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Positive Effects of Morphological and Perceptual Boundary Factors on Vitality in the Static Activity Streets: Syntactic and Fractal Approaches

Fatma Arzu Tibet*
Berrin Akgün**

Abstract

Street vitality is a concept that makes the city more liveable with its economic and sociological gains. Static activities on the street contribute to vitality by supporting social interaction. This study investigates the positive effects of the perceptual and morphological boundary characteristics of static activity streets on the user. Using Space Syntax and fractal method, this research consists of two phases and the use of two different scales. The first step involves analysing the connectivity and enclosure factors of 13 static activity streets in Balıkesir city center at the street scale. By correlating the analysis results with the number of users determined by the observation method, the effect of street-scale boundary factors on user behaviour was determined. As a result of the first step, Aygıt Street, which has the highest boundary factor value at the street scale, was selected for the second step of the research, which is the building-scale analysis. The surrounding and permeability factors that create boundary effects at the building scale were analysed through street facades and sections, and the value was evaluated together with the areas preferred by people engaged in static activities. As a result of the correlation analysis between the boundary factor value and user behaviour, it has been determined that the connectivity, which creates a morphological boundary effect at the street scale, and the enclosure factor, which creates a perceptual boundary effect, positively affect the users. It was determined that elements such as awnings, eaves, flower beds, and signboards, which determine the surrounding factor that creates a morphological boundary effect at the building scale, increase the number of users. It is concluded that the wall surfaces on the street facades, which determine the permeability factor that creates a perceptual boundary effect at the building scale, positively affect user behaviour. The model created in this study, which brings together two different approaches, namely urban and architectural scales and morphological and perceptual boundary factors, is intended to form a basis for the design processes of spaces and streets that support static activities in cities.

Keywords:
Fractal geometry, Morphological boundary, Perceptual boundary, Space syntax, Static activity.

* Department of Architecture, Faculty of Architecture, Balıkesir University, Balıkesir, Turkey. (*Corresponding author*)
Email: arzu.tibet@gmail.com

**Department of Architecture, Faculty of Architecture, Balıkesir University, Balıkesir, Turkey.
Email: bakgun@balikesir.edu.tr

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INTRODUCTION

"A boundary is not that at which something stops but, as the Greeks recognized, the boundary is that from which something begins its presencing."

(Heidegger, M., 1971)

Street vitality is an important theme in the leading works on urban spaces by many well-known researchers in the literature (Jacobs, 1961; Alexander et al., 1977; Whyte, 1980; Carmona et al., 2003; Gehl 2011). Researchers have developed theories by examining vitality based on walking activity (Hillier & Hanson, 1984; Kubat, 2013; Ewing & Handy, 2006). Streets contribute to vitality in daily life by being used not only for people to walk but also for static activities such as sitting, eating and drinking, and resting. Researchers have defined static activities that create vitality on the streets that include standing, meeting, sitting, seeing, hearing and speaking (Whyte, 1980; Mehta, 2009; Mahdzar, 2013; Gehl, 2011; Gürer, 2017).

The morphological and perceptual factors created by the street and the surrounding environment on the street affect human behaviour (Jacobs, 1961; Shultz 1971; Alexander et al., 1977; Carmona et al., 2003).

Researchers have suggested that a low number of street connections has a restrictive effect on pedestrian movement and that this feature affects user behaviour (Jacobs, 1961; Hillier & Hanson, 1984). Whyte (1980) observes that static activities tend to take place in long and narrow spaces that have stronger boundary effects, creating a sense of enclosure in people. While structural architectural elements such as awnings, flower beds, glass panels surround static activity spaces (Ewing, 2006; Gehl, 2011), while impermeable walls on the streets create a boundary effect at the architectural scale (Mehta, 2009; Ataol, 2013) create a boundary effect at the architectural scale. There are studies in the literature that address the relationship between urban space and boundary factors at different scales (Whyte, 1980; Gehl, 2011; Mehta, 2009; Farahani & Beynon, 2015; Hassan et al., 2019).

In the literature, studies have been conducted with different approaches to the level of accessibility of static activity spaces (Mahdzar, 2008), including as a component of vitality (Mehta, 2006; Gehl, 2011), the relationship between the morphological structure of these spaces and user behaviour (Alexander et al., 1977; Montgomery, 1998), and the duration of use of static activity spaces (Gehl & Svarre, 2013). However, only one of these approaches is typically accepted in studies on static activity. There is no model that examines static activity streets at both street and building scales with numerical tools, evaluates two different approaches based on morphological and perceptual boundary factors together, and combines them with user behaviour (Figure 1). This study aims to fill this gap by combining two different approaches to reveal the importance of the boundary factors that are effective in the formation of

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static activity spaces not only at the urban scale but also at the architectural scale.

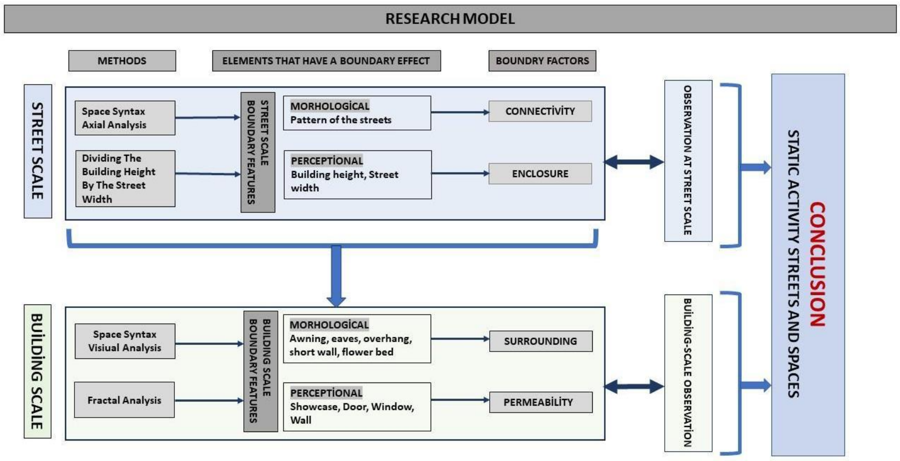

Figure 1. Research model.

