		Sky	32%
		Obstacle	***47%***
		Ground	21%
		2 Dimensional	6021.37
		3 Dimensional	0.47
Kireçburnu Coast		Sky	37%
		Obstacle	***17%***
		Ground	46%
		2 Dimensional	921.46
		3 Dimensional	0.17

● focal point ■ visible area

Figure 7: Two and three dimensional visual connectivity values of study areas.

As a result of the two-dimensional visual connectivity analysis, the areas are ranked from the highest value to the lowest as follows: 1. Tarabya Square (9399.58), 2. Tarabya South Coast (8825.62), 3. Kireçburnu Park (6021.37), 4. Kireçburnu Coast (921.46) and 5. Tarabya North Coast (363.09). Tarabya Square, which has the highest two-dimensional visual connectivity value, also has the highest number of connections. The two-dimensional visual connectivity value of Tarabya South Coast, which has one connection, is higher than Kireçburnu Park, which has two connections. The reason for this situation is that Tarabya South Coast has more linear paths. Thus, there are fewer obstructions in the field of view. This allows more areas to be seen so the two-dimensional visual connectivity value becomes higher. In Kireçburnu, on the other hand, because the roads are more curved, obstructions enter the field of view and restrict the visible area. Kireçburnu Coast and Tarabya North Coast, which are not connected with the urban fabric, have the lowest two-dimensional visual connectivity values. Tarabya North Coast, which is located far away from the connection points, has the lowest two-dimensional visual connectivity value.

As a result of the three-dimensional visual connectivity analysis, the areas are ranked from the highest value to the lowest as follows: 1. Tarabya Square (0.50), 2. Kireçburnu Park (0.47), 3. Tarabya South Coast (0.46), 4 Tarabya North Coast (0.30) and 5. Kireçburnu Coast (0.17). Tarabya Square, which has the highest three-dimensional visual connectivity value, also has the highest number of connections. Kireçburnu Park ranks second in three-dimensional visual connectivity value as well as in the number of connections. Tarabya South Coast ranks third in three-dimensional visual connectivity value as well as in the number of connections. Kireçburnu Coast and Tarabya North Coast, which are not connected with the urban fabric, have the lowest values in three-dimensional visual connectivity. Among these areas, the three-dimensional visual connectivity value of Kireçburnu Coast is lower because there are no structures close to the coastline in the forested area and the topography is steeper than Tarabya North Coast. The order of the three-dimensional visual connectivity values, the number of arrows hitting the obstructions, is directly proportional to the number of connections. The reason is that with more connections a larger area enters the field of view making the inner parts of the urban fabric more visible. As the number of connections increases, the number of obstructions entering the field of view also increases.

As a result, the visual connectivity values were also high in the areas which have the highest number of connections. Tarabya Square has the highest value in both visual connectivity analyses. The visual connectivity values of the two unconnected areas -Tarabya North Coast and Kireçburnu Coast- were also low, which are ranked fourth and fifth in both analyses. Three areas connected with the urban fabric are in the first three ranks, while two unconnected areas are in the last two ranks in both analyses. Accordingly, two and three-dimensional visual connectivity are consistent with each other and the number of connections. In terms of both physical and visual connectivity values, Tarabya Square is always ranked first, while Tarabya North Coast and Kireçburnu Coast are usually in the last two ranks. Accordingly, the sub-components of spatial connectivity are also consistent with each other.

4.2 Evaluation of Pedestrian Movement and Space Usage Analysis

Figure 8 shows how the number of people passing through the areas varies in different time periods throughout the day. The areas are ranked according to the total number of people passing through from the highest to the lowest as follows: 1. Kireçburnu Coast (310), 2. Tarabya Square (294), 3. Kireçburnu Park (287), 4. Tarabya South Coast (283), and 5. Tarabya North Coast (188). The number of people passing through Tarabya North Coast is quite low compared to the others. The facts that this area has no connection with the urban fabric and is far from the connection points are thought to contribute to this result. While there is less pedestrian movement in all areas in the mornings and afternoons, pedestrian movement increases in the evenings and peaks at night. The reason that the number of people who prefer to walk along the coast is high at night, is that most people are working during the day, thereby only leaving the night as having free time to go for a walk.

