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Research Article

A method proposal to detect user movement patterns in urban space: The case of Edirne-Kaleiçi*

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ABSTRACT

This study aims to define the factors that affect users' movement preferences and propose a method to identify the movement patterns in urban space. The proposed method was tested on Edirne-Kaleiçi, which was chosen as the study area. Edirne proves to be an appropriate case given that the spatial construct of the city bears the characteristics and the political-ideological, social, and economic impacts from different periods throughout history. Thus, the effects of socio-economic factors can be observed when movement preferences are identified. In this context, available literature and different perspectives on "movement" were examined, and the components that affect movement were revealed. As a result of the model constructed with "Natural Movement" (based on Space Syntax Analysis Method), "Directed Movement" (based on Urban Network Analysis Method) and other additional components, movement patterns in the urban fabric were determined. Although the choice, integration, and intensity values are high for users according to the physical construct of streets in Kaleiçi, the movement remains in a very limited area due to the socio-economic structure and one type of intensive land-use type (retail). In addition, as a result of the correlations made with the observation data (pedestrian-vehicle counts, land market values), the consistency of the model was tested, and a positive/high-level relationship was determined. This method approach will contribute to the literature because it will help integrate many different attributes under the concept of "movement" and make them questionable.

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INTRODUCTION

When the built environment is examined, it is possible to observe two different layers of the space. The first one of these layers is the space that is lived, experienced, and shaped based on physical space, and the other layer is an abstract space formed by social and economic relations and can be defined as "both in place and out of place." These two layers of space are shaped by human beings who are the producers of these spaces. At the same time, human beings

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are also shaped (essentially) due to the processes of production experience in these layers.

The first of the preliminary inferences can be made by remembering Aristotle's proposition that space has an unstable, dynamic structure [1] and Heidegger's proposition that space changes over time as a plane of interaction/experience [2] An absolute mutual relationship exists between the physical environment and human behavior. Lewin (1936) was among the first to develop the theoretical background that user behavior is a function of the relationship between people and physical space. Based on the formula he defines as $B = f(P, E)$(B: behavior, P: person, E: environment), he suggests that behavior emerges as a result of the mutual interaction and relationship individuals experience in the physical space/environment, and states that the context of both the individual and the environment should be addressed while analyzing "behaviors" [3]. Craik (1971) determined that features such as spatial qualities, places where actions take place, social structure and situation should be considered when the effects of the physical environment are examined [4]. Bilgin (1984) and Gärling (1998) state that places are loaded with meaning and are a prerequisite for "urban experience," and spatial qualities are one of the essential factors in determining behavior and actions [5,6].

Golledge brought a different perspective on the interaction between spatial qualities, behaviors, and movement in public urban life [7]. Accordingly, the main landmarks (significant buildings, main axes, important regions, etc.) in urban space affect users' travel tendencies and route choices. In another study, Golledge scrutinized the factors that create behavioral movement patterns in physical space. These patterns are formed based on the strategies to define the reference elements in urban space, understand and define the street/road network, and draw routes, thereby constituting the basic code of environmental information. From this point of view, the detection of user movement patterns in a space can be used as a primary factor that is informative in defining spatial features and revealing cognitive space features [8]. In this respect, physical space can affect the behavioral structures of users who live in it, and create different flow and movement dynamics. Montello prioritizes visual access among the physical space qualities [9]. Visual access is the degree to which different places and features in an environment can be seen. When visual access is high, it becomes easier to maintain spatial orientations, and their ambiguity is reduced. Visual access helps to keep tension at acceptable levels in simple or familiar environments while reducing tension in complex or unfamiliar environments. Montello also asserts that street pattern is among the main components that affect behavioral movement and visual access in physical space.

Identifying the movement patterns in an urban environment will be a crucial auxiliary factor in revealing the distinctive spatial structure. In addition, locating user routes in the urban environment will help produce appropriate solutions in planning/design processes, land-use site selection, and transportation modeling. In light of these, this study aims to define the factors that affect users' movement preferences and propose a method for identifying the movement patterns in urban space, based on the interaction between "urban environment ↔ person ↔ behavior." The proposed method was tested on Edirne-Kaleiçi, which was chosen as the study area. Edirne proves to be an appropriate case given that the spatial construct of the city bears the characteristics as well as the political-ideological, social and economic impacts from different periods throughout history. Thus, the effects of socio-economic factors can be clearly observed when movement preferences are identified. In this context, available literature and different perspectives on "movement" were examined, and the components that affect movement were revealed. The following parts of the study introduce the model designed to measure these components, and discuss the analysis findings obtained with current base maps in Edirne/Kaleiçi. Comments were made on the consistency of the model through the correlations between the observation data. This method approach will contribute to the literature because it will help integrate many different attributes under "movement" and question them.

LITERATURE REVIEW

Review of the Literature on Movement

The concept of movement is considered as one of the main components in measuring social and economic integration, which also affects behavior and actions in urban space [10–14]. In terms of morphology, it is emphasized that the street pattern is the most stable component in the urban form and organization, and the most resistant component to transformation/change. It is also stated that street patterns should be one of the basic elements that should be addressed given that parcel patterns and the built environment are more affected by urban change/transformation in comparison to the street pattern [15–20]. Louf and Barthelemy indicate that the street pattern contains information based on the structure and the organization of cities. Thus, it should be considered in urban evolution and configuration [21]. Hillier and Iida found a high correlation between urban configuration and movement capacity [22]. The street pattern by itself determines the movement capacity. In this context, the flow directions created by the street pattern are referred to as "natural movement". In contrast, the flow directions created by the land-use effect are identified as "directed movement."

Paul divides the movement in the urban fabric into three main groups: a) purpose-based movement (flows towards attractive functions due to land-use effect), b) linear/natural movement (linear flow directions created by the street pattern), c) non-purpose-based movement (movements that start with natural movement but then get affected or

terminated by a certain land use) [23]. According to this approach, movement should be evaluated together with the land use structure. Similarly, Suzuki states that the movement in the urban fabric affects both the spatial configuration and the site selection of different land uses [14]. The built environment is continuously organized over time to facilitate or restrict urban access, to direct movement and to enable interaction [24–26]. In this respect, urban movement capacity has the potential to trigger the reproduction or rearrangement of space [27–31]. Steadman argues that movement patterns in the entire city or in a sub-region can be reshaped even with a change in the street pattern alone - regardless of any other factors [32].

The Space Syntax and Urban Network Analysis methods were examined for their suitability for this study even though there are many different models to determine the spatial formation and movement flows in the urban fabric. In particular, Seamon indicates that the Space Syntax approach proves to be a suitable framework to phenomenologically explain experiences, behavioral patterns, and praxis [33]. The analysis types covered within the scope of these mathematical models are explained in detail in the method section.

