DEVELOPMENT OF A MIXED-METHOD APPROACH TO ANALYZE WALKABILITY: A CASE ON TWO URBAN RESIDENTIAL NEIGHBORHOODS IN ANKARA

A Ph.D. Dissertation

by
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Ankara
August 2021

To my mother

DEVELOPMENT OF A MIXED-METHOD APPROACH TO ANALYZE WALKABILITY: A CASE ON TWO URBAN RESIDENTIAL NEIGHBORHOODS IN ANKARA

The Graduate School of Economics and Social Sciences
of
İhsan Doğramacı Bilkent University

by

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THE DEPARTMENT OF
INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN
İHSAN DOĞRAMACI BİLKENT UNIVERSITY
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August 2021

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy in Interior Architecture and Environmental Design.

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ABSTRACT

DEVELOPMENT OF A MIXED-METHOD APPROACH TO ANALYZE WALKABILITY: A CASE ON TWO URBAN RESIDENTIAL NEIGHBORHOODS IN ANKARA

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August 2021

In these times when the devastating effects of global warming are felt, giving up fossil fuels and developing active transportation routes are prerequisites for sustainability in the cities. Walkability was introduced as a key factor in urban planning and the promotion of healthier, environmentally friendly, economically productive, and socially active communities. The main aim of this study is to propose a mixed-method that combines exploratory factor analysis, multi-criteria decision-making analysis, and mapping techniques to analyze the walkability of existing and newly developing urban neighborhood settlements in a metropolitan city and to contribute to the literature in this field. Based on the theories and researches the relationship between perceived and objectively measured walkability was analyzed. This study proposes a bottom-up approach for investigating the walkability factors, rather than seeing walkability as an index of pre-set criteria. The emergent perceived walkability parameters derived from the exploratory factor analysis provided fruitful results for both Multi-Criteria Decision-Making Analysis and Multi-Criteria Overlay Walkability Maps. The findings of this study will provide

important clues for both city planners and decision-makers to analyze walkability.

Keywords: Exploratory Factor Analysis, Multi-Criteria Decision-Making, Multi-Criteria Overlay Mapping, Perception, Sustainable City Planning, Walkability

ÖZET

YÜRÜNEBİLİRLİK ANALİZİ İÇİN BİR KARMA YÖNTEM YAKLAŞIMI GELİŞTİRİLMESİ: ANKARA'DA İKİ KENTSEL KONUT MAHALLESİ ÜZERİNE BİR ÖRNEK

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Danışman: Doç. Dr. Yasemin Afacan

Ağustos 2021

Küresel ısınmanın yıkıcı etkilerinin hissedildiği bu zamanlarda, kentlerde sürdürülebilirliğin ön koşulu fosil yakıtlardan vazgeçmek ve aktif ulaşım yollarını geliştirmektir. Yürünebilirlik, şehir planlamasında daha sağlıklı, çevre dostu, ekonomik olarak üretken ve sosyal olarak aktif toplulukların teşvik edilmesinde kilit bir faktör olarak tanıtılmıştır. Bu çalışmanın temel amacı, metropol bir kentteki mevcut ve yeni gelişmekte olan kentsel mahalle yerleşimlerinin yürünebilirliğini analiz etmek için açımlayıcı faktör analizi, çok kriterli karar verme analizi ve haritalama tekniklerini bir araya getiren karma bir yöntem önermek ve bu alandaki literatüre katkı sağlamaya çalışmaktır. Teorilere ve araştırmalara dayanarak algılanan ve nesnel olarak ölçülen yürünebilirlik arasındaki ilişki analiz edilmiştir. Bu çalışma, yürünebilirliği önceden belirlenmiş kriterlerin bir indeksi olarak görmek yerine, yürünebilirlik faktörlerini araştırmak için aşağıdan yukarıya bir yaklaşım önermektedir. Açıklayıcı faktör analizinden elde edilerek ortaya çıkan algılanan yürünebilirlik kriterleri, hem Çok Kriterli Karar Verme Analizi hem de Çok Kriterli Yer Seçimi ile Yürünebilirlik Haritaları oluşturmak için verimli sonuçlar sağlamıştır.

Bu çalışmanın bulguları hem şehir plancıları hem de karar vericiler için önemli ipuçları sağlayacaktır.

Anahtar Kelimeler: Açıklayıcı Faktör Analizi, Algılama, Çok Kriterli Karar Verme (ÇKKV), Çok Kriterli Yer Seçimi ile Haritalama, Sürdürülebilir Şehir Planlama, Yürünebilirlik

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This thesis was written in the conditions of COVID-19 pandemics and Marmaris Bozburun Peninsula wildfires. I hope this thesis would contribute to designing a better, healthier, and sustainable world.

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LIST OF ABBREVIATIONS

AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
DMA	Density, Mixed-use, and Accessibility
EFA	Exploratory Factor Analysis
ELECTRE	*Élimination Et Choix Traduisant La Realité* (Elimination Et Choice Translating Reality)
EVG1	Eigenvalue Greater Than One
GAIA	Geometrical Analysis for Interactive Aid
GIS	Geographic Information Systems
IBM	Integrated Behavioral Model
KMO	Keiser-Meyer-Olkin
MACBETH	Measuring Attractiveness Through A Categorical-Based Evaluation Technique
MAUT	Multiple Attribute Utility Theory
MCDM	Multi-Criteria Decision-Making
NGOs	Non-Governmental Organizations
NEWS	Neighborhood Environment Walkability Scale
PROMETHEE	Preference Ranking Organization Method for Enrichment Evaluation
SAW	Simple Additive Weighting
SLa	Street Level approach
SPSS	Statistical Package for the Social Sciences
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

The built environment is a physical stage of events and movement. Urban areas are largest in the scale of the built environment and they are places people get together to dwell, work, study, worship, perform and interact (Gibson, 2009). According to those human actions of living, design professionals create an ecology of spaces to provide a standard of living within a quality of life. Bonaiuto and Alves (2012) stress that quality of life is congruence between objective properties of the physical environment and one's life expectations or achievements. According to them, quality of life has four basic elements: First is objective environment, second is behavioral competence, the third is perceived quality of life and the last one is psychological well-being.

Creating a built environment within a quality of life is getting harder each day, due to crowding, reckless consumption of natural resources and materials for the built environment, insufficient energy usage, pollution, unsustainable habits of consumerism. Human beings have the characteristic of multiplying in their habitat and dominating that region, just like many other creatures on earth. However, the evolved cortex layer in the brain, which distinguishes the creature called human from other mammals, is both responsible for an unsustainable life and a solution center capable of eliminating these problems. At this point, we need to choose the right solutions in the light of all the information we have obtained with our developed brain. In recent years, we have been observing and living that the effects of global climate change have increased and the natural habitats have been shrinking due to urbanization all over the world. These devastating human-induced effects threaten the survival of the human species as floods, wild forest fires, drought, extreme atmospheric events and even pandemics. “In 1983, the United Nations established the World Commission on Environment and Development to create a report that would analyze global environmental challenges and make policy recommendations” (Gowdy and Manner, 2009, p.119). According to that report, which was called as Brundtland Report, from small towns to megacities, it is indicated that half of the human population will live in urban areas by the turn of the 21st century (Brundtland Commission, 1987). It is expected that 95% of the population growth to be experienced towards 2050 will occur in urban areas of developing countries (Davis, 2006). As humanity, we are responsible for the dangerous climate change (See figure 1). It is scientifically proven that ‘human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years’ (United Nations Climate Change, 2021, August 07). Hence, sustainability and well-being are at risk. How to maintain the ecological understanding of the concept of quality of life is in question.