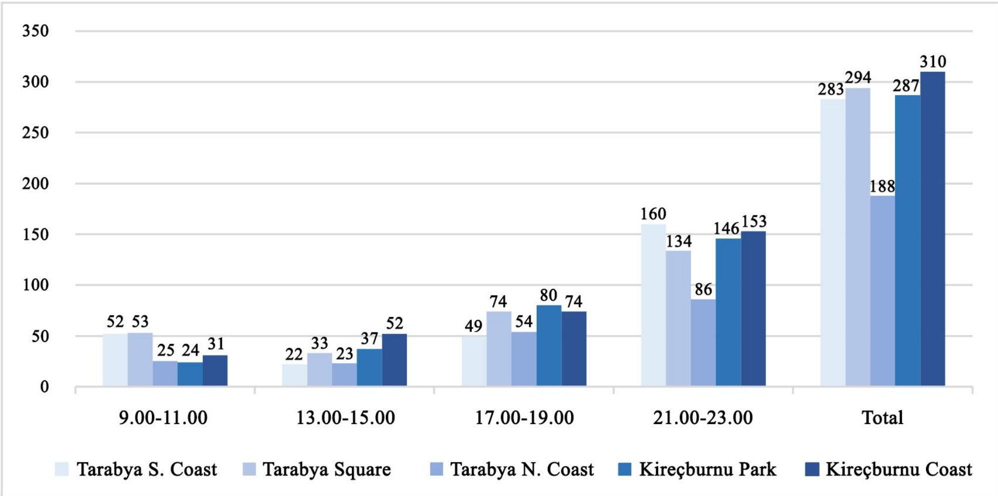


Figure 8: The number of people passing through according to observation hours and in total.

Figure 9 shows how the number of people using the areas varies in different time periods of the day. The areas are ranked from the most used to the least in total as follows: 1. Kireçburnu Park (934), 2. Kireçburnu Coast (921), 3. Tarabya Square (345), 4. Tarabya South Square (337) and 5. Tarabya North Coast (301). The number of people using the Kireçburnu Park and Kireçburnu Coast is quite high compared to the others. The facts that these places have the green areas which can be used actively and do not have obstructions that interrupt the visibility of the opposite shore are thought to be effective in this result. Tarabya North Coast, which doesn't have a connection with the urban fabric and is far from the connection points, has the least number of users. In all areas except Tarabya South Coast, while there is less usage in the mornings and afternoons, usage increases in the evenings and peaks at night. The reason that the number of people who prefer to spend time on the coast is high at night, is that they work during daytime can only spend time in the evenings. On the other hand, in Tarabya South Coast, the number of users decreases at night because the area doesn't have any urban equipment (play, sports area) and contains obstructions that prevent the visibility of the opposite shore.

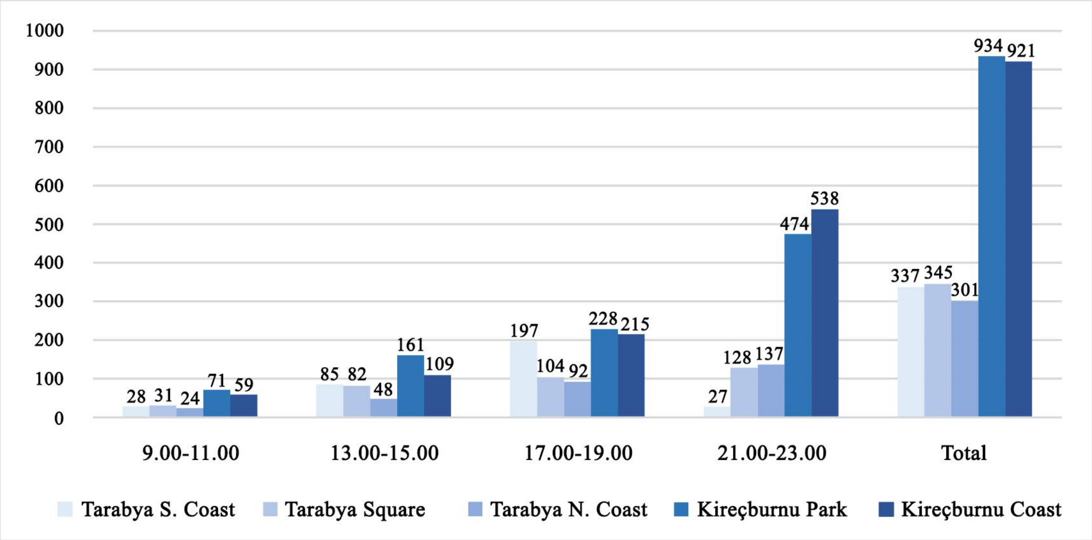


Figure 9: The number of people using the area according to observation hours and in total.