The book titled "The Social Logic of Space," when explaining the relation among spaces, touches on the existence of a "common language" that determines the spatial appearances and the configurational structure of the city [24]. Social and economic information is embedded in the space, so the physical space is formed by the tangible projection of the networks of abstract social relationships. In this respect, the configurational structure of the space can bring about social advantages and disadvantages. The Space Syntax Theory recommends analyzing the syntactic features of the space to define the spatial form quantitatively and analytically. It argues that spatial formation can be measured by analyzing the relationship between how the network is seen by its individual parts and its place in the entire network [15,24,34]. According to this perspective, spatial configurations are a visual expression of the social structure [35]. Social network patterns consist of persons' psychological, cultural, auditory, and visual interaction with their immediate environment [36]. Due to these face-to-face interactions, social network patterns develop with a particular focus on "human-space" [37]. Although space is shaped by people, it is possible to suggest that the spatial construct also has a formative effect on social relations [38]. Accordingly, the spatial/structural configuration is an indicator of the social structure of a settlement [39]. Space (at the building-scale or at the city-scale) has unique configuration processes, and it is the primary plane where socio-cultural events happen. Therefore, the Space Syntax method offers an appropriate perspective for the studies that will be conducted in this context. The Urban Network Analysis model was developed by The City Form Lab at the Massachusetts Institute of Technology in 2012. The model evaluates the street pattern and the land-use pattern together. In this respect, it features a dimension that differs from other models for it determines the effects of attributes such as land use type, number of employees, and location on urban networks, and evaluates the effect of accessibility in urban networks on the attractiveness of land uses [40,41]. The model has five different sub-analyses: reach, gravity, betweenness, closeness, and straightness [40].

When the studies on spatial morphology are examined in line with the purposes of this study, it was observed that the concept of "movement" was kept as the main focus of street patterns, especially in the last decade, and "movement" is the main component when defining and analyzing spatial qualities. Given the descriptive features of a city, it is apparent that political-ideological, economic, social, cultural, and natural qualities both affect movement and are affected by movement. Table 1 summarizes of the relevant literature in terms of main themes, mathematical models, sub-analysis topics, and factors that affect movement preferences. When studies that utilize the Space Syntax Theory and other studies are evaluated together, it is observed that most of the studies are based on street patterns and are focused on physical structure. On the other hand, land use has been evaluated in a limited scope in general, and in some studies, it has not been addressed at all. In addition, in parallel with the approaches in the literature presented in previous sections, it is seen that the Space Syntax method is used in the majority of the studies, and integration and choice are the fundamental analyses used to examine movement. When other factors that affect movement were compiled, it was observed that criteria such as land use (in a limited context) and different types of transportation stand out. The following section provides an in-depth examination of the components in line with the literature review. This study differs from other examples since it combines physical and socio-economic spatial qualities under natural and directed movement, proposes a holistic conceptual framework for mobility, and offers a new perspective by utilizing the Space Syntax and Urban Network methods together. It is anticipated that the method presented in this study will make a new/different contribution to the literature.

Review of the Literature on the Components That Affect Movement in Space

This section evaluates the literature review on the components that affect movement and the literature summary presented in the previous section, along with the final components.

Golledge states that, although movement and route selection in the urban space is generally affected by the environment, the existing street pattern is the factor with the highest influence on movement, mainly because users tend to choose the shortest route [8]. In their research, Penn et al. argue that street patterns in the urban space have a constructive or decisive character in a way that affects all urban relations and behaviors beyond the provision of existing

Table 1. Summary of the available literature on movement

#	References	Mathematical Model Used in the Study	Sub-Analysis Topics Covered in the Study	Factors that Affect Movement Preferences
1	[21]	-	-	Statistical Evaluations
2	[42]	-	-	Different Types of Transportation
3	[43]	-	-	Land Use, Time/Distance Between Residential-Urban Use, Time Spent in Urban Uses
4	[44]	-	-	Different Types of Transportation
5	[45]	GIS Analysis	-	Different Types of Transportation, Proximity to Transfer Stations
6	[46]	GIS Analysis	-	Different Types of Transportation, Type of Land Use, Travel Distance and Duration, Personal Preferences
7	[47]	GIS Analysis	-	Street Form and Road Networks, Plot Pattern, Ratio and Typology of the Built Environment, Open Spaces
8	[48]	Gross Network Connectivity	-	Environmental Transport Network Attributes
9	[49]	Hidden Markov Model	-	-
10	[50]	Cellular Automation Models	-	Intensity of Urban Activities
11	[41]	Urban Network Analysis	Gravity, Reach	Urban Block/Parcel Formation, Street Form and Road Networks
12	[51]	Urban Network Analysis	Gravity, Betweenness	Land Use, Street Form and Road Networks
13	[52]	Cumulative Opportunity Measurement Model, User Surveys	-	Average access time to Retail and Service areas, Land Use Preferences and Travel Trends of Users, Location of Transfer Stations
14	[53]	MAUAP Model	-	Pedestrian Spaces, Accessibility of Public Service Buildings, Building Entrances and Exits
15	[10]	Space Syntax Analysis	Integration (Global, Local)	Street Form and Road Networks
16	[54]	Space Syntax Analysis	Integration (Global, Local), Choice	Land Use
17	[55]	Space Syntax Analysis	Integration (Global, Local)	-
18	[56]	Space Syntax Analysis	Choice	Land Use, Population Structure
19	[11]	Space Syntax Analysis	Integration (Global, Local)	-
20	[57]	Space Syntax Analysis	Integration (Global, Local), Choice, Visual Integration	Land Use, Urban Block/Parcel Formation, Social Interaction Points, Building Heights
21	[58]	Space Syntax Analysis	Integration (Global, Local), Choice	-
22	[59]	Space Syntax Analysis	Segment Analysis	Land Use
23	[60]	Space Syntax Analysis	Segment Analysis	Land Use
24	[61]	Space Syntax Analysis	Integration (Global, Local)	Land Use, Building Heights, Road Widths
25	[62]	Space Syntax Analysis	Integration (Global, Local)	Land Use
26	[63]	Space Syntax Analysis	Integration (Global, Local)	Land Use (retail, food and beverage, recreation)
27	[14]	Space Syntax Analysis	Connectivity	-
28	[64]	Space Syntax Analysis	Integration (Global, Local), Connectivity	-
29	[65]	Space Syntax Analysis	Integration (Global, Local)	Land Use, Street Form and Road Networks
30	[66]	Space Syntax Analysis	Connectivity, Mean Depth, Integration (Global, Local), Choice	Pedestrian/Vehicle Counts, Parking Capacities, Land Use
31	[18]	Space Syntax Analysis, Fractal Analysis	Integration (Global, Local)	Street Form and Road Networks
32	[59]	Space Syntax Analysis, Pedestrian Simulations	Integration (Global, Local)	Land Use, Street Form and Road Networks

accessibility lines [61]. However, they also indicate that this movement is especially affected by factors such as land use, road widths, building heights and densities; and thus, in locations with attractive functions, movement capacity may exceed the capability offered by the street pattern. Therefore, areas with high movement capacity determine the preferences of land uses and the choices of residential users. Perkins et al., on the other hand, state that movement in the urban fabric is affected by the diversity of land uses along a street (it is assumed that all land use types are equally attractive), the optimum distance covered and time spent to reach other urban uses, and the time spent/can be spent in urban uses. They found that, out of all components, land use types had the most significant impact [43].