Space Syntax, one of the two main methods used in this study, is a set of theories and techniques that analyse the spatial constructions of cities and buildings and how these constructions function at different scales (Hillier & Hanson, 1984; Kubat et al., 2007). The Space Syntax method is effectively used today as a model that offers the opportunity to analyse this spatial network created based on the linear movement and visual perceptions of people. In the research, the Space Syntax axial analysis connectivity value was used to measure the connectivity factor that creates a boundary effect at the street scale. The surrounding factor that creates a boundary effect at the building scale was measured with the Space Syntax visibility analysis controllability value. Ostwald et al. (2008) argued that while an increasing number of scientific or computational tools have been developed for the analysis of architectural plans (Space Syntax), methods for investigating their visual properties are limited. Consequently, the researcher underlined the necessity of applying different methods for the analysis of building heights and the construction of facades (including visual qualities) and emphasized the importance of fractal geometry. The perceptual boundary factor permeability value, which creates a boundary effect at the building scale, was analysed with the fractal method.

This paper focuses on the positive effects of morphological and perceptual boundary factors on static activity streets. In this study, streets used for activities such as sitting, eating, drinking, resting, and meeting, where tables and chairs were spread over the street area in a way that affects pedestrian flow, were named static activity streets. The aim of the research is to analyse static activity streets in terms of morphological and perceptual boundary factors at street and building scales with quantitative methods and to develop a method that reveals the positive impact of these factors on users. The boundary factors considered in the study were connectivity and enclosure at the street scale, and surrounding and permeability at the building scale. The research, in which the streets in Balıkesir city center were selected as the study area, consists of two steps. One of the objectives of the first step was to determine the relationship between street-scale boundary factors and user behaviours in 13 static activity streets. The second objective was to identify the streets most affected by the street-scale boundary factors. In the second step, the street with the highest street-scale boundary effect was analysed in terms of building-scale boundary factors and evaluated together with the number of people using the static activity spaces (Figure 1). The hypotheses in this study are as follows:

Hypotheses at Street-Scale

- The connectivity factor, which comes from street-scale boundary characteristics, positively affects the use of static activity streets. Streets with fewer connections are used more for static activities, and the number of users increases as the number of connections decreases.
- The enclosure factor, which creates a boundary effect on the streets, positively affects the number of users in a static activity street. As the level of street enclosure increases, the number of users also increases.

Hypotheses at Building-Scale

- The higher the surrounding factor that creates a boundary effect at the building scale, the higher the number of users. The number of structural elements that create a boundary effect will positively affect the number of users in a static activity street.
- The permeability level of facades at the building scale will affect static activity. Facades with impermeable walls increase the number of users in static activity streets.

In urban space, the design of streets where static activities take place contributes significantly to vitality. The knowledge of morphological and perceptual boundary factors on static activity streets can be used to improve these streets, making these areas more liveable.

This paper is organized as follows:

The literature section presents the theoretical framework, focusing on the concept of boundaries and static activity in streets. The next section details the methodology and materials used to measure static activity and boundary relationships, and provides information about the study area. The findings section presents the relationship between the analysis of boundary factors and the counts of static activity users. The study concludes with a discussion and conclusions.

LITERATURE REVIEW

In the literature, morphological and perceptual boundary factors that affect static activity influence user behaviour and contribute to vitality in urban spaces (Jacobs, 1961; Alexander et al., 1977; Montgomery, 1998; Carmona & Tiesdell, 2007). Researchers have examined boundary factors at the street scale (Hillier & Liada, 2005; Songülen, 2012; Gehl, 2019; Ya, 2021) and building scale (Mehta, 2006; Gehl, 2011; Farahani & Beynon, 2015; Hassan et al., 2019).

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At the street scale, the connectivity of streets has a limiting effect on urban morphology and affects the purposes of use (Hillier & Hanson, 1984; Özer, 2014). The connectivity value, which indicates the connectivity of the streets, guides the determination of the level of accessibility (Körmeçli, 2023). Long blocks on streets with low connectivity create a boundary effect at the street scale (Jacobs, 1961; Hillier & Hanson, 1984; Carmona et al., 2003; Van Nes & Yamu, 2021).

The enclosure factor, which creates a perceptual boundary effect at the street scale, is defined as the building height to street width ratio (Stamps, 2002; Cooper & Oskrochi, 2013; Akbarishahabi, 2017). Enclosure is a perception created by the continuity of buildings. This feature has been recognized as one of the boundary qualities that affect perception in spatial organization (Cullen, 1961; Alexander et al., 1977; Cooper & Oskrochi, 2013). The enclosure factor creates a sense of belonging by establishing human-scale spaces and positively affects static activities on the streets (Whyte, 1980; Gehl, 2011; Akbarishahabi, 2017).

The building scale includes values on specific parts of the street, such as facade mobility, permeability, walls, awnings, and flower beds, and refers to the level of observation focused on the building itself (Akbarishahabi, 2022).

In streets, building-scale structural elements such as awnings, canopies, eaves, and short walls create a boundary effect by surrounding static activity places (Ewing & Handy, 2006; Gehl, 2011; Hassan et al., 2019). The sense of enclosure that such architectural elements create in static activity spaces on the streets generates a sense of security in people (Mehta, 2006; Farahani & Beynon, 2015).

Permeability, which researchers consider a building-scale factor in streets, affects static activity (Mehta, 2009; Hassan et al., 2019). At the building scale, doors, windows, and storefronts create important openings in terms of physical or visual relationships and function as permeability (Schulz, 1971; Gehl, 2019). The ratio of doors, windows, and transparent surfaces on street facades affects static activity by creating a wall effect on permeable facades (Ewing & Handy, 2006; Mehta, 2006; Hassan et al., 2019).

The fundamental idea of Space Syntax is derived from the effort to understand evolution and flows within the city: analysing the form of a built environment to understand evolution by examining social activities like human movements within the city. The axial line-based representation of a city's structure is the oldest approach to space syntax (Hillier & Hanson, 1984). Axial lines are used to represent continuous movement and visibility directions, thus representing the longest visibility lines in two-dimensional urban areas (Hillier & Hanson, 1984; Özer, 2014). The connectivity value is obtained by analysing the axial map in the Space Syntax method, showing the number of lines directly connected to each street in an urban system, and lines with a high value provide direct access to other lines (Gündoğdu & Dinçer, 2020).