In Tarabya South Coast and Tarabya Square, it has been observed that both of the areas are mostly used for transition purposes in the morning and at night. People generally do sports in the morning and go for a walk at night in these areas. In both of the areas more spatial usage is provided than transition in the afternoons and evenings. Considering the increase of spatial usage in the afternoon, it can be said that Tarabya South Coast is used more intensively during rush hours. In Tarabya Square, the playground in the area, the presence of different types of seating units and green areas are effective to increase spatial usage.

In Tarabya North Coast, Kireçburnu Park and Kireçburnu Coast, more spatial usage is provided than transition at all hours. Only in the morning hours of Tarabya North Coast, the number of people passing through and using the area are almost the same. The view of all areas, the fishing site-specific function in Tarabya North Coast, the playground and different types of seating units in Kireçburnu Park are effective in increasing spatial usage. Also, the presence of large green areas suitable for use in Kireçburnu Park and Kireçburnu Coast affects the space usage positively. These areas are used for seating more than the seating units, especially during heavy usage hours.

Figure 10 shows the comparison of the total number of people passing through and using the area. In all areas, the total number of people using the area is more than the people passing through. But in Kireçburnu Park and Kireçburnu Coast, there is a considerable difference between the total number of people passing through and using the area. This is related to the large increase in spatial usage of these areas at night. The view, the playground, different types of seating units and the presence of large green areas are very effective in the high usage numbers.

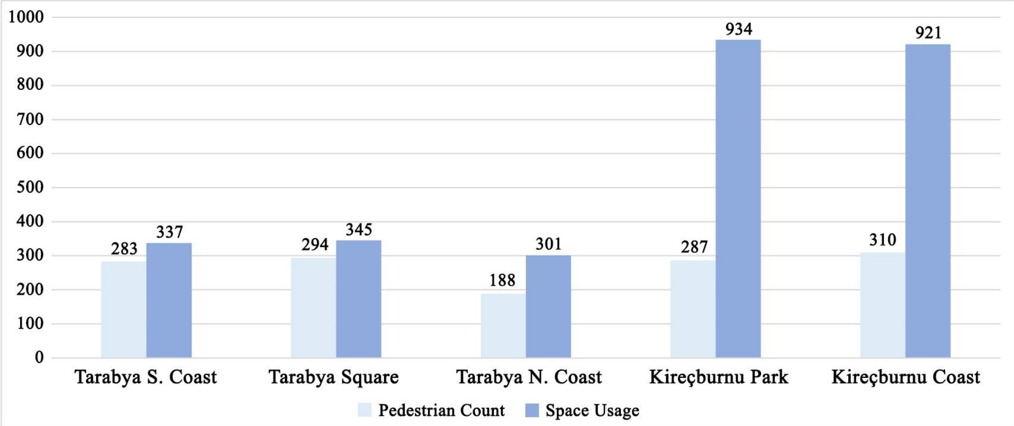


Figure 10: The total number of people passing through and using the area.

Figure 11 shows which parts of the areas are used and the density of the users in these areas. In the space usage maps of the areas, the density in Tarabya South Coast is mostly in the section where people can swim and the area in front of it. While the density in Tarabya Square is mostly on the seating units, in Tarabya North Coast it is on the seaside and the seating units. Similarly, in Kireçburnu Park and Kireçburnu Coast, people are mostly located in the sea-facing seating units and in the green areas close to the sea.

