A GIS-Based Walkable Service Area Analysis from a Smart Growth Perspective in the City of Edirne

Rumeysa Ceylan

Department of Urban and Regional Planning,
Faculty of Architecture, Yıldız Technical University, Istanbul, Turkey
rumeysceylan@gmail.com

Abstract

Today it is generally agreed that one of the most important problems of many cities is uncontrolled urbanization. Different approaches have been tried to investigate how cities should be developed. Among these approaches, the Smart Growth movement initially emerged as a response to all of the negative externalities (environmental corruption, rising costs, poor infrastructure, and operational and maintenance issues) resulting from urban sprawl. The Smart Growth approach is based upon 10 main principles. Among these principles, “creating walkable environments” plays a crucial role in promoting society’s health, relating to both physical and mental conditions. Moreover, walkable areas stimulate revitalization of public spaces, open space, and local shops. From the perspective of Smart Growth, evidence has shown that there is excessive use of the automobile, which dramatically increased greenhouse gas emissions in many cities, including the city of Edirne in Turkey. However, the topography of the city is quite suitable for walking and cycling trips. The main purpose of this paper is to measure walkability in Edirne City and to identify areas with low walkability scores. In this way, the quality of pedestrian facilities, safety, and the comfort of walking can be increased. Different methodologies exist in the literature for walkability analysis. One of them, Walkable Service Area Analysis (WSAA), is a spatial network analysis based on a Geographic Information System (GIS). ArcGIS software from the Environmental Systems Research Institute (Esri) has been used to perform WSAA in this article. Through the GIS-based walkability analysis and using the calculated index, the walkability scores of neighborhoods were determined and the results have been classified into five categories (not walkable, low walkable, medium walkable, high walkable, and exceptionally walkable) in the city of Edirne.

Keywords: Smart Growth, walkability, GIS science, sustainability, Edirne.

Introduction

In recent years, urban settlements have faced different dimensions of environmental threats ranging from global warming to the loss of biodiversity. At this point, it is important to emphasize that the concept of "sustainability" has been at the center of the urban agenda at the global scale. For instance, in the 1970s, a number of policy changes were carried out because of increasing environmental problems and the revitalization of problematic urban centers (*Herndon*, 2011). In 1972, remarkable publications (e.g. Ecologist: Blueprint for Survival) were published concerning the limits of growth. The Habitat Forum, held in 1976, discussed the measures that could be taken against environmental problems caused by urban growth. In addition, two important recommendations were made by the "Green Paper" of the European Commission (1990): (a) high densities should be supported and (b) urban sprawl should be avoided for a sustainable urban form (Hall, 2006). In the 1990s, great debates among scholars, politicians, and media groups about sustainability at global, regional, and local levels emerged. As a result of these discussions, new movements were put forward to improve urban environment, such as New Urbanism and "Transit-Oriented Development" by Duany and Plater-Zyberk (1993). This neo-traditionalist approach has emphasized concepts such as a walkable community, compact urban form, neighborhood, or small town social relations. At the end of the 1990s, Smart Growth, one of the other significant new movements, emerged as an environmental agenda in the context of American urban sprawl problems (with the development of regions, cities, and towns) such as traffic congestion, air pollution, inefficient use of energy, loss of open space and natural resources, and loss of spirit (Jacobs, 1961; Scheffler, 2003; Wu, 2007).

Smart Growth has 10 main principles: (a) mixed land use; (b) compact building design; (c) a variety of housing opportunities and choices; (d) creating walkable neighborhoods; (e) fostering distinctive and attractive communities with a strong sense of place; (f) preservation of open space, farmland, and natural beauty and critical environmental areas; (g) direct development of existing communities; (h) variety of transportation options; (i) predictable, fair, and cost-effective development decisions; and (j) community and stakeholder collaboration for development (Downs, 2005; Khodeir, Elsisy, & Nagy, 2016; Smart Growth Network [SGN], 2001; Wey & Hsu, 2014). Among these principles, "creating walkable neighborhoods" characterized by the design of the living environment has become more attractive, useful, safer, and healthier because of facilities such as safe streets, less automobile dependence, and low transportation costs.

This article investigates a measure of the effectiveness, street connectivity, and pedestrian access to neighborhoods in promoting walking and cycling as alternatives to driving cars to reach shopping, recreation areas, universities, schools, and other common destinations using network analysis and the calculation of walkability scores.

According to the "Public Transport Project Report" of the Municipality of Edirne (2010), the lack of diversity and quality of modes of transport has greatly increased the use of private cars. This causes many problems, especially traffic congestion, noise pollution, and air pollution. A survey conducted by the Management of Transportation revealed that more than half of the people living in Edirne City stated that they would not use their private vehicles if there was diversity in modes of transportation. People are open to different types of transportation, which is a great opportunity for the Smart Growth principle of "creating walkable environments." Furthermore, Edirne City has another advantage for implementing the principle of "creating walkable environments," with its slope below 8% and its topography which is suitable for walking and cycling trips. For all of these reasons, Edirne City has been chosen as a study area.