Hillier argues that the utilization of open spaces is closely tied to the visibility field or isovist properties of space. This suggests that the visual field created by the spatial configuration significantly influences human behaviour. In this context, Turner (2007) suggests that visibility analysis can be used to discuss the morphological characteristics of the built environment, as well as how people can navigate or engage with the visible space. It can also help uncover the importance of objects located within that space. Visual controllability is a concept in space syntax theory proposed by Turner (2007). It focuses on identifying areas within a built environment that may be easily visually dominated by others. This concept helps in understanding how certain spaces can be visually controlled or influenced by the surrounding environment or users.

In the late 1970s, Benoit Mandelbrot proposed that natural systems often exhibit characteristic geometric complexity at different scales, leading to the formulation of fractal geometry in mathematics. Architectural designers, embracing fractal geometry a few years after Mandelbrot's initial formulation, have more widely used it for the analysis of the built environment (Mandelbrot, 1982). Fractal analysis is used as a tool to assess the characteristics of street images (Cooper & Oskrochi, 2008). The fractal method, which analyses the street texture through street images, generates value by calculating the heights of the buildings, decorations, width of the street, landscape elements, silhouette, and other third-dimensional elements. Spaces with fractal characteristics lead to the formation of sensations such as peace, satisfaction, liking, comfort, and happiness in individuals psychologically (Cooper et al., 2008; Kalavi, 2021). Fractal dimension analysis is a method used to measure the relative density and diversity of geometric information in an image or object. To examine architectural design, it is necessary to look at mass movements, door-window openings, and window details at every scale (Ostwald & Vaughan, 2016).

MATERIALS AND METHOD

Study Area

For the study area, 13 streets with static activity spaces in Balıkesir, Turkey, city center were selected. The reasons for the selection of these streets include:

- Location within the boundaries of the central business district determined by local governments.
- Pedestrian streets.
- Proximity to shopping centers and transportation options.

The selected static activity streets had low pedestrian activity. The centerline of the street was primarily used for movement, and the majority of the people were static activity users. These streets have spaces for sitting, resting, meeting, and other activities, and they exhibit a changing user profile throughout the day (Figure 2).

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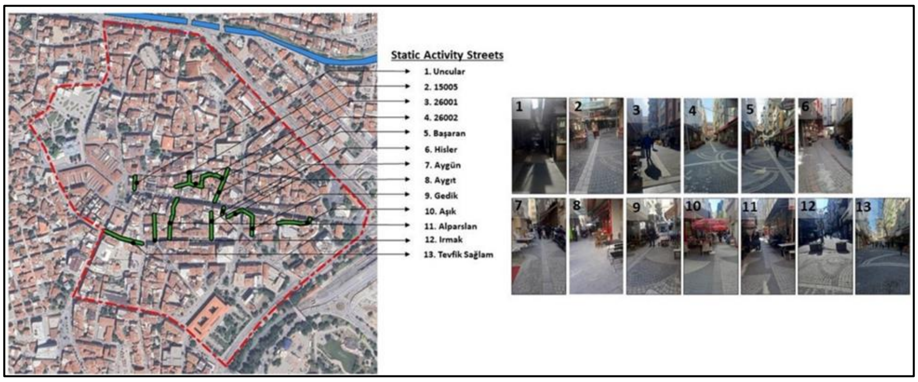

Figure 2. Static activity streets in Balıkesir, Turkey city center. Source: Author.

Data acquisition method

Data on static activity streets were obtained in two steps: street scale and building scale. As a result of determining the boundary factors of the 13 streets that constitute the first step of the research, Aygıt Street, with the highest boundary factor, was selected for the building scale analysis. Additionally, in the first step, the effect of the boundary factors at the street scale on users engaged in static activity was determined (Figure 3).

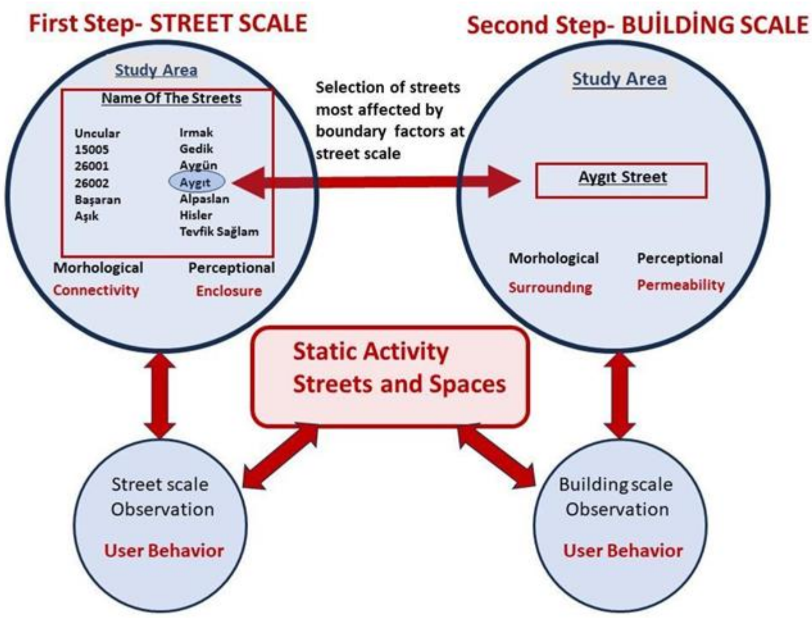

Figure 3. Stages of analysis based on the effects of boundary factors on static activity.

Data Collected at Street Scale:

- Obtaining the connection value of 13 streets with Space Syntax axial analysis.
- Determining the building height/street width ratios of 13 street sections.
- Determining the number of users engaged in static activity as a result of observations made on the streets on three days of the week (Monday, Wednesday, Saturday) and during two different time periods (12:00-13:00; 16:00-17:00).

The criteria that were effective in the selection of the days and hours for counting on the streets are as follows:

Monday was the most preferred day for users coming from rural areas of the Balıkesir city center and therefore offered a variety of users. Wednesday was chosen to determine how many people use the streets on an ordinary day between the other two busy days. Saturday was the only holiday on which shops are open, making it one of the most preferred days in the city center. The selected interval of 12:00-13:00 was chosen because the static activity spaces in the city center are primarily used by employees during these hours. The 16:00-17:00 interval was chosen because it is the time period most used by urbanites shopping in the Balıkesir city center.