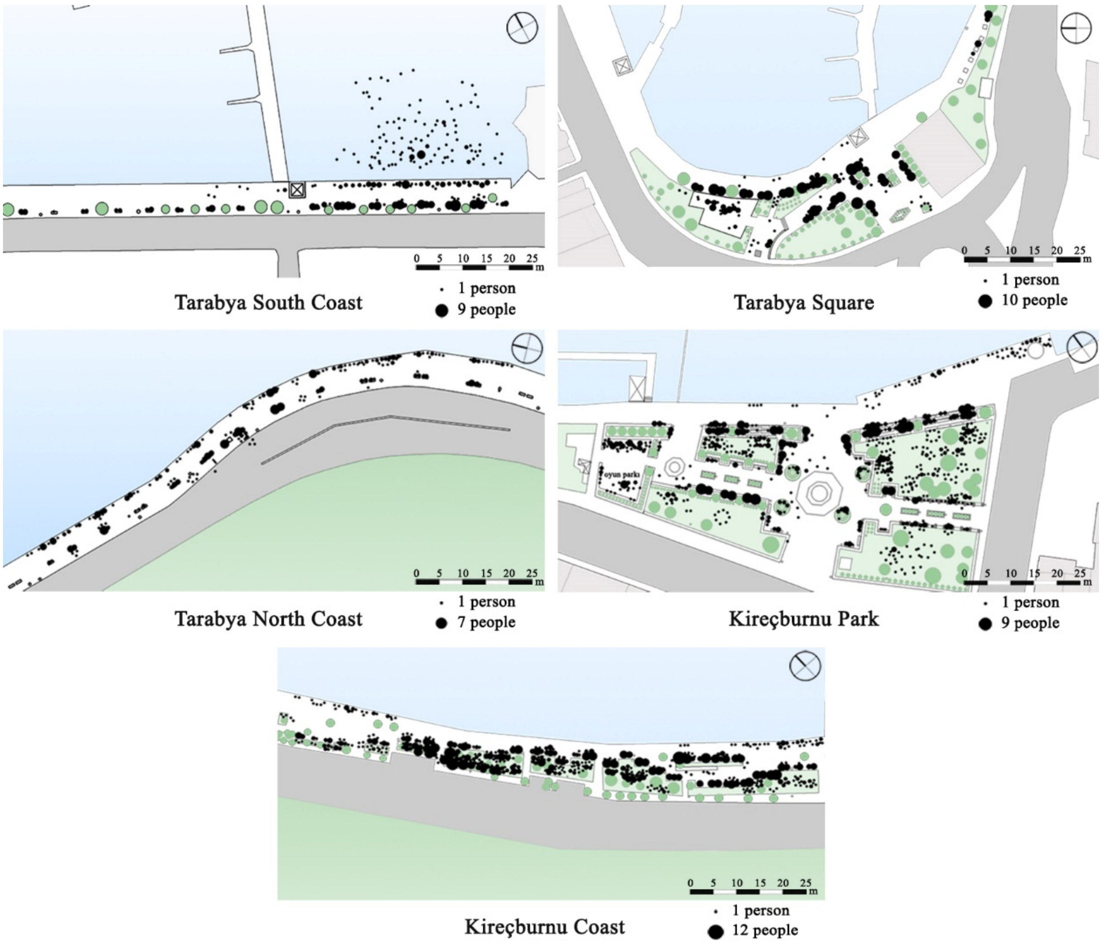


Figure 11: Space usage maps of the study areas.

Figure 12 indicates which activities there are and their rates for each area. In Tarabya South Coast, the area is mostly used for seating, followed by swimming. The site-specific swimming function is effective in increasing the usage of the area in front of the swimming part. In Tarabya Square, the area is mostly used for seating, then respectively, play and sports activities. The playground and sports field in the area contribute to the spatial usage. In Tarabya North Coast, the area is mostly used for seating. People mostly bring their own chairs but also use the seating units in the area. The site-specific fishing function ranks second in activity rates because the area is suitable for fishing due to its location. In Kireçburnu Park and Kireçburnu Coast, the areas are mostly used for seating. People who bring their own chairs are effective in that result. In addition to seating units, the green areas are also used mostly for seating, and it increases the space usage considerably. In Kireçburnu Park, play and sports activities rank second in activity rates. In addition to the playground, the green area is used for playing and sports as well.