In this article, firstly, the Smart Growth perspective and creating "walkable environments" issues are discussed. In the following section, the data and methodology of the study are explained. Different methodologies exist in the literature for walkability analysis. One of them, Walkable Service Area Analysis (WSAA), is a spatial network analysis technique based on a Geographic Information System (GIS). Thus, in the data and methodology section, ArcGIS (ESRI, 2014) solutions have been used to perform WSAA. Through the GIS-based walkability analysis and the calculated index, the walkability scores of neighborhoods are calculated, and the results are classified into five categories such as *not walkable* (0), *low walkable* (10–20), *medium walkable* (20–40), *high walkable* (40–60), and *exceptionally walkable* (60–100) in the city of Edirne. In the last part of the study, the findings are evaluated.

Smart Growth Perspective and Walkability Principle

The Smart Growth approach has been introduced by the American Planning Association towards the end of the 1990s to avoid urban sprawl and achieve urban sustainability goals (Khodeir et al., 2016). Smart Growth is a city planning and transportation approach aiming the creation of compact and walkable cities to prevent urban sprawl (Wey & Hsu, 2014). Along with that, there is no single definition of Smart Growth in the literature. However, it is seen that the different definitions in the literature are very close to each other. The definitions are generally described through Smart Growth principles. Smart Growth has 10 main principles, and also these create the basis of a Smart Growth approach. These principles are (a) mixed land use; (b) compact building design; (c) a variety of housing opportunities and choices; (d) creating walkable neighborhoods; (e) fostering distinctive, attractive communities with a strong sense of place; (f) preservation of open space, farmland, and natural beauty and critical environmental areas; (g) direct development of existing communities; (h) variety of transportation options; (i) predictable, fair, and cost-effective development decisions; and (j) community and stakeholder collaboration for development (Downs, 2005; Khodeir et al., 2016; SGN, 2001; Wey & Hsu, 2014). These principles are generally about equitable allocation of both natural resources and costs/benefits in urban space, protection of critical environmental areas and agricultural areas, making streets more attractive, and stimulating economic activities, as well as solving transportation, commercial area, and residential area connections. These principles also include planning strategies about transportation policies in a different scale, and the main objectives of these strategies are to reduce carbon emissions and protect public health with the reduction of private car use, the development of public transport, and walkable transport system (ICMA & EPA, 2006). Hence, all of these principles complement each other and help to illuminate the phenomenon of Smart Growth.

The principle of “creating walkable neighborhoods” is linked to all other principles along with being the most basic element of Smart Growth. The fact that communities have a walkable living environment means that elderly citizens, handicapped people, and children have a number of pedestrian paths with safe crossing connections and well-designed landscape to suit their needs. These changes reduce not only overuse of car but also car ownership, decrease green gas emissions, and strengthen local business as well as improving social relations among citizens (Speck, 2013; Kotharkar & Bahadure, 2015). Insofar, the benefits of walking can be summarized in three main titles: economic benefits, social benefits, and environmental benefits. All of these constitute the general description of the principle of “Creating Walkable Neighborhoods.” This principle is fundamental because walking is the most socially equitable mode of society in terms of accessibility and walkability. In addition, walking activity is an environment-friendly transportation mode (Ariffin & Zahari, 2013; Jacobs, 1961; Khodeir et al., 2016; Wey & Hsu, 2014). But, what are the factors that affect willingness to walk? The essential factor is related to network design of neighborhood which consists of grid networks with short blocks for shortening pedestrian trips, sidewalks for safety, setbacks, and parking for the pedestrian friendly area, residential density, and street connectivity. Besides, network design of neighborhood, weather conditions, and safety are shown to affect walking. According to the study done, it has been concluded that people are more willing to walk in high temperatures. In addition to this, it has been found that places where the walking rate is higher are more secure (Ariffin & Zahari, 2013).

As it has been seen in the perspective of Smart Growth, what is understood by creating walkable neighborhoods is the implementation of strategies for improving walkability. Although the term “walkable” has been used since the 18th century, the term “walkability” is rarely encountered in dictionaries, but is frequently used in practice (Forsyth, 2015). According to Rattan, Campese, and Eden (2012), walkability is defined as a measure of the effectiveness of community design in promoting walking and cycling as alternatives to driving cars to reach shopping, schools, and other common destinations. In this part of the study, the term “walkable” was used as an umbrella concept, and in the following part, WSAA will be based on the term “walkability.”

Data and Methodology

There are different methods that existed in the literature on walkability because the walkability of cities and neighborhoods has become an important and common concern for many different planning approaches such as Smart Growth. Some of these methodologies are qualitative (self-reported information or systematic field observation) and others are quantitative (mathematical network analysis methods).

These methods can be quite different from each other depending on the research objectives for “walkability”. For instance, researchers investigating the benefits of walking for health may not be interested in the purpose and location of the walking, while researchers analyzing automobile dependence might focus on how travel habits can be changed. Both of these hypothetical methods are based on resident's interviews and surveys to measure actual travel activity (Holbrow, 2010). On one hand, these type of qualitative methods used for walkability have unfavorable negative aspects such as long-term observations, difficulty of reaching the correct information (problems in survey research), and expenses (Duncan, Aldstadt, Whalen, Melly, & Gortmaker, 2011). On the other hand, some conventional methods in the literature are also insufficient, such as the bird's-eye distance method. This method is not satisfactory because walkability has more comprehensive meaning than distance. Instead of these methods, other researchers interested in the equity of physical access and use different GIS methods to focus on the network connectivity, condition of sidewalks, and other street infrastructure. One of the GIS methods is WSAA which is increasingly recognized in walkability studies because of the use of real (or current) data. WSAA, a method used for walkability analysis, is a spatial network analysis based on GIS, and this method includes a direct measure of connectivity by using network distance. Therefore, Holbrow's (2010) methodology for measuring walkability was used and developed with respect to spatial characteristics in Edirne's case. In this study, ArcGIS software from Esri solutions was used to perform the WSAA.