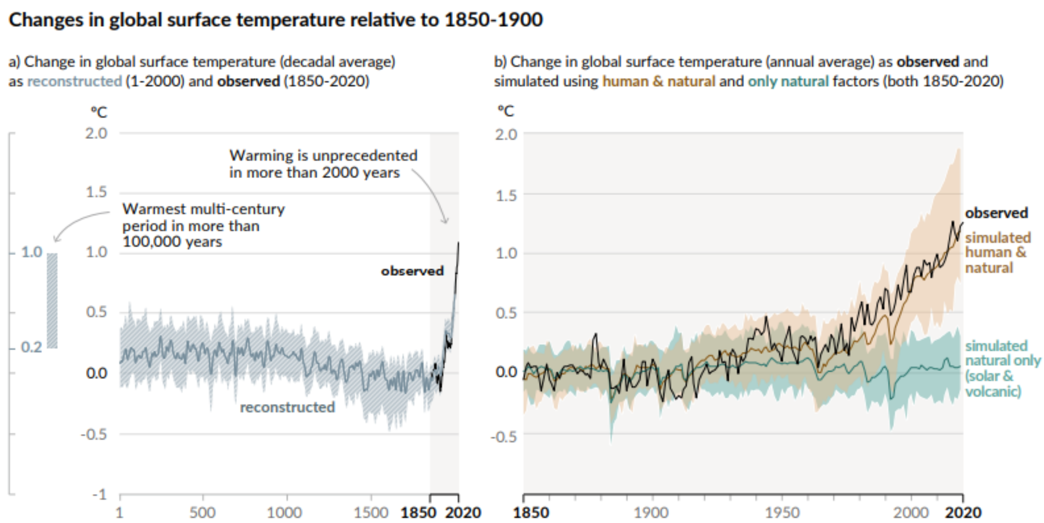


Figure 1. History of Global Temperature Change and Causes of Recent Warming (United Nations Climate Change, 2021, August 07).

1.1 Importance of Walkability and the Problem Statement

Like in any other country around the globe, Turkey has dense population in urban environments. According to the latest official statistical data announced by the Turkish state, ‘the proportion of people living in cities and districts in Turkey, which was 92.8% in 2019, increased to 93% in 2020. On the other hand, the rate of people living in towns and villages decreased from 7.2% to 7%’ (TÜİK Kurumsal, 2021, February 04). However, the rural/urban population ratios declared by the Turkish state after 2012 diverged from the reality (Özçağlar, 2016; Wikipedia contributors, 2021, June 19). Özçağlar (2016) claims that, in the statistics after 2012, the administrative areas of the provinces with metropolitan municipalities are treated as urban areas with the law numbered 6360 adopted in 2012 and the ratios of the population of rural settlements were accepted as zero percentage. Even if we take the information that the urban population in Turkey is 77% and the rural population is 23%, according to the official data of 2012 as a reference (as cited in Özçağlar, 2016), this ratio is showing the population growth in urban settlements in Turkey is beyond the predictions of the Brundtland Commission in 1987. The dense urban population in Turkey also necessitates emergency action plans on sustainability.

Increasing urban structuring and automobile-dependent urban designs in the last 25 years in Turkey cause unhealthy and unsustainable conditions for people living in the cities. With the widening roads, oil-based transportation, traffic speed and exhaust gas emissions have increased. This problem makes walking in the city dangerous and difficult. It is also a threat to a sustainable life and well-being. This is also the problem of what kind of a healthy life the citizens living in dense areas prefer. Since the cities are not designed as walkable, they affect the citizens negatively regardless of their economic conditions. Due to the lack of appropriate urban designs, it leads to the formation of vulnerable groups of people in terms of safety and accessibility, based on gender (e.g. women cannot walk on the street feeling safe at night), age (e.g. baby strollers and aged people), and restriction (e.g. people with disabilities).

According to the resolution adopted by the General Assembly of the United Nations on 25 September 2015, an agenda of sustainable development by the year 2030 was accepted (United Nations, 2015). Seventeen sustainable development goals were set and signed by all member countries and stakeholders. In the third goal of the resolution, it is indicated that all countries, in particular developing countries should ensure healthy lives and promote well-being for all at all ages; strengthen the capacity for early warning, risk reduction and management of national and global health risks. That could be linked with the healthy urban performance and walkability of the cities. According to the 11th goal of the resolution, countries should make cities and human settlements inclusive, safe, resilient and sustainable. Countries should provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons. Active transportation (walking and cycling) is an important part of this sustainable transport system. Walking is introduced as environmentally friendly behavior in the concept of quality of life and well-being.

All countries, including Turkey, and all stakeholders, acting in collaborative partnership, will implement this plan by 2030. There are recent academic studies on the active transportation in the cities in Turkey, mainly on neighborhood and street scale (Akkar Ercan and Belge, 2017; Belge, 2020; Çubukçu et al, 2015; Çubukçu, 2013; Doğan, 2021; Nordfjærn and Şimşekoğlu, 2013; Gündoğdu and Dinçer, 2020; Özbil et al., 2019; Özbil, Yeşiltepe and Argın, 2015; Özer and Kubat, 2015; Paykoç, 2019; Seles and Afacan, 2019; Tekel, 2016; Vural Aslan et al., 2018; Yıldırım et al., 2012).

Walkability is a complex phenomenon dependent on various objective and subjective parameters. Researchers use a wide range of methods to study this topic, to make its complex structure more readable, and to develop research models for city planners and decision makers. Moreover, walkability is conditional on other factors that cannot be controlled (Lee and Talen, 2014). To choose best practice for a walkable neighborhood, both users and experts should be able to weigh the walkability indices. In several studies, there is no hierarchical weighting of walkability indices (Bradshaw, 1993; Krambeck, 2006; Walkscore.com, 2010). Walkability index scores may differ among different user groups and demographics. Cultural issues affect walkability too. For example, although there exist traffic regulations in Turkey, car drivers usually do not stop at pedestrian crossings (Emniyet Genel Müdürlüğü Trafik Başkanlığı, 2021). Speeding by motorized vehicles is another cultural and urban design problem. The importance attributed to motor vehicles also causes these cultural and design problems. “A wide range of different actors are involved in discourse that relates to pedestrians and all have a different definition of how to measure walkability” (Lo, 2009, p.148). Socio-cultural contexts, perceptions and emotions “refine walking behavior over the years, within the structures of opportunity given by the socio-cultural context and its reflection on the urban environments” (Hermann-Lunecke, Mora, and Vejares, 2021, p.193). On the other hand, urban design characteristics may affect walkability scores too. For example, circuity, the ratio of network distances to straight-line distances, is an important measure of urban street network structure and transportation efficiency (Boeing, 2019). The researchers found that walking networks tend to allow for more direct routes than driving networks do in most cities in the US. According to the results, average driving circuity exceeds average walking circuity in all but four of the cities that exhibit statistically significant differences between network types (Boeing, 2019).