Omer and Kaplan state that land-use types are ranked as follows based on their effect on movement: retail > financial institutions and private services > public services > industrial facilities > residential areas. They assert that retail services have the potential to create higher mobility than other land-use types [59,60]. Zhang argues that land-use types identified as RCES (retail, catering, entertainment, small service) have the highest effect in the relationship between land use types and movement. Zhang also mentions that when moving on a line from high RCES density to lower RCES density, the amount of movement decreases, and residential function is not movement-generating [65]. Likewise, Perdikogianni and Penn state that retail, catering, and recreational areas are the main attractive functions in creating mobility [63]. Blue and Adler argue that movement depends on speed and intensity, and that movement capacity will be higher on lines where mass events (such as sports activities, concerts, and religious services) are intense [50]. Muller [42] and Richards [44] assert that movement depends on the different modes of transport available on a line. Jiang et al. found that transfer stations have the highest movement potential depending on the transport modes [67]. Morales et al. argue that movement capacity depends on different modes of transportation on a line, type of land uses, travel distance/travel times, and personal preferences [46].

The "Theory of Movement Economics," the conceptual framework of which was put forward by Hillier in his 1997 study titled "Cities as Movement Economies," features the fundamental assumptions of the Space Syntax Theory; however, it was a rather advanced framework given that it also addressed economic relations and land uses [68]. In general, the theory assumes that spatial accessibility has an economic effect on land use, and the interaction between street patterns and land uses will lead to new experiences in the urban environment. Movement Economy is simply based on three main components: configuration, movement and attraction [56,68,69]. The structure of the spatial formation [configuration] first creates the natural flow and movement in a city [movement], and this affects the site selection criteria of land uses [attraction]. Depending on the location and types of land uses [attraction], new "directed" movement flows [movement] different from how natural flows occur [56,62,68]. To summarize, [configuration] creates [natural movement] and [attractive factors], and then [new/directed movement] and [new attractive factors] create [new types of configuration] [15].

Blanton and Fargher, on the other hand, argue that, before anything else, social patterns should be revealed to analyze the urban fabric. In addition, they state that street patterns that provide movement in public spaces express a social structure that offers an organized, social, and collective life [70]. Therefore, revealing the movement potential in a city enables the scrutiny of socio-economic relations from the neighborhood unit up to the city scale [12,71,72]. Flow and movement in cities are shaped by the socio-cultural profile as well as the economic and/or political interventions of the inhabitants of a space [18,73–75].

It is apparent that movement has also been discussed with its social and economic dimensions in the Structuration Theory. In his book titled "The Constitution of Society" published in 1984, Anthony Giddens defined the interaction between society and space within the scope of the Structuration Theory in line with social theories. The urban experience, which is defined by the concept of "social praxis" and conveys the tangled relationships such as social, economic, political, cultural, and symbolic, [73,76–78] produces actions in physical space, and space is shaped in line with these relationships [79]. This "praxis" can affect the behavioral reactions of users and direct their natural movements in urban space [80–83]. Kaufmann et al. describe the affected movement as "movement capital" [84]. Bourdieu states that the positions and hierarchies of individuals in social space are shaped in line with the type and power of representation in different areas, characterizes the power of representation as "capital accumulation," and identifies economic, political, cultural, social, and symbolic capital as the primary types of representation. Representation types have a footprint on urban space in the form of commercial and retail services, public institutions, and non-governmental organizations (land-use types). The urban experience and representation types also have a footprint on urban space in the form of movement capacity and interaction [77].

The review of the literature demonstrates that movement in the urban space is divided into two types: "natural" and "directed" movement. Accordingly, the components that affect movement can be identified as follows:

For natural movement;

- Spatial configuration qualities (the configuration of street patterns),
- The variety of transportation modes, and the presence of a transfer station along the street (for short transportation infrastructure), and
- Topographic mobility (slope analysis).
- For directed movement;
- Types of land use in parallel to economic, political, cultural, social, and symbolic capital that can be defined by the Structuration Theory, and
- Primary accessible lines to land use types.

STUDY AREA

Edirne is located at the confluence of the Arda, Tunca and Meriç Rivers, and it is bordered to the east by Kırklareli and Tekirdağ, to the south by Çanakkale and the Aegean Sea, to the north by Bulgaria, and to the west by Greece. The Kaleiçi area, which was chosen as the study area, was the first center of settlement in Edirne. Kaleiçi is bordered by Ağaçpazarı Street to the north, Ağaçpazarı and Tabakhane Streets to the west, Darül Hadis Street to the south, and Saraçlar Street to the east (Figure 1). Today, Kaleiçi area is made up of Dilaverbey, Mithatpaşa and Çavuşbey Neighborhoods. In addition, the area lies within the Urban Protected Area, which was declared with the Edirne Cultural Heritage Preservation Regional Board's decision dated 1988[1]. Kaleiçi also remains within the 1st and 3rd Degree Archaeological Sites, which was declared in 2007[2].

During the site selection for this study, the fact that Kaleiçi has been shaped by external factors (such as earthquakes, fires, occupations) and internal factors (such as street patterns, land-use-specific planning, and other interventions) throughout history was considered. Until the 1970s, the spatial development in Edirne was quite limited, with renewal/transformation activities within the existing city limits. After the 1970s, however, there was a growing trend to the south and southeast towards the D-100 highway (formerly E-5), where industrial facilities, some large-scale public institutions and the university were located. Intensive zoning activities occurred due to the influence of new attractive factors. In particular, before Kaleiçi was declared as a protected area, high-rise residences were built, and a land-use typology heavy on trade/service began to emerge in the historical urban texture. The former mixed-use structure and the unique features of the physical space began to disappear. Pursuant to the development plans approved in 1985, relatively high-rise development with wider floor area and retail land uses were granted in the blocks and plots along the Talatpaşa, Balıkpazarı and Saraçlar Street in the Kaleiçi area [85]. Following the decisions of the Edirne Cultural Heritage Preservation Regional Board in 1988, 2003 and 2007, urban conservation plans were developed specifically for the area.

It is possible to suggest that the spatial qualities and the unique character of Kaleiçi have undergone severe changes over time. In this respect, the method defined within the scope of this study can prove to be a guide in analyzing the existing distinctive spatial structure and formulating new planning/design decisions.