Two types of data sets were utilized as indicated in Table 1. To collect the data, a field trip was made to Edirne City in November 2014. Both local authorities and planning companies were also visited to obtain a digital database. The first category of the data set is the land use data in CAD format, received from BHA Planning and Consulting Company, which has been converted into GIS format. The second data set consists of destination points such as recreation area (park), day-care center, elementary schools, and bus stops, all of which are extracted from the land use map and converted into GIS format.

Table 1. Methodology and Data of Walkable Service Area Analysis (WSAA)

Analysis	**Methodology of Analysis**		**Database**
WSAA	First, land use of Edirne City, which was prepared in the CAD environment, was reorganized in a Geographic Information Science (GIS)-based system	ArcToolbox > Georeferencing	BHA Planning and Consulting Company (2006), Basemap and Land Use map (CAD format)
	Second, all destinations in the city were pointed in the GIS-based system	Arccatalog > Point features	All destination points created within the .shp format (2014)
	The midpoints of avenue and streets were taken as references. Based on the reference points, a data set was created with walk and sidewalk connection.	ArcToolbox > Feature to Line > Spatial Adjustment > Network Dataset	A street set created, based on a geographic database (2014)
	Walkable service areas were calculated from selectable destination points to the middle of the avenue and streets	ArcToolbox > Network Analyst > Service Area Properties > New Service Area>Solve	A network set created, based on a geographic database (2014)
	The polygonal service areas were calculated using the network analyst converted to the raster surface	ArcToolbox > Polygon to Raster > Raster Grid Cell Size 5 meters	Raster-based interfaces created for all vector service areas (2014)
	Mapping of the service area value of each center introduced the map where the resulting walkability scores were classified	ArcToolbox > Spatial Analyst Tools > Local > Cell Statistics > Sum	
	The generated raster values divided each neighborhood (zones) by the split command	ArcToolbox > Analysis Tools > Local > Extract > Split	Neighborhood borders created in .shp format

Study Area

Edirne is a city with an area of 82,100 ha, located to the west of Turkey's Thrace region. It is also in the middle of the plains surrounded by the Tunca and Meric rivers. The city of Edirne is described as the gateway to Europe, with Greece in the West and Bulgaria in the north (Figure 1). Despite the importance of its location, among the transportation modes in the city of Edirne, the most frequently used one is highway transportation. For instance, the Istanbul–Kapikule TEM highway (O-3), which has international importance, is the mainstay of transportation infrastructure. To reduce the traffic jam of the D-100 highway (TEM) and to increase the accessibility of the region, a Rapid Train Project has been carried out between Istanbul and Edirne.

Figure 1. Location of Edirne and Edirne Central Districts (*map was created using basemap of the ArcGIS 10.2 program*)

In the city of Edirne, the relationship between settlement suitability and walkability has been analyzed in the context of Smart Growth principles. According to this, first of all, the results of elevation and slope analysis of the city were evaluated. When the results were examined, it has been found that about 60% of the study area is between 60 and 120 m above the sea level. When the residential area was analyzed, it was observed that the texture of the settlement is compatible with the topography. In addition, the slope value ranges between 3% and 10%, which can be considered as suitable for the settlement.

The population of Edirne City was 173,037 in 2016, and there are a total of 24 neighborhoods. Furthermore, the historical center of Edirne is continuing to grow rapidly toward the west. In this process, rapid urbanization and destruction of the historical buildings have begun to damage the cultural identity of the city and the demand for areas outside the residential area, where land values are lower than those in the center of the city, have increased. The residential areas that sprawl in the peripheries have caused the deterioration of the natural structure. The technical and social infrastructure has increased the costs, and irregular settlement patterns have occurred. The cultural identity of the city will continue to deteriorate unless the historical sites are integrated with the new development areas through urban planning.

According to population statistics, the number of students of Trakya University, which is one of the most important reasons for the increase in population growth rate after 2004, increased approximately from 13,000 to 21,000 in this period. In the last 10 years due to the students' preference for being close to the University, the population of Sukrupasa, I.Murat, Kocasinan, and Fatih neighborhoods has increased very quickly. These neighborhoods are signaling that the population living here will increase in the future. Also, it is seen that the population of Barutluk neighborhood is increasing rapidly due to residence development designed by TOKI (Housing Development Administration of Turkey) and with the second stage of this project will continue to rise. Population decrease in the old neighborhoods alongside this growth is the most important sign of the urban sprawl. Rapid urbanization and unfair distribution of the city's resources have caused the increase of automobile ownership, the increase of carbon footprint, technical and social infrastructure costs, and the irregular settlement pattern.