The conditional and contextual factors of walkability requires multiple methods to analyze. “The growing body of literature about walking has been accompanied by the emergence of new methods to capture its complexity” (Hermann-Lunecke, Mora, and Vejares, 2021, p.194). Methodological characteristics of the studies on walkability are: (i) Studying design setting and sample characteristics, (ii) theoretical framework, (iii) physical activity assessment, and (iv) neighborhood environment measures (Orstad et al., 2017).

- **Design setting and sample characteristics:**

Some studies modeled examples of suburban, urban, high-rise, and informal morphologies as design settings to show how different urban design characteristic profiles emerge according to different measures of walkability (Doğan, 2021; Dovey and Pafka, 2014; Gündoğdu and Dinçer, 2020; Lindelöw et al. 2017; Özbil et al, 2019). For example, while Doğan (2021) focuses on comparing success levels of five different medium size cities' urban centers in Turkey in terms of walkability attributes, Özbil et al. (2019) focus on comparing the pedestrian networks of peripheral residential neighborhoods of the city of Istanbul, Turkey. However, none of these studies compares urban and newly developed urban residential neighborhoods within the design setting of walkability. Some other studies focus on sample characteristics, such as sampling methodology and reliability of auditing walkability in general (Usssery et al., 2019), children and youths (Cerin et al., 2019; Christian et al., 2017; Murtagh et al., 2011; Webb Jamme, Bahl, and Banerjee, 2018), elderly (Lee and Dean, 2018; Loo and Lam, 2012; Van Cauwenberg et al., 2012), women (Yıldırım et al., 2012), immigrants (Brown et al., 2013), people with diverse abilities and vulnerabilities (Moura, Cambra, and Gonçalves, 2017; Stafford and Baldwin, 2018), and people with diverse socio-economic status (Hermann-Lunecke, Mora, and Vejares, 2021; Steinmetz-Wood and Kestens, 2015; Su et al., 2019; Yıldırım et al., 2012).

- **Theoretical framework:**

In the literature on walkability, some studies elaborate more on behavioral and philosophical theories. For example, as an eco-friendly behavior, walking was examined by extending the Theory of Planned Behavior (TPB) (Ajzen, 1991) by various predictors (Al-Saraifi and Grierson, 2019; Bird et al., 2018; Murtagh et al., 2011; Seles and Afacan, 2019). This theory is based on the predictability of a behavior within cause and effect relationship and represented by linear structural models.

A preliminary study related to this dissertation was executed in 2019. This previous study aimed to broaden Theory of Planned Behavior (TPB) by including healthy urban performance attributes of the residential neighborhoods as an additional predictor for walking behavior (Seles and Afacan, 2019). A validated TPB questionnaire (Ajzen, 1991; Fishbein and Ajzen, 2010) was translated to Turkish, and a formative research was conducted to make the questionnaire suitable for the walking behavior. The questionnaire was conducted before the conditions of COVID-19 pandemics and the participants (n=220) filled the questionnaire face-to-face. Some residents had biases to fill the previous study's questionnaire and refused to participate. When conducting the survey face-to-face, there was an opportunity to reflect on the meaningfulness of the questions according to the responses given. The pandemics have changed the perception of walking on the street. The previous questionnaire was lack of investigating the effects of it. The case setting was chosen from the most popular residential neighborhood area in Ankara, Turkey, which was Ayranci Neighborhood of Çankaya District. We did not know if the study could lead different results if conducted in a newly developed urban neighborhood. The study highlighted two aspects of planning for a walkable neighborhood: (i) a walkability model based on the three constructs of Theory of Planned Behavior (TPB) should not neglect the measured and experienced urban performance; (ii) utilizing pedestrian environment for walking requires a collaborative and an experiential approach as well as a multi-parameter decision-making process. The study shows the effect of the walkability of the residential neighborhood on walking behavior. Although the influence of existing urban neighborhood design was investigated as healthy urban performance, the street layout were not analyzed. The influence of perception on key walkability parameters was not questioned.

For the rest, some studies handled walkability within the framework of the Assemblage Theory (Deleuze and Guattari, 1987). The task of this theory "is to understand the dynamics of complex systems where the outcome of a system depends on unpredictable interactions between parts" (Dovey, Woodcock, and Pike, 2017, p.406). When considering the complex walkability concept, researchers focused on more relational, non-linear, and unpredictable interactions between the walkability parameters (Dovey and Pafka, 2014; 2017; 2020; Dovey, Woodcock, and Pike, 2017; Kärrholm et al., 2017; Middleton, 2010). In practice, the outcomes of this theory are the assemblage diagrams or intensity maps, which are heterogeneous, deterritorialized, and virtual rather than presuming hierarchical and causal relationship models. For example, Dovey and Pafka (2020) identify the key walkability parameters, as urban density, urban mixed-use, and urban accessibility. According to them "connecting the key parameters of walkability to walking is deductive; these properties are capacities that enable and constrain, rather than directly cause, walking" (2020, p.102). For them, there is no single key parameter measure that is going to be the most useful in understanding walkability. They preferred using mapping techniques to show how these key parameters are related to each other and explore how cities work. "As we explore the interconnections and synergies between these factors the interdependencies multiply further" (Dovey and Pafka, 2020, p.103). Hence, even the key parameters of walkability need to be investigated as assemblages of interdependent and developed factors.

Another novel theory used in walkability studies is the Subjective Value Theory developed by Fancello, Congiu, and Tsoukiàs (2020) as an extension of the Capability Approach (Sen, 1993). Both this theory and relevant approach is "focused on individuals substantive freedoms (capabilities) to choose a life one has reason to value" (Fancello, Congiu, and Tsoukiàs, 2020, p.2). Although a few studies are especially based on this novel theory and the relevant approach (Blečić et al., 2015; Fancello, Congiu, and Tsoukiàs, 2020; Garau, Annunziata, and Yamu, 2020; Ortega et al., 2020), the majority of the walkability studies that refer to a person making subjective choices among needs prefer to use Multi-Criteria Decision-Making (MCDM) analysis methods (Doğan, 2021; Fancello, Congiu, and Tsoukiàs, 2020; Garau, Annunziata, and Yamu, 2020; Manzolli, Oliveira, and de Castro Neto, 2021; Ortega et al., 2020; Ruiz-Padillo et al., 2018; Wey and Chiu, 2013). For example, Manzolli, Oliveira, and Neto (2021) proposed a framework based on MCDM analysis methodology to rank streets of the city of Lisbon in terms of walkability levels.

"MCDM analysis methods deal with the process of making decisions in the presence of multiple criteria" (Harputlugil et al., 2011, p.11). There is not a holistic method among the MCDM analysis methods, like inexistence of universal walkability factors when considering perception. We can only consider pros and cons of those methods. Most used MCDM methods are AHP, ANP, MAUT, ELECTRE, MACBETH, SAW, TOPSIS, and PROMETHEE-GAIA (Harputlugil et al., 2011; Ishizaka and Nemery, 2013). Some of the methods are for ranking problems; some others are for sorting or sometimes for description problems. For example, if it is an outranking method, sometimes researchers define the key parameters only depending on the decision problem. "Outranking methods are based on pairwise comparisons. This means that the options are compared two-by-two by means of an outranking or preference degree. The preference or outranking degree reflects how much better one option is than another" (Ishizaka and Nemery, 2013, p.6).