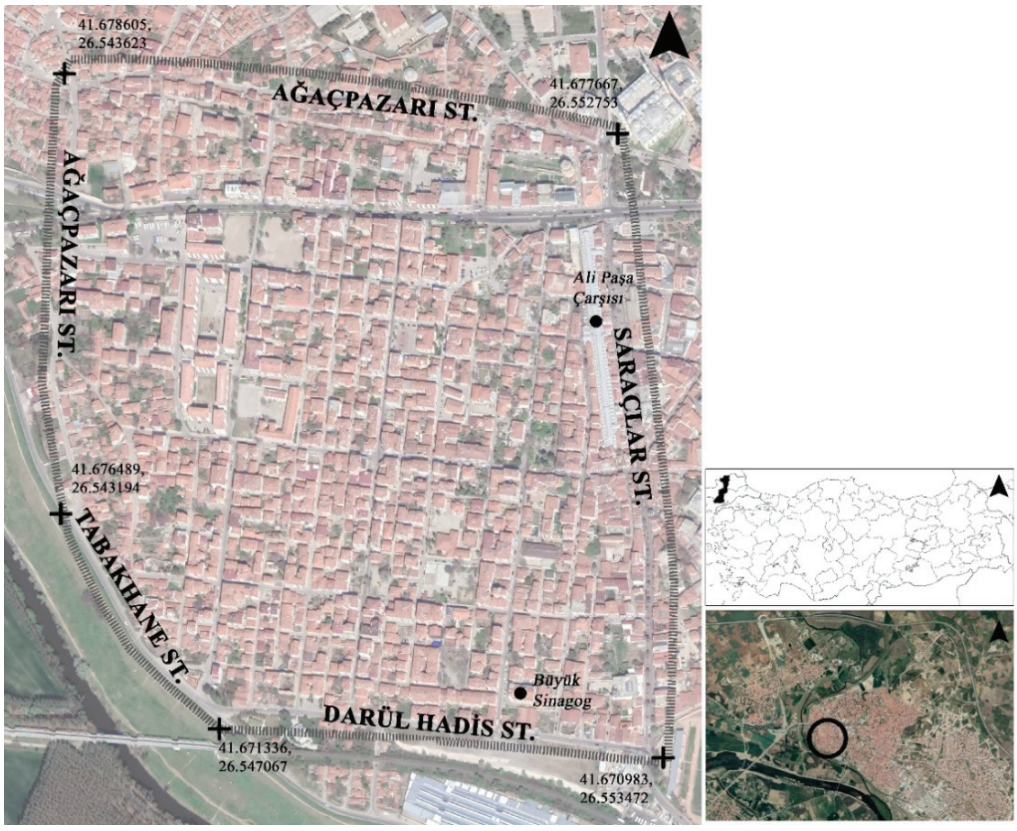

Figure 1. Location of the study area (base map: Google Earth Satellite Image, 2021).

1 27.05.1988 and numbered 8, and redefined with the decision dated 04.07.2003 and numbered 7697

2 by the decision of the same board dated 31.05.2007 and numbered 1469.

MATERIALS AND METHODS

Method

In the study, Space Syntax and Urban Network analysis models were used for the concept of movement, whose sub-components were defined in line with the literature reviews. Space Syntax Analysis was prepared by using the open-source program called DepthmapX 0.80, and Urban Network Analysis was prepared by using the open-source UNA toolbox prepared for the ArcGIS program. All the results and the database were compiled in the geographic information system compilation/editing program called ArcGIS 10.5.

The method of the study consists of two parts (Figure 2): analyzes based on the Space Syntax method within the scope of natural movement, and analyzes based on the Urban Network Analysis method within the scope of directed movement. The total movement score was determined for each line by summing the obtained values and other component values.

The analyzes made for the detection of **"natural movement"** within the scope of the study are as follows:

A. Spatial configuration qualities:

Axial line Analysis

The main factor in this analysis was the axial line movement and Choice, Integration (Global), Intensity analysis (see Space Syntax section) was applied[3]. The axial line is defined as the longest straight line representing the maximum extension of a point of space [24] (Figure 3). Axial line analyzes make it possible to evaluate the interaction between spaces and a holistic movement flow in urban scale [86,87].

Choice Analysis

Choice measures how likely an axial line or a street segment it is to be passed through on all shortest routes from all spaces to all other spaces in the entire system or

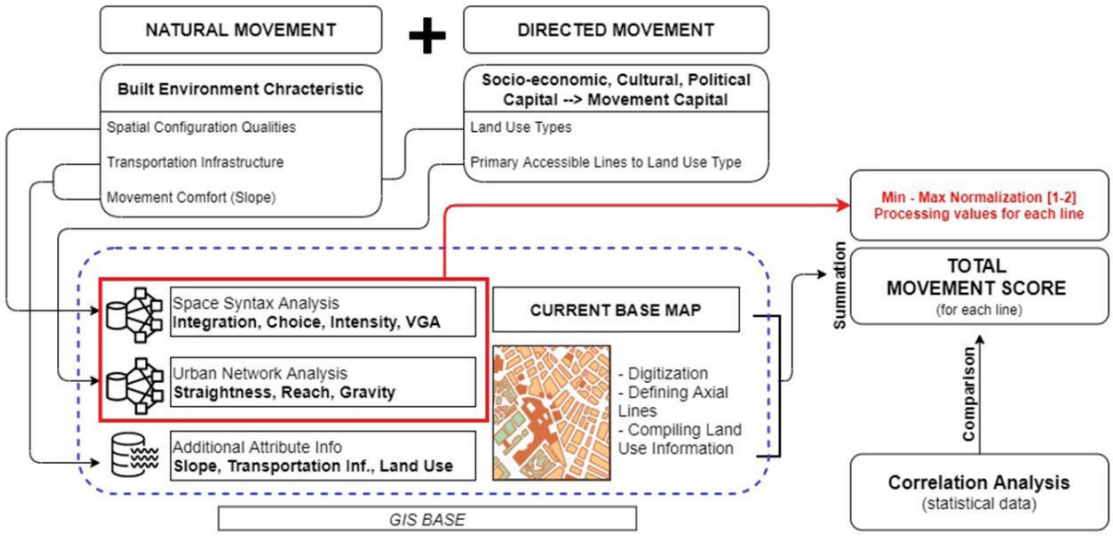

Figure 2. Graphic summary and stages of proposal method.

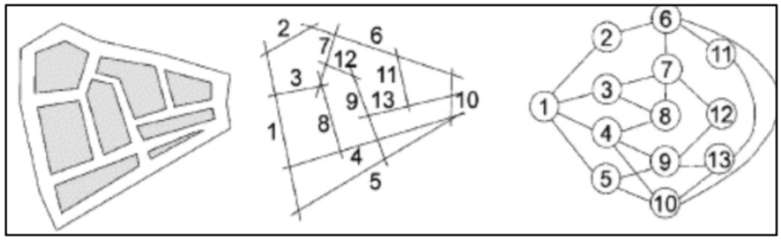

Figure 3. (First) convex area and (second) axial line illustrations according to Space Syntax Method [88].

3 Min-Max Normalization was applied to the obtained analysis results to make examinations and queries on the same value scale, and all analysis values were normalized as 1: the lowest and 2: the highest.

within a predetermined distance (radius) from each segment. The higher the choice value of a line, the higher its availability depending on choosing the shortest route in the whole system [89]. High values show the density of the lines that provide direct flow in the urban texture, and indicate the movement patterns preferred/may be preferred by the users in the region. The formula ((Eq. (1)) is as follows[4] [90]:

$$Choice\ (i) = \frac{\{\#shortest\ paths\ through\ i\}}{\{all\ shortest\ paths\}} \quad (1)$$

Integration (Global) Analysis

Integration is a normalized measure of distance from any space of origin to all others in a system. In general, it calculates how close the origin space is to all other spaces, and can be seen as the measure of relative asymmetry (or relative depth). Spaces with dense lines providing direct flow are defined as "integrated", and spaces with fewer lines are defined as "segregated". Integrated spaces have the potential to bring people together in the urban texture. The spaces with the highest integration value have the feature of being a 'transition area' in the urban flow [24]. The formula (Eq. (2)) is as follows [91] (MD: mean depth value of an axial line, n: total number of road intersections):

$$RA(i) = \frac{2(MD(i) - 1)}{(n - 2)} \quad (2)$$

Intensity Analysis

Intensity measures the relative asymmetry of a spatial network by calculating the rate of change of entropy relative to total depth. This is another way of normalizing total depth. It also offers mobility efficiency when considering the distances due to flows in the network, high values give travel efficient lines in terms of flows. The formula ((Eq. (3)) is as follows [92] (E: the entropy value of an axial line, TD: total depth value of an axial line):

$$\Delta E/_{\Delta TD} = \frac{E - E_{min}}{TD - TD_{min}} \quad (3)$$

Convex Space Analysis (Visibility Analysis- VGA)

Convex space is one in which no straight line drawn between any two points goes outside the space (Figure 2). On the urban/architectural scale, it is making a system identifiable with a minimum number of spaces [87]. When it is desired to measure the social interaction levels in a space, the system is evaluated by dividing it into convex spaces according to the Space Syntax Analysis Method [24,93]. Convex space evaluations are mainly based on two issues: (a) urban-scale evaluations for non-linear spaces, (b) architectural-scale evaluations for interior layouts, common areas and especially genotype determination [94]. Visual integration analysis (see Space Syntax section) was applied to evaluate convex spaces.