Data Collected at Building Scale:

- The controllability value, which determines the surrounding factor at the building scale, was obtained through Space Syntax visibility analysis.
- Fractal analysis provided the permeability value of the facades at the building scale.
- At the building scale, the areas of the street most used by users between 16:00-17:00 on Saturday, when static activity was highest in the previous census, were identified and evaluated together with the boundary data.

Data Analysis

The axial analysis of the Space Syntax method, used in morphological research in urban spaces, was utilized in this study to measure the connectivity factor at the street scale. The data for the study were obtained by drawing axial maps of the streets using AutoCAD software and analysing them with Depthmap software. The sections with low connectivity are long blocky streets where the boundary factor is strong (Jacobs, 1961; Peponis et al., 2007).

The enclosure factor, which creates a perceptual boundary effect at the street scale, was determined by calculating the building height/street width ratio. At the street scale, enclosure creates a perceptual boundary effect (Whyte, 1980; Kaplan et al., 1998).

In the building-scale morphological analysis, the surrounding factor was evaluated using the visibility analysis controllability value from the Space Syntax Depthmap software. Visibility calculates how each grid relates to all other grids in the system (Turner, 2007). Visual analysis is applied by adding eye-level awnings, recesses, signs, canopies, and other elements that create visual barriers on the streets to the plan drawing. The controllability value of static activity spaces indicates the level of influence of the surrounding factor.

The permeability factor at the building scale was analysed using the fractal method. Researchers have analysed building facades, doors/windows, storefronts, and other elements that provide permeability using the fractal method (Ostwald et al., 2008; Kaya, 2010; Ediz & Çağdaş, 2007). In this study, the outline + primary form was used among the five representation forms (Ostwald et al., 2016).

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In the first step of the study, to measure the positive impact of boundary factors on user behaviour, users engaged in static activities on 13 streets on three days of the week (Monday, Wednesday, Saturday) and in two different time periods (12:00-13:00, 16:00-17:00) were counted by observation. The relationship between the user count results and the boundary factor data at the street scale was obtained through correlation analysis. At the building scale, users were observed and counted on Saturdays between 16:00-17:00 to determine which street areas were preferred by users for static activity.

FINDINGS

First Step: Morphological and Perceptual Findings at Street Scale

The connectivity value, which creates a morphological boundary effect at the street scale, and the enclosure factor, which creates a perceptual boundary effect, were evaluated together with the number of users on the static activity streets.

Connectivity Factor

The connectivity value of the streets, produced based on axial analysis, determines the intersection of the streets and the level of their relationship with other streets on a colour scale ranging from red to blue. Red represents the highest, and blue represents the lowest connectivity value.

Figure 4. Connectivity value of static activity streets.

The connectivity values of the 13 static activity streets in the study area were evaluated internally. These values ranged between 2 and 4 (Figure 4). In the study area, 6 streets had 2 connections, indicating long blocks and thus a high boundary effect.

Streets 5, 6, and 10 had high connectivity values, indicating the lowest boundary effect. Streets 1, 8, 9, 11, 12, and 13 had a connectivity value of 2, suggesting these areas exhibited the highest boundary characteristics within the group. Streets with the lowest connectivity factor were considered to have the highest boundary effect (Table 1).

Table 1. Connectivity value of static activity Streets.

	Streets name	Connectivity Value
1	Uncular Street	2
2	15005 Street	3
3	26001 Street	3
4	26002 Street	3
5	Başaran Street	4
6	Hisler Street	4
7	Aygün Street	3
8	Aygıt Street	2
9	Gedik Street	2
10	Aşık Street	4
11	Alpaslan Street	2
12	Irmak Street	2
13	Tevfik Sağlam Street	2

Enclosure Factor Data

The enclosure factor, a perceptual boundary effect, was calculated by dividing the building height by the street width. Enclosure contributes to a sense of comfort and safety (Carmona, 2003; Akbarishahabi, 2017).

Aygıt Street exhibited the highest enclosure factor with a value of 8.6. Streets 2, 8, 9, and 11 had an enclosure level of 6 and above. Among these, Street No. 1 had the lowest enclosure effect (Table 2).

Table 2. Enclosure value of static activity street

	Streets name	Enclosure Value
1	Uncular Street	3
2	15005 Street	7
3	26001 Street	3,75
4	26002 Street	4,8
5	Başaran Street	4,5
6	Hisler Street	4,3
7	Aygün Street	3,4
8	Aygıt Street	8,6
9	Gedik Street	7
10	Aşık Street	4
11	Alpaslan Street	6
12	Irmak Street	3,6
13	Tevfik Sağlam Street	4,5

In the analyses conducted to evaluate the morphological and perceptual boundary characteristics at the street scale, connectivity and enclosure factors were determined for 13 streets. In Table 3, the effect of

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these boundary factors is represented using symbols ***, **, and * in order of value from higher to lower.

The boundary effect of the connectivity factor is inversely related to the number of connections. Streets with fewer connections exhibit a higher boundary effect. Conversely, the enclosure factor's boundary effect is positively related to its value. As the enclosure value increases, so does the boundary effect.

Table 3. Boundary impact levels of static activity streets.

	Streets name	Connectivity Value	Enclosure Value
1	Uncular Street	2***	3
2	15005 Street	3**	7**
3	26001 Street	3**	3,75
4	26002 Street	3**	4,8
5	Başaran Street	4*	4,5
6	Hisler Street	4*	4,3
7	Aygün Street	3**	3,4
8	Aygıt Street	2***	8,6***
9	Gedik Street	2***	7**
10	Aşık Street	4*	4
11	Alpaslan Street	2***	6*
12	Irmak Street	2***	3,6
13	Tevfik Sağlam Street	2***	4,5

Note: The impact levels of the boundary factor are evaluated as ***, ** and * from high to low.

According to the table above, Aygıt Street is identified as the area most affected by the boundary factors.

Count of Users in Static Activity Streets

To measure the relationship between boundary factors and user behaviour, the number of users on static activity streets was counted. The number of users was determined by the observation method on 13 streets where static activity was conducted on Mondays, Wednesdays, and Saturdays between 12:00 and 13:00 and 16:00 and 17:00 hours. The total number of users in 13 static activity streets in Balıkesir city center is 1895. According to this table, Aygıt Street is the most preferred area for static activity by users.