Walkability is a multi-parameter and complex field, hence researchers propose using multiple measuring and analyzing methods. To explore the urban walking capacities, few recent studies chose using multi-criteria decision-making (MCDM) analysis and mapping techniques together (Doğan, 2021; Fancello, Congiu, and Tsoukiàs, 2020; Garau, Annunziata, and Yamu, 2020; Ortega et al., 2020). For example, Doğan (2021) stresses that the walkability success levels of middle sized Turkish cities are quite low. His study shows that priority for pedestrians is seldom considered in Turkey. He proposed a mixed analyzing method of using fuzzy logic, space syntax analysis, and GIS together. The aim of Ortega et al.'s study (2020) was to provide a set of street walking quality maps for a selected district in the city of Madrid. They ranked the streets according to their walkable capacities in relation to each other by using PROMETHEE II analysis method. However, they did not superimposed street walking quality maps as a final walkability map. Fancello, Congiu, and Tsoukiàs (2020) focused on the user groups and they proposed a MCDM analysis method aimed to elaborate walkability decision maps especially for those groups of citizens.

Researchers who combine MCDM and mapping techniques usually prefer Space-Syntax to analyze their case areas (Doğan, 2021; Garau, Annunziata, and Yamu, 2020; Hajrasouliha and Yin, 2015; Özbil et al., 2019; Özer and Kubat, 2015). “The space syntax analysis method attempts to understand the interrelationships between the shaping features of the urban space and the functions by multiplying the integration value of a line by its segment length” (Doğan, 2021, p.9). This method is good for controlling the connection of any axial line to all other axes on the axial map (Hillier and Hanson, 1984). However, this is not a method for giving a ranking of the suitability of raster space using a grid-based approach. The multi-criteria weighted-overlay analysis can allocate the suitability of areas based on the walkability attributes. One of the most widely accepted definition was by Gandhi (2021, para.1-2):

> Multi-criteria weighted-overlay analysis is the process of allocating areas on the basis of a variety of attributes that the selected areas should possess. Although this is a common GIS operation, it is best performed in the raster space using a grid-based approach… Working in the raster space gives you a ranking of the suitability - not just the best-suited site. It also allows you to combine any number of input layers easily and assign different weights to each criterion. In general, this is the preferred approach for site suitability.

This method generally preferred for producing real estate evaluation maps. There is not any study using this method for producing walkability evaluation maps. The closest web based tool for evaluating the suitability of an area’s walkability is the Walk Score^{TM} (Walkscore.com, 2010). However, “it is a commercial product, and its detailed algorithm to calculate a score is not open to public” (Koohsari et al., 2018, p.115).

- **Physical activity assessment:**

The studies worked on the objective assessment of physical activity of citizens mostly compare it with the perceived environmental factors. Researchers working on walkability tried to find associations between the perceived walkability and objectively measured walkability. “Physical activity behavior not only depends on the objective environment but on how a person perceives the environment” (McCormack, 2008, p.402). The previous studies claim that the perceived neighborhood environment and objectively measured physical activity are related but distinct constructs, therefore perception has a higher effect on walking behavior than the effect of objective environment (Jáuregui et al., 2016; Koohsari et al., 2015; Lee et al., 2017; McCormack, 2008; Orstad et al. 2017).

According to Orstad et al. (2017), the perceived neighborhood environment and objectively measured neighborhood environment are related but distinct constructs that account for unique variance in physical activity. They abstracted 85 relevant peer-reviewed studies published between 1990 and 2015. They also claim that researchers have reported low levels of agreement between perceived and objective measures of the neighborhood environment. Studies that are more recent support this view. Koohsari et al. (2015) underline perception is so influential that those living in more walkable environments, but perceiving them as less walkable, and living in less walkable areas but perceiving them as more walkable. As an example, according to them, for residents who perceive their environment as less walkable is related to their physical activity level. They claim “it is possible that people who are not active (and hence spend less time outdoors) know their local environments less well; thus, it may be more likely to perceive it as less walkable” (p.243). Jauregui et al. (2016) stress that perceptions should not be considered as proxies for objective measures. According to Lee at al. (2017), there was a mismatch between perceived and objective measures of walkability. They reported greater satisfaction results of perceived walkability but not significant results on objective measures. Hinckson et al. (2017) state that subjective environment has a greater explanatory power than objective index. Desgeorges et al. underlines that perceived and objectively measured walkability “do not refer, however, to the same construct: objective measurements provide an inventory of a neighborhood’s active-friendly attributes, while the perceptions of individuals refer to their appraisal of their neighborhood opportunities for active travel” (2021, p.1). On one hand, objective measurements are referring the walkability parameters of a built environment. On the other hand, subjective measurements (perceptions/preferences) refer to the capacity to walk in a built environment.

As mentioned above, walkability is a concept that have both perceived and objectively measured attributes to analyze. Both attributes are complementary and explaining the walkability of a built environment (Desgeorges et al., 2021). However, they refer different methodological approaches to analyze the phenomenon.

Those studies used normative methodologies to analyze the walkability and measured physical activity of the residents showed a mismatch between perceived and objectively measured walkability. However, researchers yield to show associations between perceived and objectively measured walkability with non-normative approaches and non-linear thinking in recent years.

- **Neighborhood environment measures:**

According to Mezoued, Letesson, and Kaufmann, “a walkable city implies a reconfiguration and a re-territorialization of its spaces and activities. It must strive to evolve towards a sustainable urban context with all its associated implications in terms of environmental, economic, social, and mobility aspects” (2021, p.17). However, they claim that the choice and weighting of the enhancers and impediments to walking in the city are problematic (2021). Therefore, those improvements and implications should be based on the analysis of both survey and geospatial data.

All studies analyze current urban neighborhood design and street layout by determining walkability parameters. Researchers developed and used assessment tools, as they were deemed appropriate that they associate with these walkability parameters. Recent studies systematically show that relevant walkability factors and their sub parameters studied consistently in pedestrian mobility publications over the last twenty years (Talavera-Garcia and Soria-Lara, 2015) (See Figure 2).