Visual Integration Analysis

Visual integration measures visual distance from all spaces to all others. High-value spaces have the potential to bring more people together than low-value spaces [95]. In other words, it is possible to say that spaces with high visual integration value will attract movement flows and affect travel preferences within the system [96]. In this analysis, it is possible to say that the subject of "visual access", which is one of the main factors affecting movements and flows in behavioral psychology, is discussed in terms of visual integrity and linearity [9] The formula ((Eq. (4)) is as follows [97]:

$$Visual\ Integration = {}^{1}\Big/\frac{RA\ (i)}{\frac{2(i(log_2(i+2)/3) - 1)}{(i-1)(i-2)}} \quad (4)$$

B. The variety of transportation modules and the presence of a transfer station on the street line (for short transportation infrastructure): Within the scope of the study, the presence of additional transportation modules on the axial lines was examined. As a result of the field study, the public transport line routes passing through the Kaleiçi region were determined and discussed in the evaluation.
C. Topographic mobility: Within the scope of the study, slope analyzes were made in the Kaleiçi region, the general slope in the region was determined to be between 0-5%, this slope range was not considered in the calculation phase since it does not affect the comfort of movement significantly.

The analyzes made for the detection of **"directed movement"** within the scope of the study are as follows:

D. Types of land use parallel to economic, political, cultural, social, symbolic capital that can be defined within the scope of Structuration Theory: The identified land-use types (based on the ground floor functions of the buildings) were scored according to their attractiveness factors, taking into account the socio-economic and political structure. In line with the evaluations stated in the relevant literature, the attractiveness coefficient scale has been determined as trade/service (highest), recreation areas, public institutions, industry/manufacturing areas (lowest), and residential areas are excluded from the analysis as they will provide the lowest movement. These coefficient values are considered as a sub-component in Urban Network Analysis.

4 For an example calculation, see [89].

E. Primary accessible lines to land use types: Reach, Gravity, Straightness analyzes (see Urban Network Model) were applied within the scope of evaluations between accessibility in urban networks and attractiveness effect of land use types [5].

Reach Analysis

It is a query for buildings that can be reached with the shortest distance within the entire street network or within a certain radius. It is stated that locations with high value buildings have the potential to attract the highest movement. The formula ((Eq. (5)) is as follows [40] (G: graph value of an axial line, r: radius, d[i,j]: the shortest distance between points i and j, W[j]: coefficient value of the destination j):

$$Reach^{n}[i] = \sum_{j \in G-\{i\}; d[i,j] \leq r} W[j] \quad (5)$$

Gravity Analysis

Unlike the Reach analysis, it is used to determine the locations that will create the attraction effect in the urban texture, together with the land use attractiveness coefficient values given in the Title D. Gravity analysis offers a measure that combines the attractiveness of structures with potential travel costs into a single value. The formula ((Eq. (6)) is as follows [40] (β: exponent that controls the effect of distance decay on each shortest path between i and j):

$$Gravity^{r}[i] = \sum_{j \in G-\{i\}; d[i,j] \leq r} \frac{W[j]}{e^{\beta . d[i,j]}} \quad (6)$$

Straightness Analysis

It is a query for buildings that can be reached on a straight axis within the entire street network. It is used in the determination of connection and nodal points in the urban texture, and in the determination of locations with low transportation costs. The formula ((Eq. (7)) is as follows [40] (δ[i,j]: bird flight distance between buildings between i and j):

$$Straightness[i]^{r} = \sum_{j \in G-\{i\}; d[i,j] \leq r} \frac{\delta[i,j]}{d[i,j]} . W[i,j] \quad (7)$$

Accordingly, the lowest/highest values and evaluation ranges that the components discussed in the study will take under ideal conditions are as follows (Table 2). Analysis values were collected for each line and the resulting movement score was obtained. Min-max normalization was applied to all analysis results, the values arranged in the 1-2 range were summed for each line, and the resulting score was calculated. In addition, the averages of both analysis and result score values were calculated and comments were developed. In ideal conditions, the total movement score is expected to be between 7-15. However, in the raw analysis results, lines with a value of 0 were excluded from normalization. For this reason, values below 7 are divided into "low-level movement capacity", and values between 7-15 are divided into "medium-level movement" and "high-level movement" according to the natural breaks that occur within them.

Table 2. Model evaluation summary table

Analysis Headings			Lowest*	Highest
Natural Movement	Section A	Choice	1	2
		Integration	1	2
		Intensity	1	2
		Visual Integration	1	2
	Section B	Transportation Infrastructure	0	1
	Section C	Movement Comfort	Excluded.	
Directed Movement	Section D	Land-Use Attractiveness Coefficient	Used as a subcomponent for Sect. E.	
	Section E	Reach	1	2
		Gravity	1	2
		Straightness	1	2
Total			**7**	**15**

** Values that are 0 in the raw analysis results are excluded from the min-max normalization.*

5 Min-Max Normalization was applied to the obtained analysis results to make examinations and queries on the same value scale, and all analysis values were normalized as 1: the lowest and 2: the highest.

RESULTS AND DISCUSSION

Within the scope of the study, the analyzes specified in the method section were applied. The findings obtained with the order specified in Table 2 are explained below.

A. The analysis findings for spatial configuration qualities are as follows (Figure 4): When the space syntax analysis is evaluated, it is seen that Balıkpazarı, Saraçlar, Cumhuriyet and Talat Paşa streets have the highest choice values. In parallel with the literature, the main linear lines, which provide connection to many sub-lines, took the highest values. It is seen that the integration is mainly high in the sub-lines fed by these lines and concentrated in the middle center (in the inner region fed by the high-value choice lines). Compared to the northern and western regions, more integration is observed in the south of Talat Paşa street. Intensity was also highest in this region. Visual integration has the highest values in Talatpaşa, Balıkpazarı, Arif Paşa, Maarif, İzmir, Osman Nuri Peremeci streets, which have wide street forms. When a holistic evaluation is made in terms of street characteristics and intersection features; Talatpaşa, Balıkpazarı, Arif Paşa, İzmir, Maarif streets have the potential to collect/direct the highest movement.

B. Within the scope of field studies, different transportation modules (public transportation lines) passing through the Kaleiçi region have been identified. Accordingly, a total of 13 lines passes through Talatpaşa Street, and a total of 2 lines pass through Arifpaşa, Maarif and Darül Hadis streets. The high integration and movement potential seen in these street lines in terms of their configurational qualities, as well as the presence of public transport on these lines, shows a high usage tendency compared to other lines.

C. Since there is no natural character (Figure 5) that will negatively affect the movement comfort in the study area, it is not included in the calculation.