GIS-Based WSAA in Edirne City

Basically, WSAA analysis of the city of Edirne is based on the calculation of walkable service areas of some public destinations (primary education, social center, and university), recreation areas (parks and kinder garden), transportation points (public transportation stops), commercial areas, and hospitals. Then, all these service areas have been overplayed in GIS. Each step of this study will be discussed in detail in the below sections.

Step-1

In the first step, the land use of Edirne City was obtained in the CAD environment transferred into ArcGIS format. Then, through the field work, the land use and its attributes were updated. Neighborhood children's playgrounds, recreation areas (park), day-care centers, elementary schools, high schools, university, hospital, social facilities, religious facilities, bus stops, and mixed-use buildings were chosen as the destination points where citizens in the city visit regularly and intensively.

All these destination points were created in GIS environment (Arccatalog/Point Features) (Figure 2 displays two of these points such as bus stop and recreation area). As seen in Table 2, 11 selected destination points were mainly rated with values between 1 and 14 depending on the intensity of their usage in the city. However, it has been determined that the distance values to these points change from 400 to 800 m (Baş, 1985; Holbrow, 2010). The "weight" was determined according to the attracted population of the related destination (see Table 2).

Table 2. Walking Distances and Weights of Selected Destination Points in Edirne City (*resources of Holbrow [2010] and Baş [1985] were utilized for accessing distance standards of urban destination point*)

Destination points	Distance (m)	Weight	Total grade (Distance × Weight)
Neighborhood children's playground	400	6	2,400
Recreation area (park)	400	12	4,800
Day-care center	400	6	2,400
Elementary schools	400	8	3,200
High schools	800	8	6,400
University	800	12	9,600
Hospital	800	10	8,000
Social facilities	800	8	6,400
Religious facility	800	8	6,400
Bus stop	400	8	3,200
Mixed-use building (multifunctional)	400	14	5,600

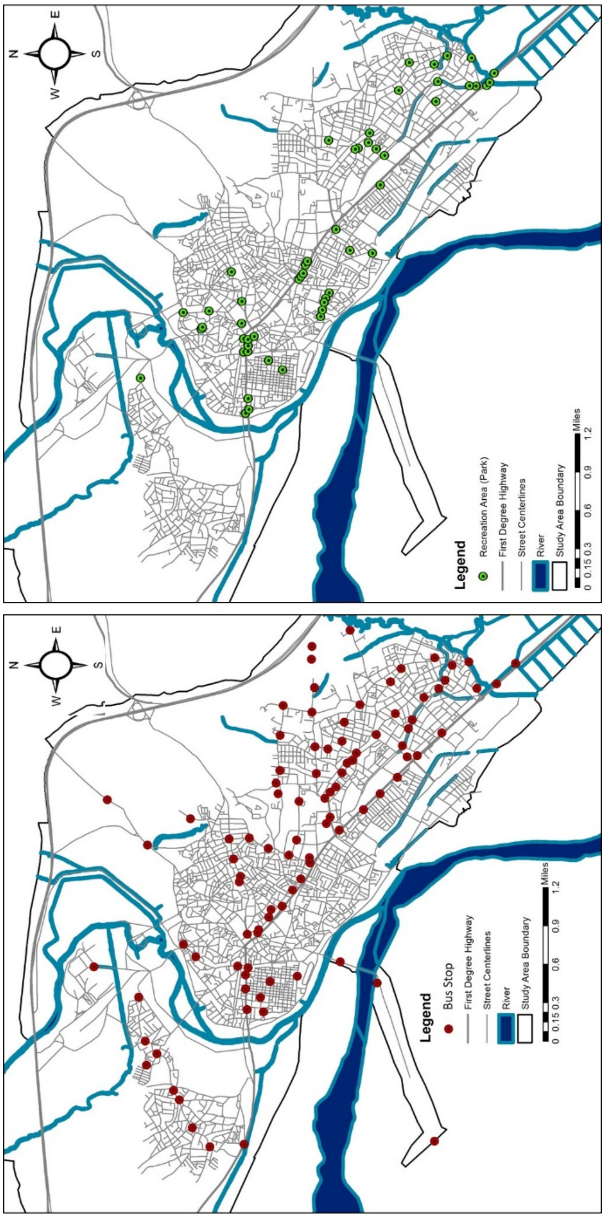

Figure 2.

Selected destination points (bus stops and recreation areas) are shown in the GIS-based system for Edirne City (*maps were created using land use database of BHA-Planning and Consulting Company and the ArcGIS 10.2 program*)

Step-2

In the second step of the WSAA methodology, the midpoints of avenues and streets have been taken as references. Based on these reference points, a data set with walk and sidewalk connection was created. Selectable points, walkable service areas to the middle of the avenue and streets, were measured (Spatial Analysis and Network Analysis). The polygonal service areas were calculated using the network analysis and converted to the raster surface. The main purpose of this process is to divide each service area into fragments of the same size (Raster Grid Cell Size: 5 m in this study) and assign a value to a cell (value is obtained as a result of multiplying the points with the access points). Totally, 11 walkable service areas are created for each type of destination points. Figure 3 shows two of these service area (walkability areas for the bus stop and recreation area) analyses as an example.