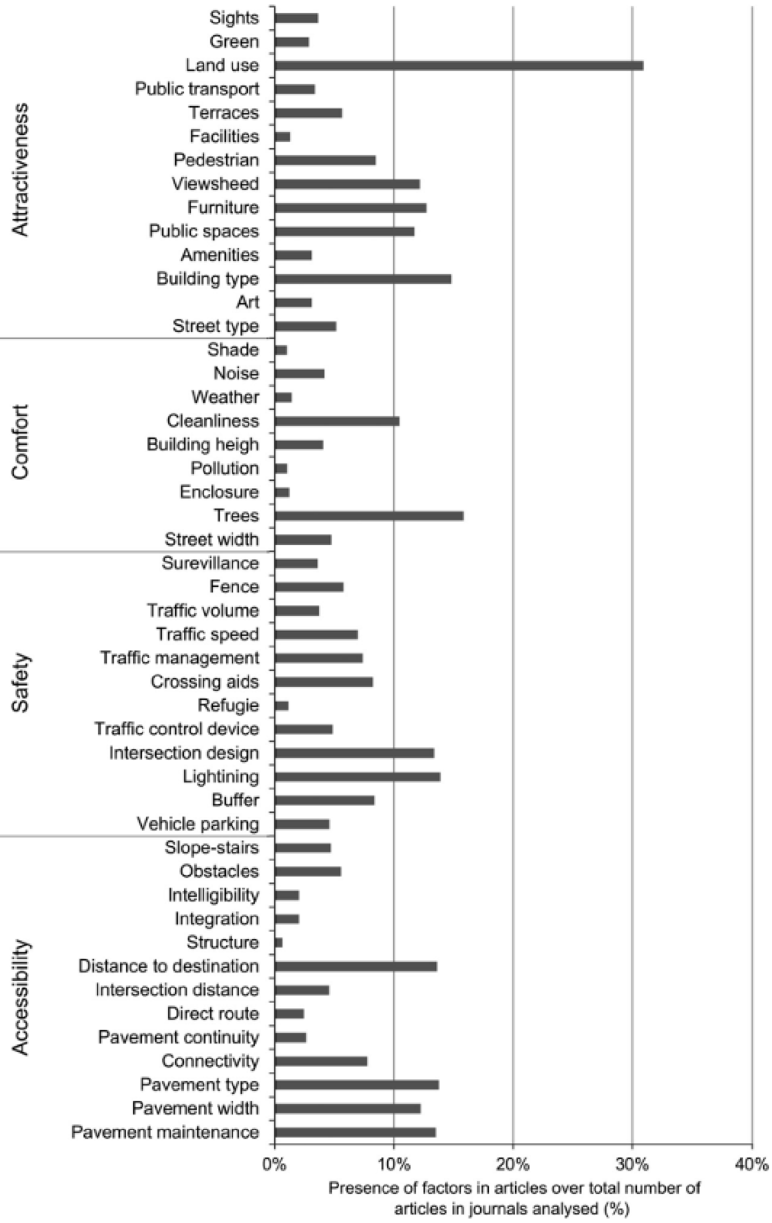


Figure 2. Relevant factors in pedestrian mobility publications according to the ratio taken from the total number of papers analyzed from journals over the last 20 years. (Adapted from Talavera-Garcia and Soria-Lara, 2015).

Cambra puts that “the measurement or assessment of walkability has been done by these following several methods: audit tools, checklists, inventories, level-of-service scales, and surveys” (as cited in Paykoç, 2019, p.23). Maps too should be added as novel assessment tools to this list. However, there is not a consensus on the best practice for measuring walkability. Therefore, the parameters in a built environment always changing interdependently and perceptions of the users change contextually.

Dovey and Pafka (2020) claim that although there are plenty of walkability parameters identified and studied in the literature on that field, the key parameters are the urban Density (concentrations of buildings and people), the urban Mixed-use (the mix of different functions and attractions), and the urban Accessibility (the access networks we use to navigate between them), which they abbreviated as the urban DMA. Many studies also widely recognized the urban DMA as the key factors of built environment to measure walkability (Cerin et al., 2006; Cervero and Kockelman, 1997; Jáuregui et al., 2011; Lee et al., 2017; Lo, 2009; Saelens and Handy, 2016; Sung and Lee, 2015; Wang and Yang, 2019). Although the main factors do not change much, researchers can make slight changes in the grouping of these titles or deciding the number of indicators according to the objectives of their research.

While determining the walkability factors, users or experts are generally asked about the observed and perceived features of the selected regions in terms of walkability. In selected regions, Exploratory Factor Analysis (EFA) is used to investigate the walkability factors specific to that region. Fontaine (2005) identifies Exploratory Factor Analysis as a formal model that can explain the interrelationship between a set of underlying and reduced group of variables, which are called factors, among the observed items. Cervero and Kockelman (1997) first used this formal model in walkability studies. Factor analysis was used to linearly combine variables into the density and design dimensions of the built environment in San Francisco Bay Area in the U.S. Their research finds that density, land-use diversity, and pedestrian-oriented designs generally reduce trip rates and encourage non-auto travel in statistically significant ways. In an another example, in a study which was done more recently in Japan, perceived walkability was scored using exploratory factor analysis for the respondents' perceptions of neighborhood conditions, while objective walkability was measured using the geographic information system approach (Hanibuchi et al., 2015). The data were used from the Japanese General Social Surveys (JGSS) for 2010 to study the attitudes and behaviors of the Japanese population. They found that perceived walkability was positively associated with the frequency of leisure-time physical-activity. Considering the literature, there are hardly any recent studies that explain interrelationships between a set of perceived factors among the observed items based on the key walkability attributes, which are urban Density, Mix, and Access.

1.2 Aim of the Study and Research Questions

The necessity of a new urban design to live a healthy life in an urban environment is in question. In terms of decision-makers and city planners, there is a need for research that will shed light on the problems of urban design and sustainable transportation in urban settlements. This research is focusing on the perceived walkability factors derived from the citizens living in a metropolitan city of Turkey. Moreover, the study is seeking the relationship between urban and newly developed urban settlements on a neighborhood scale in terms of walkability while comparing their urban design characteristics.

On one hand, walkability is dependent on some qualitative and quantitative parameters. On the other hand, the walkability of a neighborhood is not just a collection of walkability indices that come together. Walkability variables need to interact with one another as to yield the walkability of a neighborhood that has properties of its own; those properties are irreducible to the properties of an index. Walkability is an interrelational urban capacity.

In summary, what is missing in the studies in the previously mentioned literature is to show that there is a link between all these guiding theories and related approaches, that they have intersections, and that they are complementary to each other, rather than just comparing or contrasting them.

The main aim of this study is to propose a mixed method for analyzing the walkability of urban and newly developed urban residential neighborhoods in a metropolitan city and try to contribute to the literature in this field. Rather than a comparison of walkability parameters, this study aims to show that they are actually contextual and that the factors they affect differ in each case setting. The-sub aims of the study are (i) to explore perceived walkability factors by diverse users for urban and newly developed urban residential neighborhoods of the city of Ankara and compare their walkability factor differences and similarities; (ii) to investigate relationships between perceived walkability factors and a set of developed walkability parameters; (iii) to rank the selected urban and newly developed urban main streets from highest to poorest quality, based on the developed walkability parameters, and (iv) to provide a set of walking quality maps for both of the selected urban and newly developed urban neighborhoods of the city of Ankara based on the developed walkability parameters (See figure 3).

The study has four research questions:

RQ1: How do urban key design aspects (Density, Mixed-use, and Accessibility) influence the perception of walkability in an urban and a newly developed urban residential neighborhood in a metropolitan city?

RQ2: Can there be a set of developed parameters and attributes for an urban main street in a residential neighborhood based on the idea of perceived walkability as an urban capacity?

RQ3: What is the relationship between perceived and measured walkability in an urban and a newly developed urban residential neighborhood in a metropolitan city?

RQ4: What is the relationship between the walkability of an urban main street and the walkability of the residential neighborhood it is associated with?

1.3 Hypotheses

The study has three hypotheses:

H1: Perceived walkability factors differ in different neighborhood design settings.

H2: Perceived walkability factors are significantly related to objectively measured walkability parameters.