D. Ground floor functions in the study area were determined and coefficient values were calculated. In terms of land use, two concentration zones were identified in the area (Figure 6):
   1. Zone 1: due to high integration/choice values, high linear accessibility, and concentration of commercial, retail, recreational, service (mixed) functions.
   2. Zone 2: due to high integration/choice values, high linear accessibility, and retail functions.

E. When the Reach and Straightness analysis results are evaluated, it can be seen that the values of all non-residential buildings in the region are high due to the grid plan structure of the region and the presence of long linear lines. On the other hand, it has been determined that Ali Paşa Bazaar, which is the oldest bazaar of the region, has the highest gravity values together with the recreation areas around it, and similarly, retail, recreation and public service areas at the intersection of Maarif and Balıkpazarı streets have high gravity values. However, since the intensive use in the region is only commercial functions, no differentiation can be observed in terms of attraction values, and the formation of different central regions is limited (Figure 6).

When natural and directed movement are evaluated together and the resulting total movement scores are calculated; unlike the results of the Space Syntax analysis, potential flow directions were determined on the axis of land use and gravity points (Figure 7). Talatpaşa, Balıkpazarı, İzmir, Osman Nuri Peremeci, Maarif, Saraçlar, Cumhuriyet, Osmaniye, Ortakapı streets are determined as lines with high-level movement capacity. It can be said that the flow directions are mostly concentrated at commercial, retail buildings and lines with high straightness/choice value. When the summary table for the calculated values is examined (Table 3), it is seen that the highest movement value (highest: 15) does not occur in any line, unlike the one presented in the method section. Approximately 68% of the street lines in the area have medium or high-level capacity movement, and 9 lines (approximately 7%) have high-level movement (mobility ≥ 9.8). The main reason for this is the limited variety of land use in the area, rather than the spatial configurational qualities. This can also be seen in the gravity and straightness values that support directed movement. While the Kaleiçi region has a strong collector/distribution structure in terms of natural

Table 3. Analysis results summary table

Edirne/Kaleiçi Region		
Total Movement Score	**Minimum**	3.40293
	Mean	7.719927
	Maximum	11.49638
Total Number of Lines		129
Number of Lines with 7 or More Movement Score		87
Percentage (%)		67.44

Analysis		Edirne/Kaleiçi Region		
		Min.	**Mean**	**Max.**
Natural Movement	Choice	1	1	2
	Integration (Global)	1	1.4357	2
	Intensity	1	1.4436	2
	Visual Integration	1	1.55875	2
Directed Mov.	Gravity	1	1.03905	2
	Straightness	1	1.05345	2
	Reach	1	1.44764	2

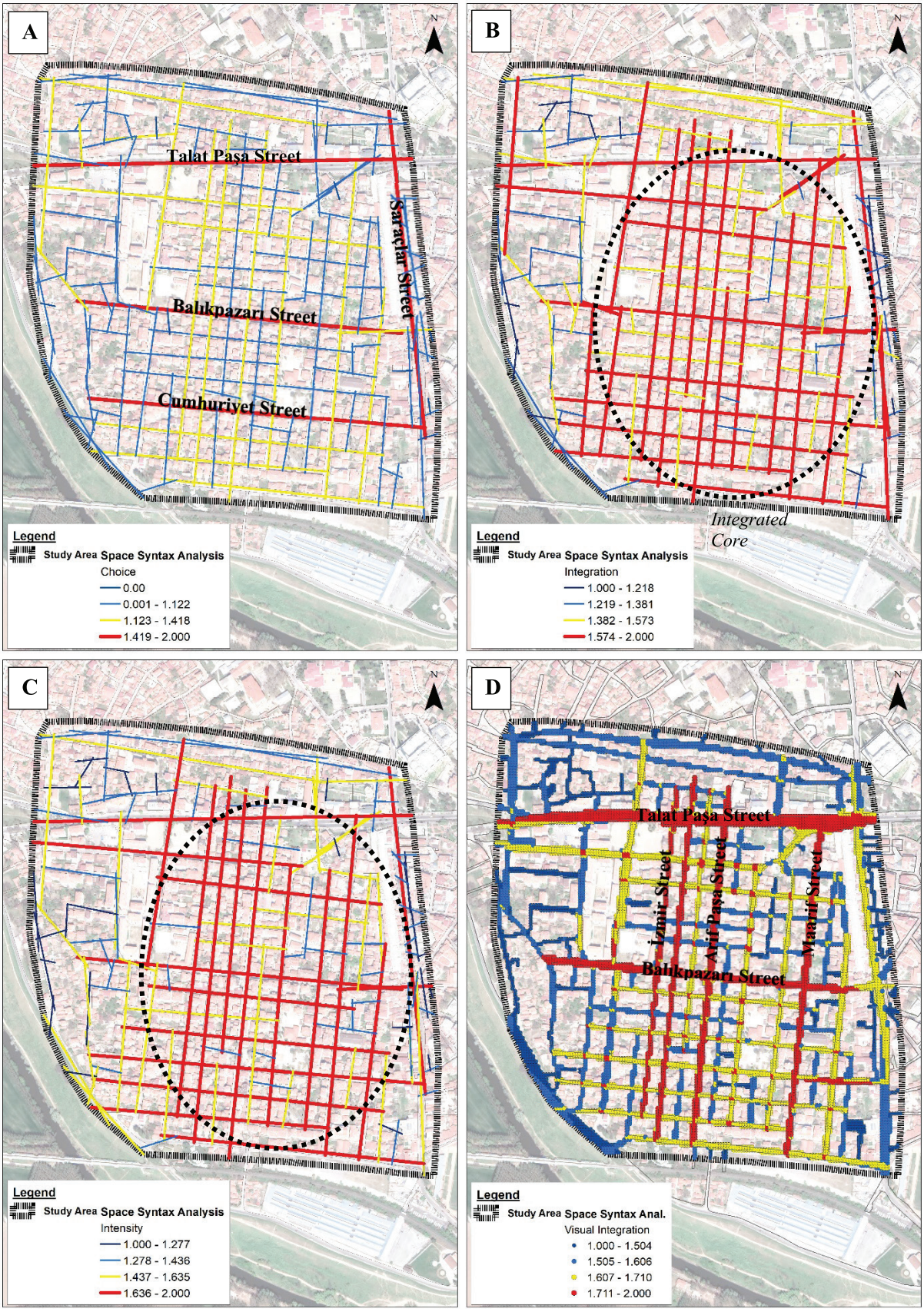

Figure 4. Study area natural movement analysis (base map: current Google Earth Satellite Image, scale: 1/3000) (a: choice, b: integration (global), c: intensity, d: visual integration).

Figure 5. Study area slope analysis (base map: current Google Earth Satellite Image, scale: 1/3000).

movement. It has limited qualities that will create attraction and direct different flows -as a result of the effects of different development axes, political/administrative interventions, and changes in the socio-economic structure in the historical process-.