Table 4. Count of users in static activity streets.

	Streets name	Count of users
1	Uncular Street	80
2	15005 Street	205
3	26001 Street	134
4	26002 Street	86
5	Başaran Street	84
6	Hisler Street	66
7	Aygün Street	55
8	Aygıt Street	338
9	Gedik Street	168
10	Aşık Street	108
11	Alpaslan Street	189
12	Irmak Street	125
13	Tevfik Sağlam Street	257

The relationship between the number of users on static activity streets and street-scale boundary factors determines the extent to which these factors affect users.

The Effect of Boundary Factors on User Behaviour at the Street Scale

The relationship between the number of users obtained as a result of observations made in the static activity streets and the factors that create morphological and perceptual boundary effects was assessed using correlation analysis.

The correlation coefficient indicates the direction and strength of the relationship between independent variables. This coefficient ranges between -1 and +1: positive values indicate a direct linear relationship, while negative values indicate an inverse linear relationship. According to the correlation analysis, positive (+) values indicate a positive correlation level, and negative (-) values indicate a negative correlation level (Table 5).

Table 5. Correlation analysis value range.

Correlation	Relation degree (+,-)
Low	0,29-0,10
Middle	0,49-0,30
High	0,50-1,00

In the correlation method, correlation levels are evaluated as low, medium, and high. Low is considered as 0.10-0.29, medium as 0.30-0.49, and high as 0.50-1.0. Data with a value less than 0.10 is not considered a correlation.

As a result of the correlation analysis, the user relationship with the connectivity factor in static activity streets was determined to be negative/strong with a value of -0.55. The low connectivity value

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positively affected the number of users; users preferred streets with few connections and limited pedestrian movement (Table 6).

The correlation between the number of users and the enclosure value of the analysed static activity streets was 0.77 (Table 6). This result shows that there is a strong relationship between the enclosure value and user behaviour. The number of users increased as the enclosure value, which creates a boundary effect, increased. People preferred secluded and enclosed streets for static activity.

Table 6. Boundary factors and user relationship at street-scale

	Streets name	Connectivity Value	Enclosure Value	Count of users
1	Uncular Street	2	3	80
2	15005 Street	3	7	205
3	26001 Street	3	3,75	134
4	26002 Street	3	4,8	86
5	Başaran Street	4	4,5	84
6	Hisler Street	4	4,3	66
7	Aygün Street	3	3,4	55
8	Aygıt Street	2	8,6	338
9	Gedik Street	2	7	168
10	Aşık Street	4	4	108
11	Alpaslan Street	2	6	189
12	Irmak Street	2	3,6	125
13	Tevfik Sağlam Street	2	4,5	257

Correlation connectivity and count of user's value:	**-0,554303468 (High)**
Correlation enclosure and count of user's value:	**0,770694415 (High)**

In the analyses conducted at the street scale, which is the first step of the research, it was found that the boundary effect created by the connectivity and enclosure factors positively affects users engaged in static activities. The fact that the relationship between the enclosure factor and the number of users is higher than the relationship between connectivity and the number of users is an indication that the enclosure factor affects the number of users more positively.

As a result, two of the hypotheses of this research have been proven. Another result of the first step of the research is the selection of the street with the highest boundary factor at the street scale. Aygıt Street, which has the highest boundary factor at street scale, will be analyzed at the building scale.

Second step: Morphological and Perceptual Findings at the Building-Scale

In the building-scale analyses, the effects of elements such as awnings, signboards, eaves, doors, windows, shop windows, and walls on the facades of Aygıt Street were examined for their impact on the boundary factors. The building-scale analyses were carried out at the ground floor level, taking into account the human scale. The morphological analysis at the building scale provided value on the surrounding factor, while the perceptual analysis provided value on the permeability factor. The analysis data were evaluated together with the number of people using the static activity patterns of the streets.

Spatial Characteristics Of The Aygıt Street

Aygıt Street was determined to be one of the streets with the highest boundary effect at the street scale, where weekday and weekend visitors engage in static activities such as eating and drinking, meeting, and socializing. There are seven small local shops on the street (Figure 5).

Figure 5. Aygıt Street photos in Balıkesir by Author

The indentations and protrusions resulting from the morphological characteristics of the buildings, along with the horizontal and vertical building elements added later, provided mobility to the ground floor facades. Signage, awnings, and window arrangements do not show continuity and similarity and lack aesthetic appeal. These elements surround and define the static activity areas.

The street is surrounded by seven shops and adjoining buildings, except for two historical buildings and a residence on the entrance side. There are restaurants, barbers, grocery stores, and four cafes on the street (Figure 6). In the static activity spaces, users utilize the tables and chairs placed on the street.

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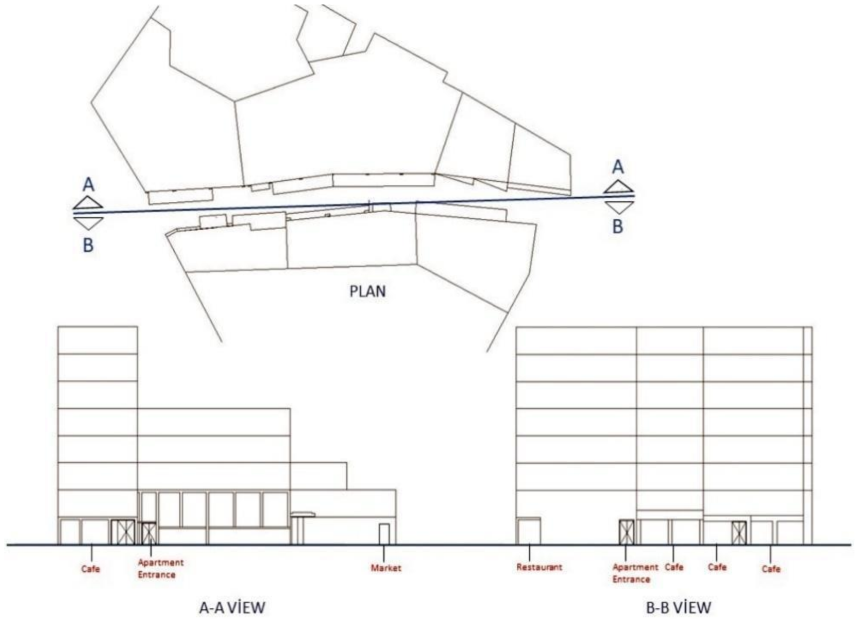


Figure 6. Aygıt Street plan and views, Drawing: Author.