H3: The walkability values of a residential neighborhood and its main street have no significant difference.

1.4 Structure of the Thesis

The chapters of the thesis are organized as follows. In the first chapter, the introduction of the thesis is described in details by focusing on the problem definition of the research, current literature on methodological characteristics of the studies on walkability, and the dissertation's aim and importance. The research questions and the hypotheses are indicated in this chapter.

In the second chapter, current literature on walkability is given in detail by highlighting origins of it, definitions and multidisciplinary characteristics of it, important academic papers and references of walkability, its elements, and aspects. In addition, the walkability framework is described as a planned healthy urban behavior. The second chapter also deals with the effects of urban design characters on walkability, discussing the urban design approaches since the beginning of modernism. Associations between perceiving a walkable urban environment and measuring walkability objectively in the light of urban design characters are also indicated in this chapter.

In the third chapter, theoretical framework of the study is formed with three behavioral and philosophical theories. Their statements are explained in detail and they are inter-related with each other and with the study. The methodology of the study is described in the fourth chapter. The survey instrument and measuring the walkability procedure are introduced.

In the fifth chapter, the analysis results are shown in the three stages. In the first stage, exploratory factor analysis results are indicated. In the second stage, multi-criteria decision-making analysis results are summarized. In the third stage, street walking quality maps are presented.

Sixth chapter is the part where the comparative analysis of perceived and objectively measured walkability is done. The results of the three stages of chapter five are discussed and its association with the theoretical framework is put.

In the seventh chapter, the contributions of the study to the related literature and suggestions for further research are discussed besides the indicated limitations. This last chapter is followed by a list of references and appendices. Figure 3 shows the relational framework of the study including the research questions, the stages of the study, hypotheses, and the results.

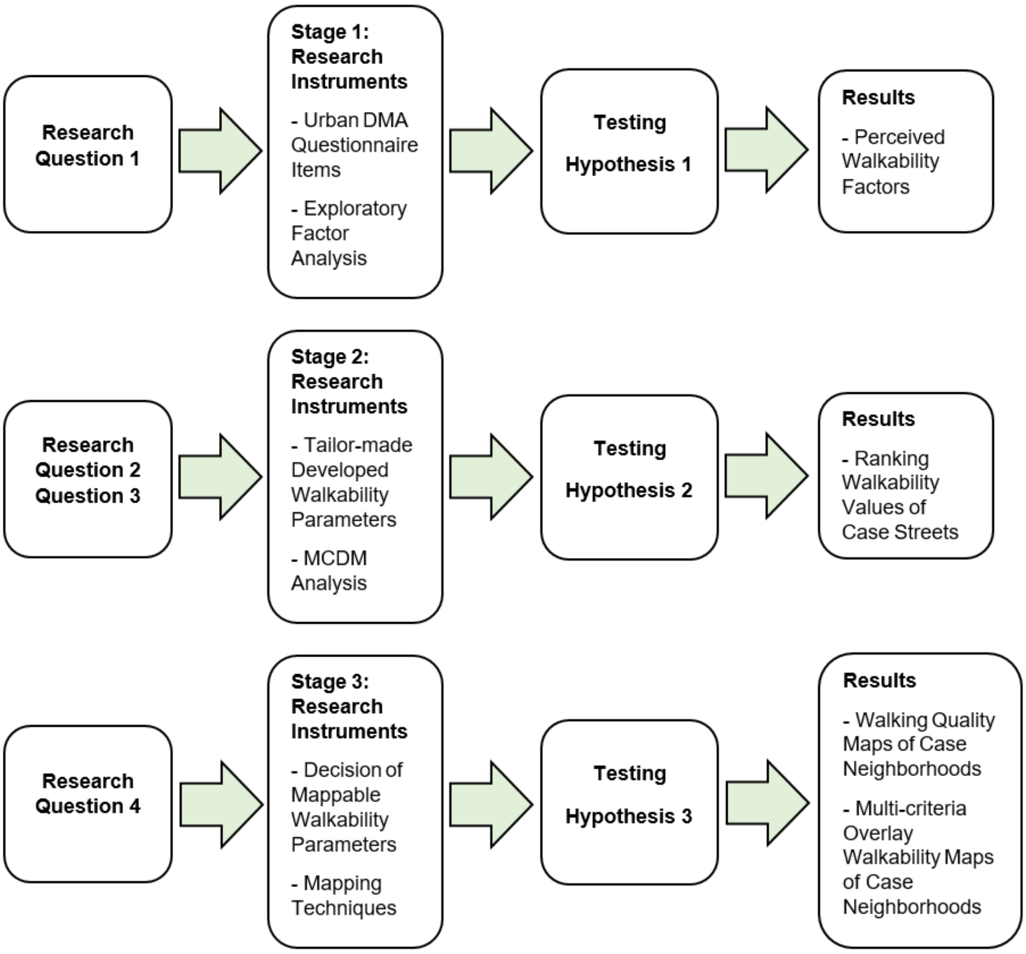


Figure 3. Framework of the Study (Drawn by the author, 2021).

CHAPTER 2

NEIGHBORHOOD WALKABILITY

Walking is an active transportation form, besides cycling, as a low-cost and environmentally friendly physical activity. It promotes a healthy life and helps to reduce carbon emissions produced by motorized transportation. Studies indicated the strong influence of urban neighborhoods on human transportation and physical activities (Lee and Dean, 2018). Moreover, the lack of walking is considered as a global health problem. World Health Organization (2007) has highlighted the importance of walking activity and creating walkable neighborhoods to enable healthy lifestyles. Each individual should obtain at least thirty minutes of physical activity with a moderate-intensity on five or more days a week (United States Department of Health and Human Services, 2008). Thirty minutes of walking distance usually defines the borders of a neighborhood zone. There are strong correlations among the healthy urban performance of neighborhoods, such as street connectivity, overall access to services and the likelihood of an individual participating in walking (Cerin et al. 2017). Frank et al. indicate that “when people have many destinations near their homes and can get there in a direct pathway, they are more likely to engage in moderate physical activity for ≥30 minutes on a random day” (2005, p.122). This is why most scholars chose cases of research on the neighborhood scale.

2.1 Act of Walking

According to Merriam-Webster's dictionary, walking is defined as to move along on foot (n.d.). Although as humans we can crawl, we walk on two feet and we use two legs for most of our locomotion, which makes us bipedal mammals (Smith, M. A., 2018). In Britannica Academic, the factors that might have driven bipedalism of hominins are listed as: "carrying objects, wading to forage aquatic foods and to avoid shoreline predators, vigilantly standing in tall grass, presenting phallic or other sexual display, following migrant herds on the savanna, and conserving energy" (Human evolution, 2020). However, none of these theories and factors have a satisfactory consensus yet.