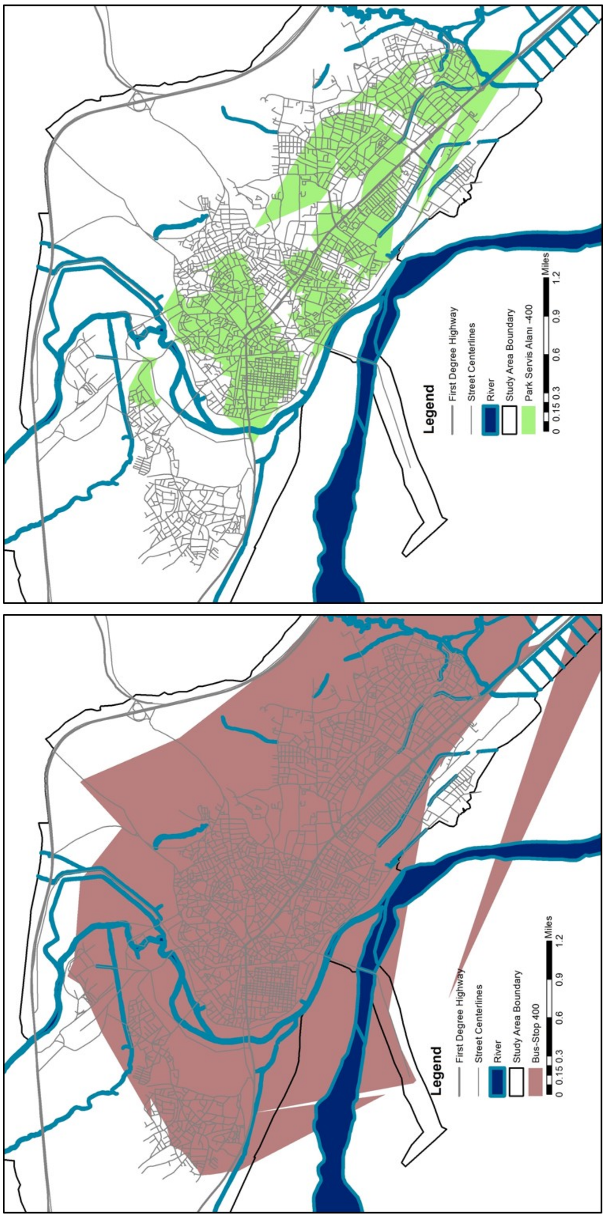

Figure 3. Walkable service areas measured from bus stop points to recreation areas (*maps were created using the ArcGIS 10.2 program and BHA Planning Company database*)

Step-3

At the third stage of the WSAA analysis, the calculated values of the walkable service area raster surfaces of 11 selected points (neighborhood children's playground, recreation area [park], day-care center, elementary schools, high schools, university, hospital, social facilities, religious facility, bus stop, and land-use) were overlaid. Thus, walkable and non-walkable service areas within Edirne City were obtained, where attached values are divided into five classes such as *not walkable* (0), *low walkable* (10–20), *medium walkable* (20–40), *high walkable* (40–60), and *exceptionally walkable* (60–100) levels. In Figure 4, raster-based walkability network analysis was shown in the GIS system. Besides, Table 3 illustrates the sizes of each walkability class and the population living in these areas.