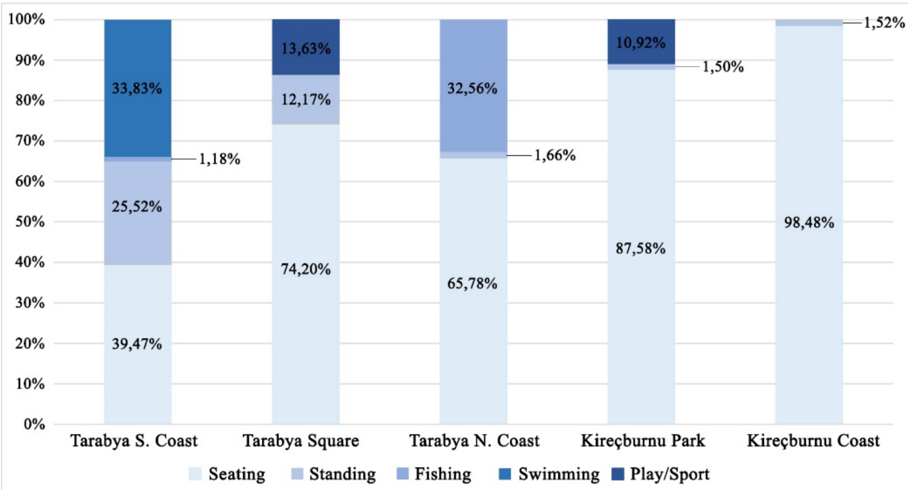


Figure 12: Activity rates of the study areas.

Finally, it can be said that the equipment such as playgrounds and sports fields in the waterfront areas, the presence of site-specific functions and the green areas that can be actively used positively affect the spatial usage.

4.3 Evaluation of Statistical Analysis

First, Spearman correlation analysis was performed to compare the sub-components of the spatial connectivity and pedestrian analysis separately with each other. Then, cluster analyses were made, and Mann-Whitney U tests were carried out to look at the effects of spatial connectivity, presence of green area, presence of urban equipment (playground, sports area), opposite shore visibility and presence of site-specific function on usage, based on the obtained clusters.

Spearman Correlation Analysis

The relationship between the components of the spatial connectivity and the pedestrian analysis was examined through Spearman correlation analysis (Table 2). As a result of the correlation analysis, there were only two values that were significant. A highly significant negative correlation was found between directional reach and the pedestrian count rate at 5:00 pm. On the other hand, there is a highly significant positive correlation between directional reach and the space usage rate at 1.00 pm. The higher directional reach means that the paths in the areas are more linear. This different result, which occurs in different time periods, does not give a general result.

Correlation Coefficients (r) Significance (p)		Physical Connectivity		Visual Connectivity	
		Metric Reach	Directional Reach	2 dim.	3 dim.
Pedestrian Count Rate-5.00pm	Correlation	0.000	***-0.738**	-0.400	0.000
	Significance	1.000	0.077	0.327	1.000
Space Usage Rate-1.00pm	Correlation	*0.200*	***0.738**	**0.600**	**0.600**
	Significance	0.624	0.077	0.142	0.142

r<0.200	very weak	***p<0.010	Significant at 99% confidence level
0.200≤r<0.400	*weak*	**p<0.050	Significant at 95% confidence level
0.400≤r<0.600	medium	*p<0.100	Significant at 90% confidence level
0.600≤r<0.800	**high**		
0.800≤r<1.000	**very high**		

Table 2: Spearman Correlation Analysis.

Apart from these two significant values, other values expressing high and very high levels of relationship were also obtained, but these values were not significant. The fact that a large number of areas could not be studied may have caused this result. In case of working in more fields, it’s expected that the coefficients expressing a higher level or above relationship would also be significant.

Cluster Analysis and Mann-Whitney U Test

Since most of the correlation coefficients were not significant, cluster analysis and Mann Whitney U Tests were performed. First, cluster analysis was made based on the four sub-components of spatial connectivity and the study areas were divided into two groups according to their similarities. In the first cluster, there are two areas with low spatial connectivity, Tarabya North Coast and Kireçburnu Coast, while in the second cluster, there are three areas with high spatial connectivity, Tarabya South Coast, Tarabya Square and Kireçburnu Park. After the cluster analysis, the Mann-Whitney U test was performed to look at the effect of spatial connectivity of these two groups on usage (Table 3).