Since our ancestors took to bipedal locomotion, approximately six million years ago (Amato, 2004), human beings started to move from one place to another with different purposes. In the beginning, it was a necessity for survival and locomotion. With urban settlement, people started to work more indoors and humans reshaped topography. The need to climb, clomp, and stomp diminished, as the need to walk on steep, uneven, and non-firm surfaces disappeared (Amato, 2004). With the development of different transportation techniques, the act of walking gained a mode of choice activity other than a necessity in an urban environment (Kärrholm et al., 2017). For two hundred years, other than just transportation, walking has involved questions of health and recreation, as well as an assertion of individual lifestyle and social philosophy (Amato, 2004). Within an urban fabric, there flourished a variety of purposes for walking:

- Transportation (going to school, commuting to work, window shopping, using public services, etc.)
- Recreation and Visiting (Restaurants, cafes, bars, parks, museums, touristic venues, etc.)
- Exercise (Health requirements, dog walking)
- Urban Social Encounter (social interaction, spiritual rejuvenation, as a political act, etc.)

- Flaneur (walking without a purpose, idleness, urban exploring, etc.)

When a person walks, changes occur. That person transports himself/herself from one point to another point. That change occurs in time and space. Frequencies of these reciprocal changes are quantifiable. Moreover, the experience and perception of walking have qualitative circumstances. That walking person needs to be considered as a multiple and highly changeable actor (Kärrholm et al., 2017). The changes do have effects on the walking person and its environment. The causal relationship of the walking person and its environment are studied both intensively and extensively by many research disciplines. Hence, the act of walking is a multi-disciplinary research subject including people and environment relations, urban design studies, and environmental design. Kärrholm et al. stress that "studies of these kinds are performed in a wide variety of disciplines such as transport research, health research, environmental psychology, urban studies, etc." (2017, p.21).

Some other researchers problematize walking itself. Anthropologists, political scientists, sociologists, psychologists, and many other social scientists ask questions to define walking behavior. For example, to develop a pedestrian policy, the researcher asks the subject "Why do you walk?", to understand the action, the researcher asks "What is a walk?", to explore the experience, the researcher asks the subject "How do you walk?" (Middleton, 2011). All these questions give the researcher a lens to focus on the act of walking and a method to define the problem.

2.2 What is Walkability?

Walkability "is a measure of whether the built environment of a neighborhood encourages people to walk" (Wang and Yang, 2019, p.43). Concept of urban walkability is a new term to describe how friendly a city and healthy an urban space is (Speck, 2012; Zuniga-Teran et al., 2017) and it was introduced as a key factor in urban planning and the promotion of healthier, environmentally friendly, economically productive, and socially active communities (Dovey and Pafka, 2020; Lo, 2009; Moura et al., 2017). Seles and Afacan (2019) stress the necessity of an effective built environment and positive behavioral intentions such as walkability in residential communities would enhance livable communities and the quality of life.

In the last decade, there are large number of studies on the relationship between physical and social environmental qualities of urban spaces and walkability (Seles and Afacan, 2019). Each researcher handled the phenomena with different indices, subject groups, models, theories and frameworks. One of the first studies that reviews evidence on the built environment correlates with walking includes 13 reviews published between 2002 and 2006 and 29 original studies published in 2005 and up through May 2006 (Saelens and Handy, 2010). More recently, Wang and Yang (2019) published a bibliometric analysis and a critical review on neighborhood walkability studies using Geographical Information Systems (GIS) that consists of 136 papers between 2008 and 2018. According to their study, the most popular research area is public, environmental, and occupational health. Other research areas are, respectively, environmental sciences and ecology, general and internal medicine, geography, and transport.

Most studied environmental qualities focus on greenery (Lu et al., 2018), aesthetic pleasantness (Rhodes et al., 2007), safety and social control with the neighborhood (Comstock et al., 2010). Van Cauwenberg et al. (2014) selected older adults as subjects. They found environments offering comfort, safety from crime, and pleasantness may attract older adults to walk for transportation. Hajrasouliha and Yin (2016) investigated the impact of street network connectivity on pedestrian volume. Their findings suggest that both the conventional metric-based measure of physical connectivity and geometric-based measure of visual connectivity have significant positive impacts on pedestrian volumes, together with job density and land use mix. Rioux et al. (2016) highlighted that large centralized parks may invite longer walks; smaller, well-distributed parks may invite more varied routes suggestive of appropriation and motivation processes. Both layouts might be combined in a single neighborhood to attract more walkers.

Walkability framework was firstly proposed by Cervero and Kockelman (1997) by introducing three principal dimensions which are density, diversity, and design. Eight years later, Frank et al. (2005) “proposed the first GIS-based composite walkability index that includes land use mix, connectivity, and residential density within a buffer around a residence” (Shashank and Schuurman, 2019, p.146). Zuniga-Teran et al. (2016) developed the Walkability Framework identifying nine walkability categories: density, land-use mix, accessibility, traffic safety, surveillance, parking, experience, greenspace, and community. These nine categories address not only the perspective of sustainable architecture and urban design, but also physical activity, land planning, transportation and health. More recently, this walkability framework was also applied in four neighborhood designs, which were traditional development, suburban development, enclosed community and cluster housing (Zuniga-Teran et al., 2017). Dovey and Pafka (2020) defined the concept of walkability as an assemblage. They focused on density, mixed-use and accessibility as key factors of walkability framework and tried to analyze walkability through the lens of mapping techniques. A few researchers tried to stress walkability as a transportation mode of choice problem and used both mapping and Multi-Criteria Decision-Making methods (Fancello, Congiu, and Tsoukiàs, 2020; Manzolli, Oliveira, and Neto, 2021; Ortega et al., 2020)

The interest among scholars produces fruitful works in urban walkability using hard-copy auditing tools. Moreover, there are digital implementations that produce indices for that popular field such as Walkscore.com™ (2010) and Pedestrian Catch (Melbourne School of Design, n.d.). Koohsari et al. (2018) examined how Walk Score™ is correlated with objectively derived attributes of neighborhood walkability, for residential addresses in Japan. They found it as a valid measure of neighborhood walkability. All these indices are possible because there is plenty of data available in the urban built environment for measuring walkability (Lee and Talen, 2014). Paykoç (2019) categorizes, defines and compares the background idea of both hard copy and digital walkability measurement tools by criticizing their keystones and their main ideas. However, these walkability parameters differ in terms of (i) the type of data used (e.g. qualitative, quantitative, GIS, objective, and/or subjective assessments of the urban environment); (ii) the method (e.g. audit instruments, levels of service indicators, checklists); (iii) the unit of analysis (e.g. pedestrian infrastructure, segment, or area); (iv) the goal (e.g. to evaluate pedestrian structures, to assess the potential of specific new projects to increase walking, to ascertain pedestrian conditions in a city); and (v) the variables considered (Ruiz-Padillo et al., 2018).

These differences cause a fuzzy and vague sea of scholarly conclusions and proposals for walkability problems. Hence, Dovey and Pafka (2020) stress the complexity of the definition and operationalization of the concept of walkability. To select and weigh the variables in walkability indices, and to create a method, definition of walkability gains a priority (Shashank and Schuurman, 2019).