Correlation Tests and Evaluations for Consistency of Findings

The movement scores for each line obtained as a result of the study were tested comparatively with real-time observable data and the existence of the relationship was

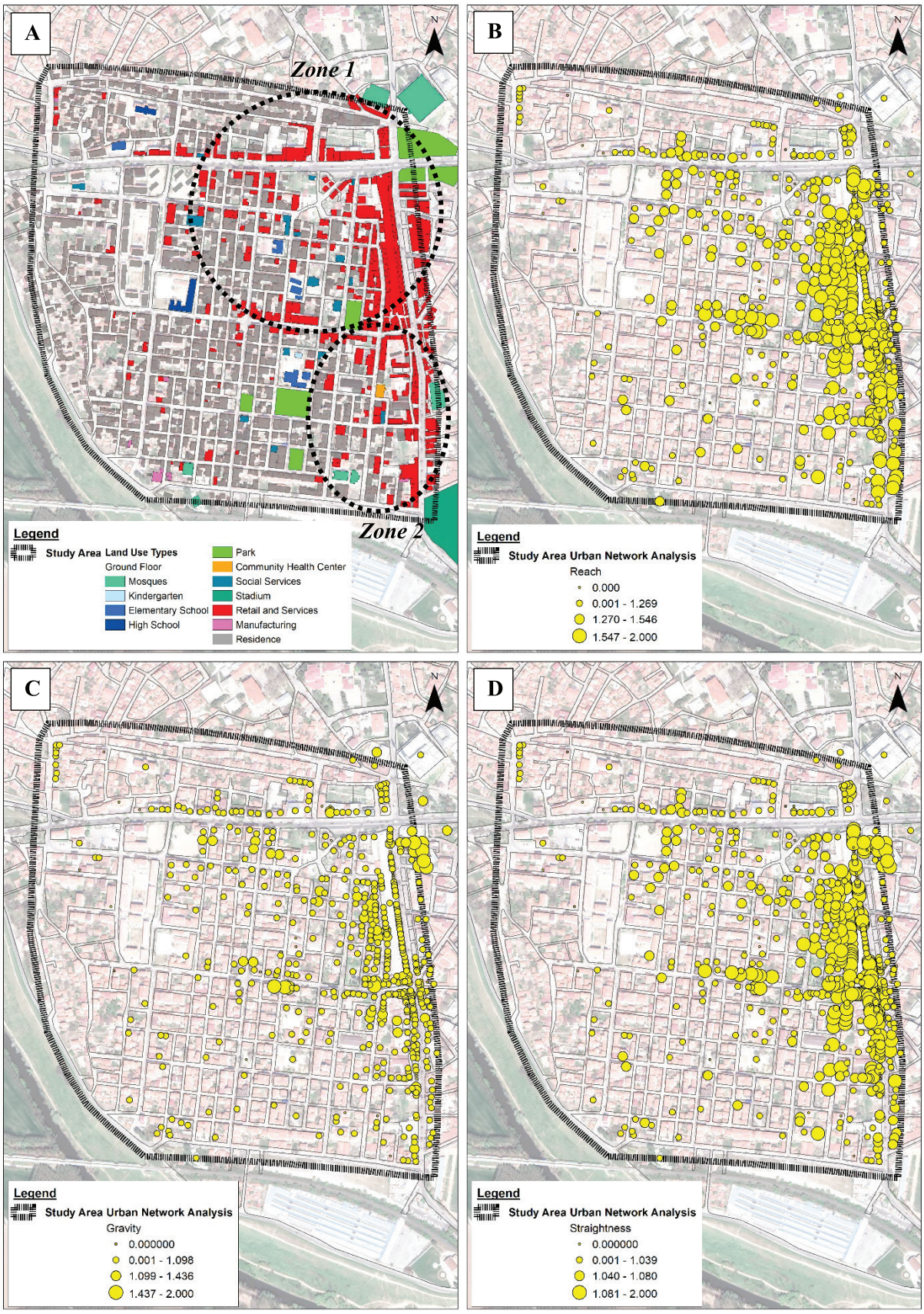

Figure 6. Study area directed movement analysis (base map: current Google Earth Satellite Image, scale: 1/3000) (a: land use (ground floor), b: reach, c: gravity, d: straightness).

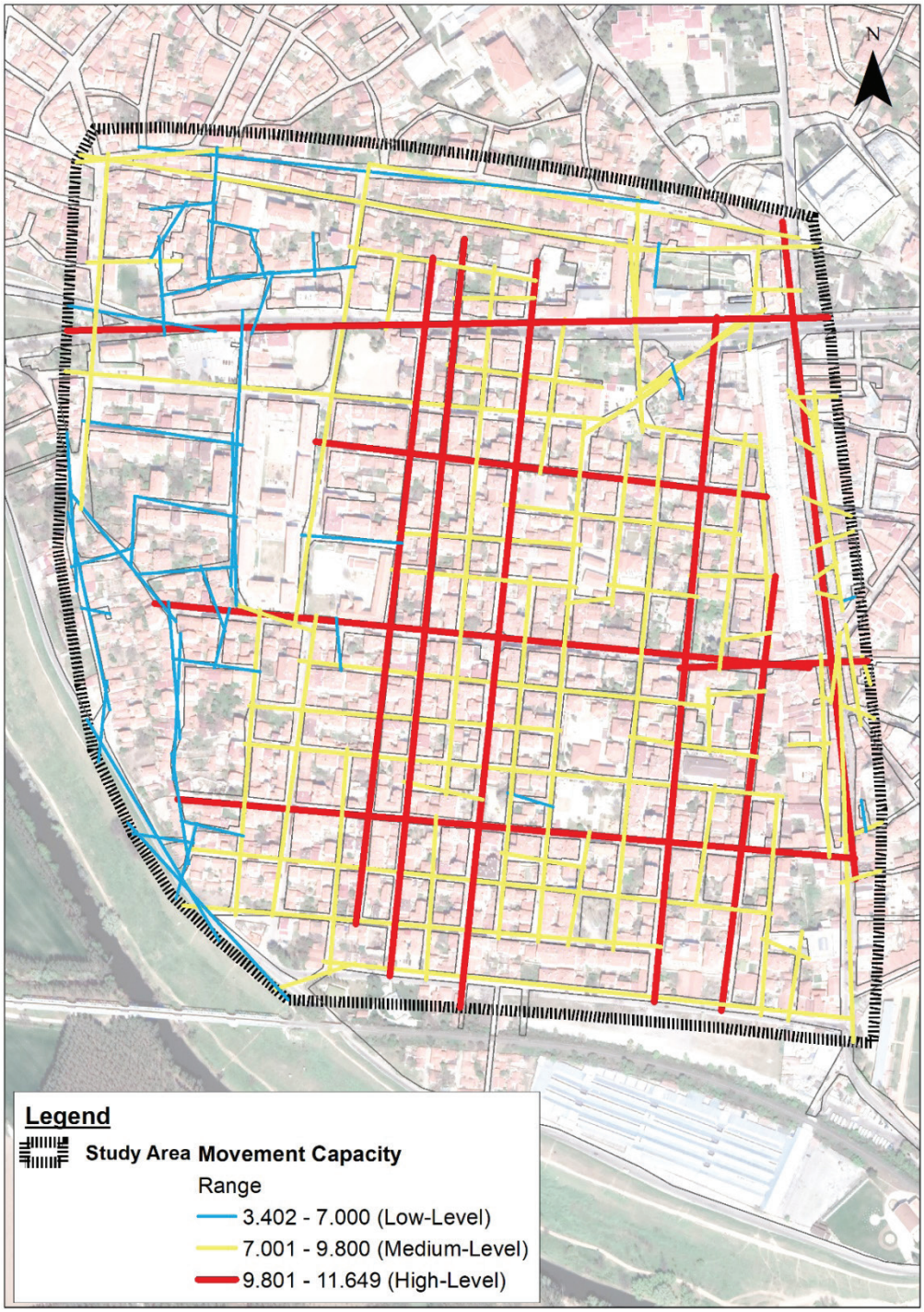

Figure 7. Study area total movement capacity analysis (basemap: current Google Earth Satellite Image, scale: 1/3000).

questioned. Proving evaluations were made for the accuracy and consistency of the result scores determined by these inquiries. The first questioning was with pedestrian and vehicle count values, and a correlation test was applied with mobility score (Table 4). Pedestrian and vehicle counts were carried out between 12:00-13:00 and 17:00-18:00 on 10 streets (in a homogeneous distribution in the Kaleiçi region) in March 2020, before the restrictions and curfews were implemented in line with the current pandemic conditions [98].