Static activity areas on the street are surrounded by ceiling elements such as awnings and canopies, with vertical signage contributing to the surrounding effect. Tables and chairs are located within these enclosed areas. On the ground floor facades of the buildings, shop doors, windows, and glass surfaces provide permeability, while impermeable walls are used for static activity.

Surrounding Factor Data

Building elements such as awnings, canopies, overhangs, and walls surround areas of static activity, creating patterns of static activity and associating with these morphological features. As the enclosing effect increases, the controllability of these areas decreases (Ewing, 2006; Turner, 2007; El Agouri, 2004).

The effect of the surrounding factor on the street was evaluated using the controllability value from the Space Syntax visibility analysis. Elements such as awnings, short walls, and signboards that contribute to the enclosure factor were analysed by adding them to the drawing in the AutoCAD program.

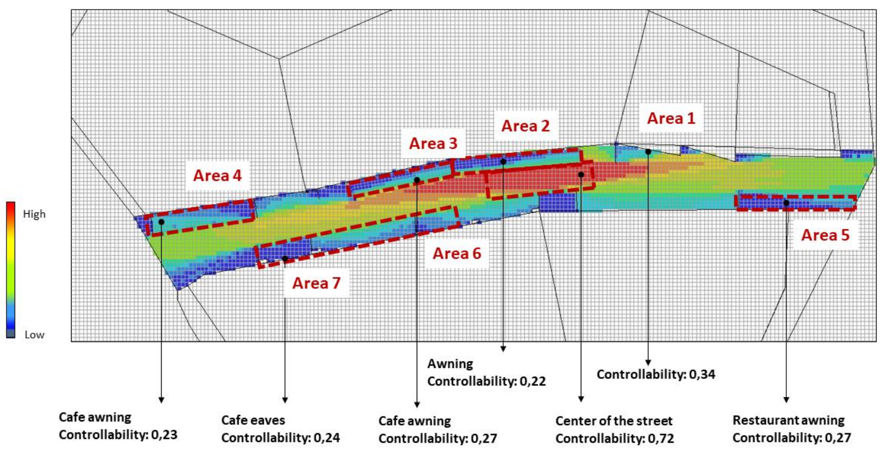


Figure 7. Aygıt Street Controllability Value.

A high controllability value represents visually dominant areas, while areas with low values represent spaces with a strong surrounding effect. The analysis uses a visual scale from red to blue: red represents areas with the highest visual controllability, while dark blue indicates unattended areas.

The visual controllability reference range for the entire street is 0.013-0.73. Areas with low controllability are those under canopies, overhangs, and eaves that create a surrounding factor.

On Aygıt Street, controllability was highest in the central part of the street, with a value of 0.72. Due to its central location, this area has the highest visibility from all directions. The controllability value of the areas surrounded by the awnings and canopies of cafes and restaurants vary between 0.22 and 0.27 (Figure 7). This is below the average controllability values of the street. These spaces with low controllability and surrounded by building elements are static activity spaces (Figure 8).

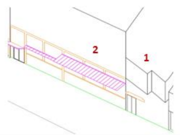
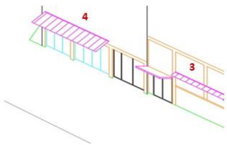
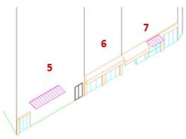
Static Activity Areas	İmages of the Street's	Boundary elements that create a containment effect (recesses, eaves, signboards, awnings, flower beds, etc.)	Space Syntax Visiual Analysis Controllability Values
Area- 1,2			1=0,34 2= 0,22
Area-3,4			3=0,27 4=0,23
Area-5,6			5=0,27 6=0,27 7=0,24

Figure 8. General findings of Aygıt Street controllability values

According to observations made between 16:00 and 17:00 on Saturday, the busiest day and time on Aygıt Street, 83 people used this street for static activity. During the observation, the areas where the users sat and the number of users were recorded.

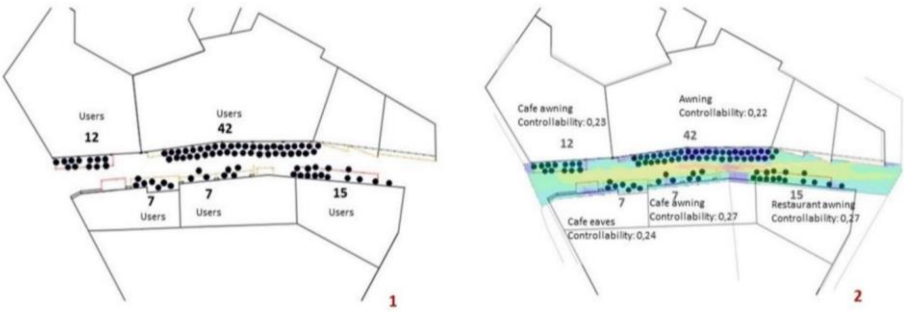


Figure 9. Aygıt Street count of users (1), impact of the surrounding factor on the user (2).

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It was determined that spaces with low controllability, surrounded by awnings and vertical signs, were used more intensively for static activities. 42 users preferred the area with a controllability value between 0.27 and 0.22 for sitting activities. Other parts of the street with the same value were also heavily used, with 15 and 12 people respectively (Figure 9).

A low controllability value at the building scale indicates a high influence of the surrounding factor, making these areas suitable for static activities. The surrounding factor was most effective in areas with the highest number of users, demonstrating its positive impact on user behaviour at the building scale.

Permeability Factor Data

The permeability of this area was influenced by 7 doors and 8 shop windows on the street facades (Ewing & Handy, 2009; Gehl, 2011; Ataol, 2013). Three of the doors are residential and four are café entrances.