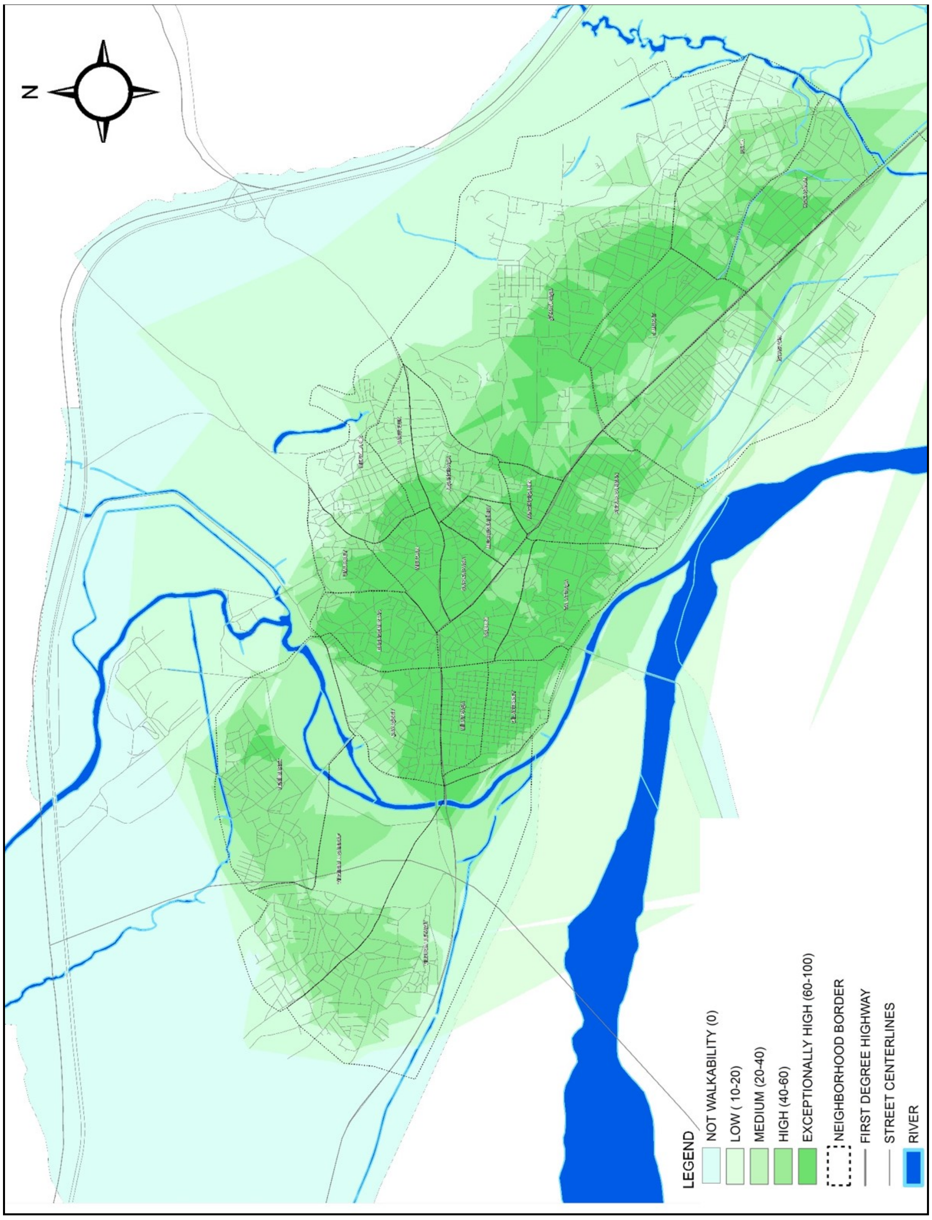

Figure 4. Raster-based Walkability Network Analysis in Edirne City (*maps were created using land use database of BHA-Planning and Consulting Company and the ArcGIS 10.2 program*)

As a result of the WSAA analysis, as can be seen in Table 3, 46% of Edirne City has an exceptionally high walkability score and 38% has a low walkability score. The population of Edirne City was 173,037 in 2016. Based on this population, it is estimated that the number of people living in low walkability areas is 57,665. On the other hand, the number of people living in high walkability area is 7,350 (Table 3).

Table 3. Area Sizes of the Walkability Class and the Population Living in These Areas

Class of walkability	Population	Area (ha)
Not walkable	68,886	401,622
Low	57,665	336,201
Medium	9,287	54,146
High	7,350	42,852
Exceptionally high	7,015	40,884
Total	150,260	875,705

Step-4

In the last step of the WSAA analysis, walkability raster values (previously created) are converted to polygons and the generated raster values are separated into neighborhoods (zones) by using a split command. Thus, walkability scores are calculated depending on each neighborhood (Figure 5). Then, the neighborhood-based walkability index is constructed and the results are classified in to five categories (Table 4).