		Physical Connectivity				Visual Connectivity			
		Metric Reach		Directional Reach		2 dimensional		3 dimensional	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Cluster	1	1762.54	1361.23	1794.82	175.16	642.28	394.83	0.24	0.09
	2	3456.29	944.28	2205.90	250.57	8082.19	1807.65	0.48	0.02
	Unified	2778.79	1330.30	2041.47	299.60	5106.22	4275.33	0.38	0.14

The effect of spatial connectivity on usage	Clusters	N	Mean	Std. Dev.	Std. Error Mean	Man U Z	P
Space Usage Rate-1.00pm	Low	2	0.14	0.03	0.02	0.000	***0.083**
	High	3	0.22	0.04	0.02	-1.732	

***p<0.100** There is variation at the 90% confidence level

Table 3: Cluster analysis and Mann-Whitney U test for spatial connectivity.

Only the space usage rate at 1.00 pm differs according to the level of spatial connectivity (p=0.083). According to the mean values, there is a positive relationship between the space usage rate at 1.00 pm and the level of spatial connectivity. The spatial connectivity causes an increase in the rate of people using the areas in the afternoon. The effect of spatial connectivity on usage was determined only at a certain observation time, and there was no significant difference in total values. The effect of the different features of the study areas on the usage was also examined. Cluster analysis was made based on the presence of green areas, and the study areas divided into two groups according to their similarities. In the first cluster, there are three areas with green areas, Tarabya Square, Kireçburnu Park and Kireçburnu Coast, while in the second cluster, there are two areas that don't have green areas, Tarabya South Coast and Tarabya North Coast. After the cluster analysis, the Mann-Whitney U test was performed to look at the effect of presence of green area on usage (Table 4).

The effect of green areas on usage		N	Mean	Std. Dev.	Std. Error Mean	Man U Z	P
Pedestrian Count-1.00pm	There is	3	40.67	10.02	5.78	0.000	***0.083**
	There is not	2	22.50	0.71	0.50	-1.732	
Pedestrian Count-5.00pm	There is	3	76.00	3.46	2.00	0.000	***0.076**
	There is not	2	51.50	3.54	2.50	-1.777	
Total Pedestrian Count	There is	3	297.00	11.79	6.81	0.000	***0.083**
	There is not	2	235.50	67.18	47.50	-1.732	
Space Usage-9.00am	There is	3	53.67	20.53	11.85	0.000	***0.083**
	There is not	2	26.00	2.83	2.00	-1.732	
Total Space Usage	There is	3	733.33	336.37	194.20	0.000	***0.083**
	There is not	2	319.00	25.46	18.00	-1.732	
Total Count (Pedestrian count+Space usage)	There is	3	1030.33	338.94	195.69	0.000	***0.083**
	There is not	2	554.50	92.63	65.50	-1.732	
Space Usage Rate-5.00pm	There is	3	0.26	0.04	0.02	0.000	***0.083**
	There is not	2	0.45	0.20	0.14	-1.732	

***p<0.100** There is variation at the 90% confidence level

Table 4: Mann-Whitney U test for the presence of green areas.

Both the total pedestrian count (p=0.083), the total space usage (p=0.083) and the total count (p=0.083) prove the effect of green area on the number of pedestrians passing through and using the area. According to the average values, there is a positive relationship between the total pedestrian count, the total space usage, total count, and the green areas. The green areas increase both the number of people passing through and using the areas.

A cluster analysis was carried out based on the presence of equipment (play, sports area) and the study areas divided into two groups according to their similarities. In the first cluster, there are two areas which have equipment, Tarabya Square and Kireçburnu Park, while in the second cluster there are three areas which do not have, Tarabya South Coast, Tarabya North Coast and Kireçburnu Coast. After the cluster analysis, the Mann-Whitney U test was performed to look at the effect of the presence of equipment on usage, but there was no significant difference in any of the values obtained. This shows that the presence of equipment has no effect on the usage of these areas.