The permeability factor in the streets was measured by the intensity of use of doors, windows, shop windows, and wall elements on the facades surrounding the static activity areas. ImageJ Software with the Fraclac plugin was used for this analysis. Storefronts, glass sections, doors, and windows on the ground floor facades of the buildings on the street were drawn in AutoCAD and analyzed using these drawings.

There are 7 buildings on Aygıt Street: 4 buildings on the AA side and 3 on the BB side. Fractal analysis of the building facades measured and drew the window, door, and transparent areas.

In the fractal analysis applied to the building facades, the grids and pixel numbers were set to be equal in each image, and data were obtained using the Frac-lab plugin. DB values were taken as the transmittance data of the structures. The fractal value ranges between 1 and 2, where 1 represents the lowest value and values approaching 2 indicate greater complexity. Permeability of the structures positively influences the fractal value; as the fractal value approaches 1, the impermeability of the facades increases.

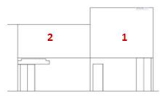
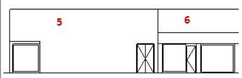
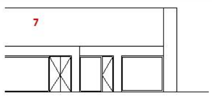
Static Activity Facades	İmages of the Street's	Boundary elements that create a permeability effect (transparent partitions, showcases, door walls, etc.)	Fractal Analysis Values
Facade 1,2			1=1,19 2=1,16
Facade 4,3			3=1,12 4=1,29
Facade 5,6			5=1,19 6=1,29
Facade 7			7=1,29

Figure 10. General findings of Aygıt Street facades and fractal values

In the fractal analysis applied to the buildings on the AA facade of Aygıt Street, it was found that the Db values for facades with walls were 1.19, 1.16, and 1.12. The view with windows, glass, and doors in the last building of the AA facade showed the highest fractal value on the street at 1.29 (Figure 10). Structural elements such as windows, glass, and doors on the facades were found to increase the fractal value. Therefore, facades with lower fractal values indicate surfaces with low permeability and a strong wall effect.

Building 3 on the AA facade was identified as having the lowest permeability with a fractal value of 1.12. This area was used by 42 people. In the fourth building, 12 people used the area with a fractal value of 1.29. Facades with low permeability were associated with higher static activity. Impermeable facades had a positive effect on static activity (Figure 11).

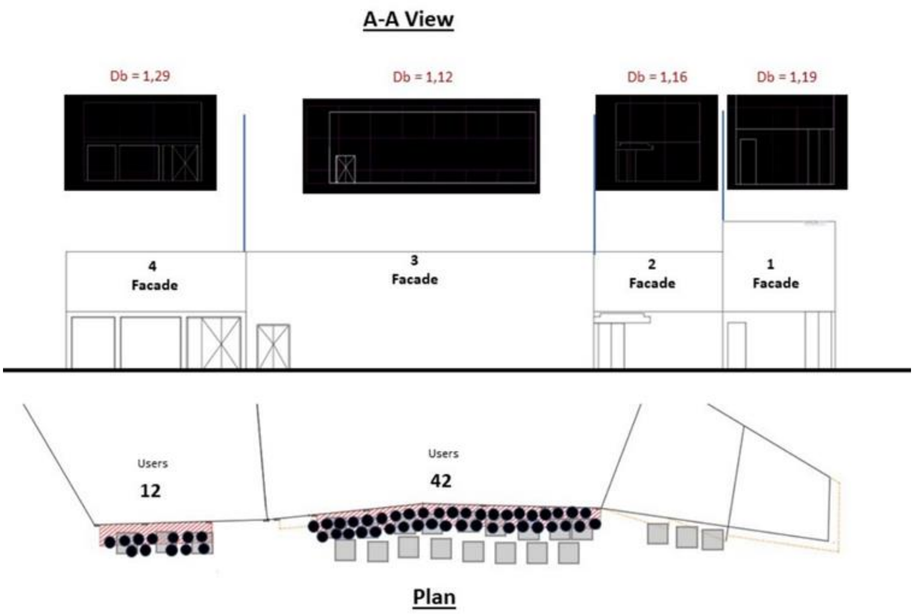


Figure 11. A-A view permeability, table/chair areas and count of users. Drawing: Author.

The fractal value of 3 buildings on the B-B facade were evaluated together with the number of people sitting in the static activity areas. Accordingly, the fractal value of the facade of the 5th building was 1.19, the fractal value of the facade of the 6th building was 1.29, and the fractal value of the facade of the 7th building was 1.29. The number of people sitting in facade 5 with a fractal value of 1.19 was found to be 15 and the number of people sitting in facades 6 and 7 with a fractal value of 1.29 was found to be 7.7 (Figure 12).

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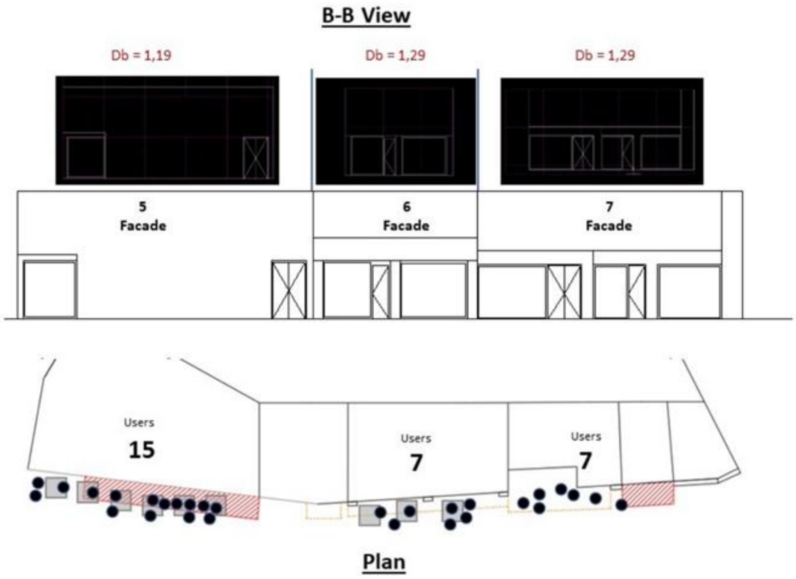

Figure 12. B-B view permeability, table/chair areas and count of users. Drawing: Author

Of the 83 users who performed static activities on Aygıt Street, 42 used the area with the lowest fractal value of 1.12. Impervious facades were found to positively affect static activities.