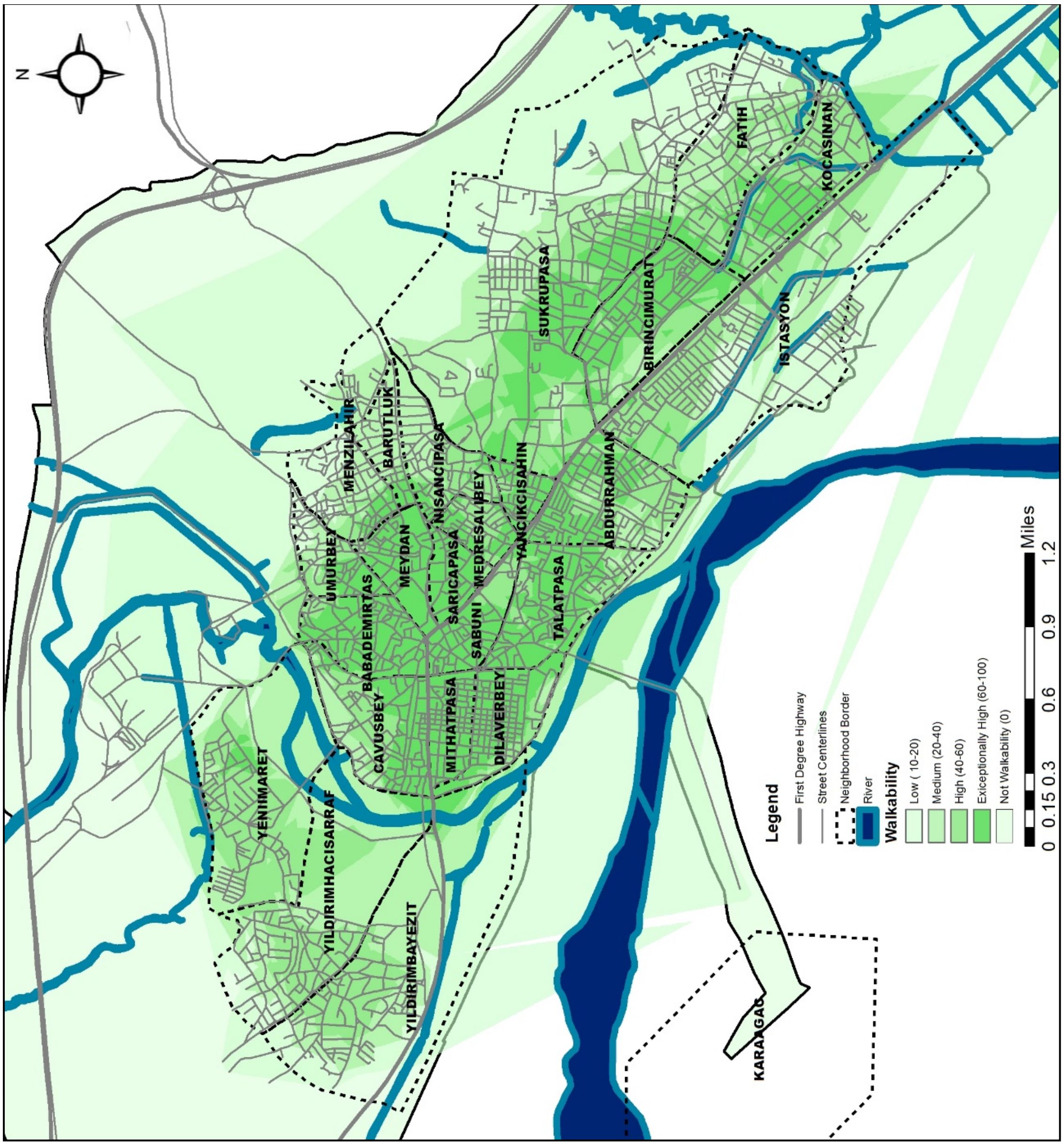

Figure 5. Walkability scores for each neighborhood in Edirne City (*maps were created using land use database of BHA Planning and Consulting Company and the ArcGIS 10.2 program*)

Table 4. Distribution of Walkability Classes According to Neighborhoods

Neighborhoods	Not walkable (0)	Low walkable (10–20)	Medium walkable (20–40)	High walkable (40–60)	Exceptionally walkable (60–100)
Yildirimbeyazit	81	0	45.5	40.03	2.83
Yildirimhacisarraf	0	34	56.59	30.07	3.65
Yeniimaret	0	3.92	51.11	53.08	3.88
Cavusbey	38	0	0	1.15	10.75
Mithatpasa	0	0	0	0	20.3
Dilaverbey	0	0.0016	1.21	6.39	26.69
Talatpasa	0	0	2.45	9.31	38.83
Sabuni	0	0	0	0	24.98
Babademirtas	0	0	0	2.45	33.36
Umurbey	0	3.83	4.37	5.88	7.84
Meydan	0	0	0	0.8	24.55
Saricapasa	0	0	0	0.72	15.23

Medresalibey	0	0	0	6.93	8.69
Abdurrahman	0	0	6.35	23.01	25.03
Yancikcisahin	0	0	0	1.24	10.75
Nisancipasa	0	0	13.45	13.81	4.21
Barutluk	9	0	4.56	1.26	2.41
Menzilahir	0	19.45	23.64	4	4.48
Sukrupasa	0	149.68	73.77	49.76	60.29
Birincimurat	0	0	4.63	16.47	40.3
Fatih	0	16.16	25.88	24.52	7.06
Kocasinan	0	0.4	1.43	33.12	20.63
Istasyon	0	70.38	53.4	62.34	4.06

According to Table 4, it is seen that the historic urban centers such as Mithatpasa (20.3), Dilaverbey (26.69), Meydan (24.55), Sabuni (24.98), and Babademirtas (33.36) are at high walkability levels, whereas new neighborhoods such as Yildirimbeyazit (81), Sukrupasa (149.68), Cavusbey (38), and Istasyon (70.38) are at very low walkability levels.

Conclusion

Evaluating Edirne City according to the 10 basic principles of Smart Growth approach, it has been seen that productive areas such as agriculture, forest, and water surfaces are under the pressure of settlement; the city center is not compact; and the transportation modes are not diversified even though the topography allows different modes of transportation. In addition, it has been determined that there is no integration among the existing modes of transport, especially pedestrian and cycling modes which have not improved compared to others. There are problematic areas in terms of walkability and accessibility where carbon emissions are high and alternative energy sources are not utilized. All these principles influence each other in terms of causes and consequences. Thus, analyzing the principle of "creating walkable neighborhoods," one of the most important components of the Smart Growth approach, will contribute greatly to resolving these problems and finding out the current situation of the neighborhoods in Edirne City. For this purpose, using GIS-based walkability analysis (WSAA) and the calculated index, the walkability scores of neighborhoods in the city of Edirne have been measured and the results classified into five categories: *not walkable* (0–10), *low walkable* (10–20), *medium walkable* (20–40), *high walkable* (40–60), and *exceptionally walkable* (60–100). According to the results from WSAA, 47% of the city of Edirne has a high walkability score and 38% has a low walkability score. When examining the populations with high and low walkability scores, it is estimated that the people who live in areas with high walkability score (7,350 people) are far fewer than those who live in areas with low walkability score (57,665 people).