Then, a cluster analysis was done based on the visibility of the opposite shore and the study areas divided into two groups according to their similarities. In the first cluster, there are three areas that have visibility and no obstructions, Tarabya North Coast, Kireçburnu Park and Kireçburnu Coast, while in the second cluster there are two areas that have no visibility and contain obstructions that affect the view, Tarabya South Coast and Tarabya Square. In these areas, boats in the marina obstruct the visibility of the opposite shore. After the cluster analysis, the Mann-Whitney U test was performed to look at the effect of opposite shore visibility on usage (Table 5).

The effect of opposite shore visibility on usage	Clusters	N	Mean	Std. Dev.	Std. Error Mean	Man U Z	P
Pedestrian Count-9.00am	Visible	3	26.67	3.79	2.19	0.000	***0.083**
	Not visible	2	52.50	0.71	0.50	-1.732	
Space Usage-9.00pm	Visible	3	383.00	215.43	124.38	0.000	***0.083**
	Not visible	2	77.50	71.42	50.50	-1.732	
Total Pedestrian Count Rate	Visible	3	0.29	0.08	0.05	0.000	***0.083**
	Not visible	2	0.46	0.00	0.00	-1.732	
Pedestrian Count Rate-9.00am	Visible	3	0.11	0.03	0.01	0.000	***0.083**
	Not visible	2	0.18	0.00	0.00	-1.732	
Pedestrian Count Rate-1.00pm	Visible	3	0.14	0.02	0.01	0.000	***0.083**
	Not visible	2	0.09	0.02	0.02	-1.732	
Space Usage Rate-9.00am	Visible	3	0.07	0.01	0.00	0.000	***0.083**
	Not visible	2	0.09	0.00	0.00	-1.732	
Space Usage Rate-1.00pm	Visible	3	0.15	0.03	0.02	0.000	***0.083**
	Not visible	2	0.24	0.01	0.01	-1.732	
Space Usage Rate-9.00pm	Visible	3	0.52	0.06	0.04	0.000	***0.083**
	Not visible	2	0.23	0.21	0.15	-1.732	

***p<0.100** There is variation at the 90% confidence level

Table 5: Mann-Whitney U test for the visibility of opposite shore.

The pedestrian count, pedestrian count rate and space usage rate values at different observation hours differ according to the visibility of the opposite shore. According to the mean values, there is a negative relationship between the pedestrian count at 9.00 am, the total pedestrian count rate, the pedestrian count rate at 9.00 am, the space usage rate at 9.00 am and 13.00 pm, and the visibility of the opposite shore. There is a positive relationship between the space usage at 9.00 pm, the pedestrian count rate at 1.00 pm, and the space usage rate at 9.00 pm and the visibility of the opposite shore. In this case, visibility of the opposite shore increases the number of people using the areas at night.

Finally, a cluster analysis was made based on the presence of site-specific functions and the study areas divided into two groups according to their similarities. In the first cluster, there are Tarabya South Coast with a swimming function and Tarabya North Coast with a fishing function, while in the second cluster there are three areas that don't have site-specific functions, Tarabya Square, Kireçburnu Park and Kireçburnu Coast. After the cluster analysis, Mann-Whitney U test was performed to look at the effect of the presence of site-specific function on usage (Table 6).

The effect of site-specific functions on usage	Clusters	N	Mean	Std. Dev.	Std. Error Mean	Man U Z	P
Pedestrian Count-1.00pm	There is	2	22.50	0.71	0.50	0.000	***0.083**
	There is not	3	40.67	10.02	5.78	-1.732	
Pedestrian Count-5.00pm	There is	2	51.50	3.54	2.50	0.000	***0.076**
	There is not	3	76.00	3.46	2.00	-1.777	
Total Pedestrian Count	There is	2	235.50	67.18	47.50	0.000	***0.083**
	There is not	3	297.00	11.79	6.81	-1.732	
Space Usage-9.00am	There is	2	26.00	2.83	2.00	0.000	***0.083**
	There is not	3	53.67	20.53	11.85	-1.732	
Total Space Usage	There is	2	319.00	25.46	18.00	0.000	***0.083**
	There is not	3	733.33	336.37	194.20	-1.732	
Total Count (Pedestrian Count+Space Usage)	There is	2	554.50	92.63	65.50	0.000	***0.083**
	There is not	3	1030.33	338.94	195.69	-1.732	
Space Usage Rate-5.00pm	There is	2	0.45	0.20	0.14	0.000	***0.083**
	There is not	3	0.26	0.04	0.02	-1.732	

***p<0.100** There is variation at the 90% confidence level

Table 6: Mann-Whitney U test for the presence of site-specific functions.