As a result of the analysis at the building scale, it was concluded that the surrounding factor of the morphological boundary features positively affects user behaviour. It was also concluded that the low permeability factor of the perceptual boundary features at the building scale positively affects static activities by creating impermeable spaces. The hypotheses of the research were confirmed at the building scale**.**

CONCLUSIONS AND RECOMMENDATIONS

In this study, boundary factors in streets were analysed using quantitative methods according to two different approaches: morphological and perceptual. Their positive effects on the formation of static activity streets were evaluated. The findings of the study demonstrated the effects of boundary factors on the formation of static activity streets.

The case study examined 13 static activity streets in Balıkesir city center. The analysis of boundary factors affecting street scale and building scale was conducted in two steps using Space Syntax and the fractal method.

The boundary factor values obtained in the first step were interpreted together with the observations of the number of users at two different times on three days of the week. The positive effects of morphological and perceptual boundary factors on the user at the street scale, which was the goal of the first step, were demonstrated, and the street with the highest boundary factors was selected for the second step.

The findings of the research are summarized relative to street scale and building scale as follows:

Street Scale:

- There is a strong negative relationship between the number of street connections and static activities. Streets with low connectivity have a positive effect on the number of users. Static activity users preferred streets with less pedestrian movement.
- The higher the enclosure value of the streets, the more static activities were preferred. Narrow and dim streets with high buildings have a positive effect on static activities, and the higher the enclosure effect, the higher the number of users.

According to the results of the first step of the research, it was proved that there is a positive relationship between the connectivity and enclosure factors that create a boundary effect and the user, and for the analysis at the building scale, the street most affected by the boundary factors was determined as Aygıt.

Building Scale:

- Building elements such as awnings, signboards, flower beds, and canopies surrounding the static activity areas on the streets support the creation of static activity spaces. As the surrounding factor increases, the number of users also increases, enhancing isolation and security in static activity spaces.
- There was a negative relationship between the permeability level of the facades on the streets and static activity. Impermeable wall surfaces, without elements such as shop windows, glass, and doors, helped to create static activity spaces and increase the number of users.

As a result, streets with low connectivity, high enclosure, and surrounded by signage, flower beds, awnings, and impermeable walls positively affected users engaged in static activities and increased the use of these areas for static activities.

Mehta (2006), one of the studies in the literature on streets where static activities take place, measured behavioural responses to the physical characteristics and use of such commercial streets. The author's research, which identifies the user behaviours that constitute static activity through detailed survey questions, is important in terms of identifying behavioural responses, but no quantitative method was used to determine the morphological or perceptual characteristics of the streets. The integration value of the Space Syntax method was used to determine the level of accessibility in the research in Pasir Gudang city, where static and dynamic activities were considered together (Mahdzar, 2013). In the research, which is an example where the Space Syntax method was used for static activity and examined 12 streets, it was determined that areas with low integration were actively used by people.

The research is important in terms of comparing the level of impact of Space Syntax integration data on dynamic and static activity, but comparing different data of this method can improve the research. Farahani & Beynon (2015) studied the relationship between vitality and sociability in Australian suburbs, mapping user activities and investigating the physical characteristics that encourage popular activity places. The physical features of the static activity streets in this study

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were identified through observation and counting. While the findings are important in terms of contributing to the understanding of the physical characteristics that influence social life and activity patterns on commercial streets, no quantitative method or approach was used to determine the physical characteristics. Another study, covering three commercial streets in Ankara, discusses the design criteria associated with the basic principles that create public spaces with static and dynamic activities and their impact on user satisfaction. The study concludes that pedestrian streets used for static and dynamic activities should be made attractive to users based on the commercial diversity of the area, pedestrianization, accessibility, appeal to different age groups, high youth use, vitality, social diversity, and street music. In this study, the effects of the characteristics of the streets on user satisfaction were addressed with the survey method, and the characteristics of the streets were not analysed (Gürer, 2017).

This study is unique compared to other studies, as it analysed the architectural and urban scale features specific to static activity streets using quantitative methods. In the study, hypotheses based on observations were confirmed by quantitative methods. Additionally, in this study, the positive effects of boundary factors on the formation of static activity streets in morphological and perceptual dimensions were analysed using quantitative methods, enabling a more comprehensive and reliable examination of the subject, which yielded solid and effective results. In the study, the data obtained by analysing the elements in the plan plane with Space Syntax and analysing the structure formed by the facades and facade units in the third dimension with the fractal method were used to determine the effects on the formation of spaces specific to static activity. The model, which consists of data from two different dimensions supporting each other, created a basis for urban design within the boundaries of the study area by enabling the boundary factors to be handled as an integrated structure.

Today, urban design is an important issue addressed by local governments. It is necessary that projects are carried out to provide citizens with quality, comfortable, and pleasant urban spaces. Static activity streets should be designed to encourage people to sit, socialize, and participate in various activities, creating lively and inviting public spaces. Designs that take into account the positive effects of boundary factors on static activity spaces result in the creation of spaces that urbanites can use.

This study was conducted in a limited area covering 13 static activity streets in Balıkesir city center. Applying the model used in this study to more streets and different cities will reveal the consistency of this model. More studies are needed to increase the duration of determining user behaviour, which is currently limited to counts made on three days of the week and at two different time periods. Another limitation of this study is that user behaviour was counted through observation. The survey method can also be used for an in-depth analysis of user behaviour.

Although the model created in this study provides a valuable formation, it may not be the most appropriate model.

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Resume

Fatma Arzu TİBET graduated from Istanbul Technical University Department of Architecture in 1986. She started his master's degree at Balıkesir University in 2010 and completed his master's degree in 2013 with a dissertation titled 'Examination of traditional Ayvalık houses with space syntax methodology' and completed his master's degree in 2013. Between 2019-2024, she completed doctorate with a dissertation titled 'A Model Proposal Based On Morphological, Perceptual And Functional Boundary Factors Affecting Static Activity In Urban Space: The Case Of Balikesir City Center'.

Berrin AKGÜN is a Professor of the Department of Architecture at Balıkesir since 2018. She has completed his master and PhD studies at Gazi University. She worked as an academic and served as the vice dean of the Balıkesir University Faculty of Architecture.

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