A walkability index has been formed based on the obtained results, and the walkability scores have been classified according to the neighborhoods for making the city of Edirne a more walkable place. According to this classification, neighborhoods such as Mithatpasa (20.3), Dilaverbey (26.69), Meydan (24.55), Sabuni (24.98), and Babademirtas (33.36) have a high level of walkability. Despite the decline of the population in these neighborhoods, located in the vibrant historic city center, over time, they still combine commercial areas with historical structures. On the other hand, new neighborhoods such as Yildirimbeyazit (81), Sukrupasa (149.68), Cavusbey (38), and Istasyon (70.38), where new public buildings, industrial sites, and the university are located, have been found to have very low walkability score. According to the results of the analysis, a compact urban development plan should be initiated at an urban scale to increase walkability in these neighborhoods. Within this framework, firstly, intensities should be increased vertically rather than horizontally, and mixed use should be developed. By this means, accessibility of residential, business, commercial, and recreational areas will be increased, and neighborhood residents will have faster and easier access to destination points. Second, the restriction of car parks in the neighborhoods and an additional charge for parking will reduce the use of individual car ownership and encourage people to walk. Last but not least, there is an urgent need for better street and sidewalk design to improve walkability. Wide sidewalks and well-defined streets should be reinforced by green connections using elements such as parks, nature trails, trees, and public space, which will encourage people to walk from both a physical and psychological perspective.

Acknowledgments

This paper is based on the individual planning approach (the city of Edirne is planned in the perspective of Smart Growth) carried out within the scope of Planning 8 Studio (in the Department of City and Regional Planning, Yildiz Technical University), and on an undergraduate thesis (the city of Edirne is examined in the perspective of Smart Growth) studied in parallel with these works.

References

Ariffin, R. N. R., & Zahari, R. K. (2013). Perceptions of the urban walking environments. *Procedia-Social and Behavioral Sciences, 105*, 589–597.

Baş, H. İ. (1985). *Kentsel Donatılar* [Dissertation]. Istanbul, Turkey: Yildiz Technical University.

BHA Planning and Consulting Company. (2006). Netcad land use database. [Data file]. Istanbul

Commission to the European Communities (1990). *Green Paper on the Urban Environment*. Brussels: European Commission.

Downs, A. (2005). Smart growth: Why we discuss it more than we do it. *Journal of the American Planning Association, 71*, 367–378.

Herndon, J. D. (2011). Mixed-Use Development in Theory and Practice: Learning from Atlanta's Mixed Experiences. *The Georgia Institute of Technology School of City and Regional Planning Applied Research Paper.* Retrieved January 2018 from https://smartech.gatech.edu/handle/1853/40790.

Duany, A., & Plater-Zyberk, E. (1993). The neighbourhood, the district, and the corridor. In P. Katz & J. V. Scully (Eds.), *The new urbanism: Toward an architecture of community* (pp. xvii–xxi). New York, NY: McGraw-Hill.

Duncan, D. T., Aldstadt, J., Whalen, J., Melly, S. J., & Gortmaker, S. L. (2011). Validation of walk score for estimating neighborhood walkability: An analysis of four US metropolitan areas. *International Journal of Environmental Research and Public Health, 8*, 4160–4179.

ESRI (Environmental Systems Research Institute). (2014). *ArcGIS Release 10.2*. Redlands, CA.

Forsyth, A. (2015). What is a walkable place? The walkability debate in urban design. *Urban Design International, 20*(4), 274–292.

Hall, T. (2006). *Urban geography* (3rd ed.). Routledge Contemporary Human Geography Series. London, UK and New York, NY: Routledge.

Holbrow, G. (2010). *A novel methodology for measuring walkability using distance to destinations along a network: Case study of Washington, D.C.* (Final project). Medford, MA: Department of Urban and Environmental Policy and Planning, Tufts University.

ICMA (International City/County Management Association), & EPA (Environmental Protection Agency). (2006). *This is smart growth*. Retrieved January 2017 from http://www.smartgrowthonlineaudio.org/pdf/TISG_2006_8-5x11.pdf

Jacobs, J. (1961). *The death and life of great American cities*. New York, NY: Random House.

Khodeir, L. M., Elsisy, A., & Nagy, M. (2016). Pre-assessment of metropolitan areas' smart growth through agent based modelling. *Procedia Environmental Sciences, 34*, 245–257.

Kotharkar, R., & Bahadure, S. (2015). Assessing sustainability of mixed use neighborhoods through residents travel behavior and perception: The case of Nagpur. *Sustainability, 7*, 12164–12189.

Municipality of Edirne. (2010) *Public transport project report*. Edirne,Turkey: Edirne Belediyesi..

Rattan, A., Campese, A., & Eden, C. (2012). *Modeling walkability* (Winter ed.). Ontario, Canada.: Esri Publications.

Scheffler, L. R. (2003). *Using smart growth principles for development in St. Landry Parish*. Baton Rouge: Master of Landscape Architecture, Louisiana State University.

Smart Growth Network. (2001). *What is smart growth?* Retrieved from http://www.smartgrowth.org.

Speck, J. (2013). *Walkable city: How downtown can save America, one step at a time*. New York, NY: North Point Press (Macmillan).

Wey, W. M., & Hsu, J. (2014). New urbanism and smart growth: Toward achieving a smart National Taipei University District. *Habitat International, 42*, 164–174.

Wu, F. (Ed.). (2007). *China's emerging cities: The making of new urbanism*. New York, NY: Routledge.