The values of pedestrian count, space usage and space usage rate at different observation hours differ according to the presence of a site-specific function. The significant differentiation in the total pedestrian count (p=0.083), the total space usage (p=0.083) and the total count (p=0.083) values proves the effect of site-specific functions on both the number of pedestrians passing through the area and usage. Considering the average values, there is a negative relationship between the total pedestrian count, the total space usage, the total count, and the presence of site-specific functions. The reason is that there are only two areas with site-specific functions and the number of people in the other three areas is much higher than these two areas. These two areas (Tarabya South Coast and Tarabya North Coast) reach more users because of their unique functions. If there were no site-specific functions in these areas, the number of users would be much lower.

When there are no users doing site-specific activities, there will be a decrease in the number of people using these low connected areas. This situation may change the relationship between the level of spatial connectivity and the number of users. In this new situation, the number of users in domains with few connections is further reduced.

As a result of all Mann-Whitney U tests, it's possible to say that pedestrian movement and space usage are not only based on spatial connectivity. Different factors such as the presence of green area, the presence of equipment (play, sports area), the visibility of the opposite shore and the presence of site-specific functions also affect pedestrian movement and space usage. Among these variables, it has been observed that the presence of green areas and the presence of site-specific functions have a strong positive effect on pedestrian movement and space usage.

5 CONCLUSIONS

This study aimed to investigate the effects of spatial connectivity on pedestrian movement and space usage so that waterfront areas can be more liveable and a part of the urban structure through spatial connectivity. The findings obtained from the space syntax analysis methods and the observations were evaluated together where the following results were reached:

• When the spatial connectivity analysis and systematic observation results were evaluated comparatively, it was seen that the spatial connectivity positively affected the number of people passing by and using the area. Therefore, as the spatial connectivity increases, the number of people, both passing by and using the area increases. This result is consistent with the results of the studies in the literature (Hillier et.al, 1993; Hess, 1997; Randall and Baetz, 2001; Saelens et.al, 2003; Hajrasouliha and Yin, 2015). However, no significant effect of spatial connectivity was found in the correlation analysis. There could be two reasons for this. First, since one side of the waterfront area is the sea, there is a unilateral connection with the inner parts of the city. The other reason is that the study could not be done in more areas due to pandemic conditions. If the number of study areas could be increased, more meaningful results could be obtained.

• The number of users was obtained high in the areas with high physical and visual connectivity based on observations. Physical connectivity makes the space accessible and visual connectivity makes it visible. These features attract the attention of people and encourage them to use the space. It's possible to include idle waterfront areas into urban use by strengthening the spatial connectivity. However, spatial connectivity isn't the only variable for increasing space usage based on the Mann Whitney U tests results. In addition to the accessibility of waterfront areas, the opportunities they host also play an important role in usage. Different features like green area, urban equipment (play and sports area), the visibility of the opposite shore and the site-specific functions also affect pedestrian movement and space usage. In particular, the positive effect of the presence of green area and site-specific functions on pedestrian movement and space usage is quite strong.

Analysing the visual connectivity by considering the third dimension can be an evaluation method that will contribute to further studies. What needs to be done to make waterfront areas a part of the city and an area that is actively used is to strengthen the spatial connectivity, to increase and diversify the equipment in the waterfront areas, especially the green areas. Thus, waterfront areas become easily accessible urban public spaces that allow users to engage in different activities. To consider the city as a whole and to provide flow in it, it's necessary to care about the spatial connectivity established between urban public spaces. In further studies, urban areas with different topological and morphological characteristics in the inner parts of the city can be examined in terms of spatial connectivity and compared with waterfront areas. Local governments and professionals working in the fields of urban design and landscape design can benefit from the results of this study. Findings obtained through this study can also shed light on urban design guidelines.

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