There is a **positive, high-level relationship with 99% confidence level** between the average number of pedestrians and movement scores (sigf: 0.009, p: 0.771). Similarly, there is a **positive, high-level relationship with 95%**

confidence level between average pass (pedestrian+vehicle) and movement scores (sigf: 0.036, p: 0.664). Therefore, it can be said that the calculated movement scores are compatible with the observable real-world and real-time user flow trends (Table 5).

Another evaluation was made with the current market values of the land. The market value of the land, which is a street-based value, reveals a value for per square meter of the land on each street line under the current conditions. It can be expected that the market values of the lands located on the street line with high-level movement will also be high. Correlation test was applied between the market values of the land and the movement scores in Talatpaşa, Balıkpazarı, İzmir, Osman Nuri Peremeci, Maarif, Saraçlar,

Table 4. Pedestrian/vehicle count locations and values

Count Locations	Hours	Automobile	Bus	Other Vehicle	Pedestrian
Arif Paşa Street	12:00-13:00	375	65	63	347
Darülhadis Street	12:00-13:00	920	144	112	104
Balıkpazarı Street	12:00-13:00	180	0	0	660
Gazipaşa Street	12:00-13:00	13	2	4	62
Hükümet Street	12:00-13:00	1320	180	60	1500
Kulekapı Street	12:00-13:00	120	0	0	420
Manyas Street	12:00-13:00	410	5	22	35
Maarif Street	12:00-13:00	780	0	0	1980
Saraçlar Street	12:00-13:00	3000	60	180	1380
Talatpaşa Street	12:00-13:00	1500	120	120	2460
Count Locations	**Hours**	**Automobile**	**Bus**	**Other Vehicle**	**Pedestrian**
Arif Paşa Street	17:00-18:00	617	65	127	458
Darülhadis Street	17:00-18:00	546	78	84	162
Balıkpazarı Street	17:00-18:00	420	0	0	1200
Gazipaşa Street	17:00-18:00	18	3	1	73
Hükümet Street	17:00-18:00	960	240	0	2100
Kulekapı Street	17:00-18:00	300	0	0	840
Manyas Street	17:00-18:00	520	26	58	74
Maarif Street	17:00-18:00	1020	180	0	1260
Saraçlar Street	17:00-18:00	2460	12	540	1020
Talatpaşa Street	17:00-18:00	3300	300	240	2800

Count Locations	Average Number of Pedestrians for eve and morning	(Pedestrian+Vehicle)			Total Movement Score
		Total Morning Pass	Total Evening Pass	Average Pass	
Arif Paşa Street	403	850	1267	1059	11.082179
Darülhadis Street	133	1280	870	1075	9.17101
Balıkpazarı Street	930	840	1620	1230	10.915661
Gazipaşa Street	68	81	95	88	9.726864
Hükümet Street	1800	3060	3300	3180	10.601487
Kulekapı Street	630	540	1140	840	9.417663
Manyas Street	55	472	678	575	9.497865
Maarif Street	1620	2760	2460	2610	11.377116
Saraçlar Street	1200	4620	4032	4326	10.601487
Talatpaşa Street	2630	4200	6640	5420	11.649638

Table 5. Result of correlation tests (movement-pedestrian/vehicle counts)

Test-1		**Movement Score**
Average Number of Pedestrians	Pearson Correlation	**0.771****
	Sig. (2-tailed)	**0.009**
	N	10
Test-2		**Average Pass**
Movement Score	Pearson Correlation	**0.664***
	Sig. (2-tailed)	**0.036**
	N	10

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6. Movement score and land market value of the streets*.

Streets	**Total Movement Score**	**Land Market Value (2020) (TL/m²)**
Talatpaşa Street	11.6496	1568.83
Ortakapı Street	9.8389	366.42
Balıkpazarı Street	10.9156	522.87
Cumhuriyet Street	10.4642	418.74
İzmir Street	10.0429	209.34
Osman Nuri Peremeci Street	10.1663	209.34
Arif Paşa Street	11.0821	311.23
Maarif Street	10.3771	366.39
Osmaniye Street	9.9528	366.42

* It was compiled from Edirne Municipality electronic database.

Cumhuriyet, Osmaniye, Ortakapı streets (higher than 9.8) where the high-level movement capacity was calculated (Table 6). When Table 6 is examined, it is seen that there is a balanced distribution in the streets other than Arif Paşa Street.

There is a **positive, high-level relationship with 95% confidence level** between the market value of the land and the movement scores (sigf: 0.017, p: 0.762). As a result of the correlation test performed with the assumption that the market values of the lands on the street line with high-level movement will be high, the relationship between the two data was determined (Table 7).

Table 7. Result of correlation tests (movement-land market value)

Test-3		**Movement Score**
Land Market Value (TL/m²)	Pearson Correlation	**0.762 ***
	Sig. (2-tailed)	**0.017**
	N	9

*. Correlation is significant at the 0.05 level (2-tailed).

CONCLUSION

The primary objective of this study is to define the factors that affect users' movement preferences, propose a method for identifying the mobility patterns in urban space, and reveal the distinctive spatial structure. In this respect, the literature review revealed that the physical space contains information on the abstract economic, social and political space, and street patterns are the main factor that helps examine this information. Based on the evaluations made in Kaleiçi, it is possible to conclude that movement flows in space are shaped in line with social and economic characteristics. The choice, integration, and intensity values are high for users according to the physical construct of streets in Kaleiçi. However, the movement remains in a very limited area due to the following factors: Different development axes throughout history, the changes in the socio-economic structure and one type of intensive land use type (retail). The study has also revealed that using the attributes of spatial configuration alone will not be sufficient in similar comprehensive studies. Thus, it must be supported by other sub-components, especially land use. The results of the analysis and correlation tests uncover a different concentration from the highly-integrated areas revealed by the

Space Syntax method, which is based on street patterns. The Urban Network Analysis method proves to be a proper perspective especially in identifying the effect of land use in directing flows and locating attractive regions. Therefore, the approach provided by these two methods, together with the other components, provides a consistent framework.

In addition, Talatpaşa, Balıkpazarı, İzmir, Osman Nuri Peremeci, Maarif, Saraçlar, Cumhuriyet, Osmaniye, Ortakapı Streets in Edirne-Kaleiçi with a high-level of movement capacity constitute the backbone of the urban life. These axes should be addressed in urban design and planning processes, and it is necessary to make sensible decisions on these axes, especially in transportation models and interventions. Land uses [for example, recreation, service (social/cultural)] should be arranged, and street patterns should be readdressed in a way to increase the attractiveness in areas with low-level movement capacity. In this way, it would be possible to achieve a holistic use of the space.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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