2.3 Walking as a Planned Healthy Urban Behavior

Active living and active transportation (walking and cycling) came to fore as a public interest during the last twenty years by the promotion of public and individual preventive health strategies of the World Health Organization (WHO). Researchers in the general and internal medicine field, relate walkability to health benefits. Iwane et al. (2000) investigated the effects of walking 10,000 steps/day or more on blood pressure and cardiac autonomic nerve activity in mild essential hypertensive patients. Smith et al. (2008) relate neighborhood walkability-density, pedestrian-friendly design, and two novel measures of land-use diversity-to residents' excess weight. Frank et al. (2004) argue that measures of the built environment and travel patterns are important predictors of obesity across gender and ethnicity, yet relationships among the built environment, travel patterns, and weight may vary across gender and ethnicity. Yates et al. (2014) showed that individuals at high cardiovascular risk with impaired glucose tolerance, both baseline levels of daily walking activity and change in walking activity display a graded inverse association with the subsequent risk of a cardiovascular event. Sarkar et al. (2018) found evidence of a protective association between neighborhood walkability and blood pressure outcomes among a large population-based cohort (429.334 participants).

Walking has also positive effects on public, environmental, occupational health, and well-being. Frank et al. (2005) reveal the relation of walkability attributes to public health. Their results support the rationale for the development of policy that promotes increased levels of land-use mix, street connectivity, and residential density as interventions that can have lasting public health benefits. Nisbet and Zelenski (2011) suggest that the pleasant moods experienced on outdoor nature walk facilitated a subjective sense of connection with nature, a construct strongly linked with concern for the environment and environmentally sustainable behavior. Moreover, “walkable communities help to cut greenhouse gas and other emissions by requiring less driving, improve residents’ health by providing more opportunities for exercise, reduce crime by facilitating social interaction, support the local economy by encouraging shopping in the neighborhood” (Çubukçu, 2013, p.33).

Environmental health is a term to describe how ecologically sustainable an urban environment is. In the 21st century, active living and active transportation are an inseparable part of ecological sustainability. Hence, walking cannot be thought of as a mode of transportation only. It is a planned healthy urban behavior and it is a sub-category of the ecological model of active living. “Ecological models can provide a framework for integrating other theories and models to create a comprehensive approach to study design and interventions” (Sallis and Owen, p.44). The ecological model of active living (See Figure 4) points out neighborhood walkability under the behavior settings domain. City planners, environmental psychologists, and environmental health specialists can use this framework to integrate other behavioral models of sustainable living.

To produce a model for sustainable living, some behavioral theories help the researchers to identify and predict those healthy behaviors. For example, “Theory of Planned Behavior (TPB), Theory of Reasoned Action (TRA), and Integrated Behavioral Model (IBM) assume that attitudes, subjective norms, and perceived behavioral control all affect behavioral intentions, which in turn are linked to behavior” (Rimer and Brewer, 2015, p.67).

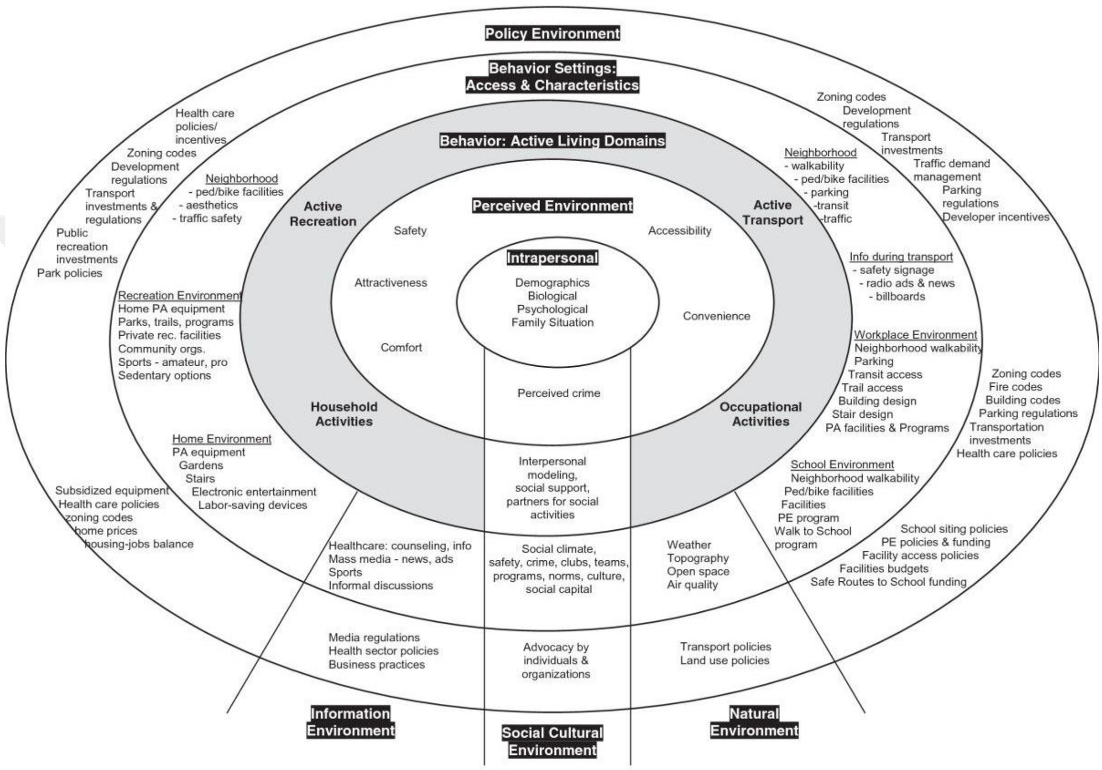


Figure 4. Ecological Model of Four Domains of Active Living (adapted from Sallis et al., 2006).

2.4 Effects of Urban Design Characters on Walkability

Urban morphology is defined as the study of the form of human settlements and the process of their formation and transformation (Wikipedia contributors, 2019; Kropf, 2017). Boeing (2019) states that topological character describes the configuration of the network and includes measures of connectivity, centrality, and clustering. A geometric character describes the network’s distances, areas, and densities. Both intermingle to define the network’s structure, efficiency, and performance. According to World Bank

Group, ‘the speed and scale of urbanization brings challenges, including meeting accelerated demand for affordable housing, well-connected transport systems, and other infrastructure... Once a city is built, its physical form and land use patterns can be locked in for generations, leading to unsustainable sprawl…, which puts pressure on land and natural resources’ (2020). To solve the socio-economic and environmental problems, architects, city planners, and government officials attempt to analyze the urban development and try to find design solutions for urban settlements.

After the World War I, modernists wanted better conditions for the people living in the cities. Le Corbusier “argued for a break with the dense, traditional city, replacing it with a planned, functional city to give people corresponding physical frameworks for life in the 20th century, with room for cars and other modern conveniences” (as cited in Gehl and Svarre, 2013, p.42). According to him (2007), “the circulation of traffic demands the straight line; it is the proper thing for the heart of a city. The curve is ruinous, difficult and dangerous; it is a paralyzing thing… The winding road is the Pack-Donkey’s Way; the straight road is man’s way” (p.93). Boeing (2019) explains Corbusier’s argument that planners must eradicate walkable, self-organized streets and paths from traditional cities to enable the development of deliberate, rational, straight-line roads for cars. This argument was made in 1929 and representing the modernist look of that era, in which the car was glorified and the city was seen as a machine that is the extension of industrialization and mass production. Modernist approach was proposing an open urban structure and offering to divide the city into residential, recreational and commercial zones and as a reaction to dense, complex, and labyrinth-like traditional city planning inherited from the medieval age (Gehl and Svarre, 2013). Gehl and Svarre underlines that “despite the humane visions for people’s lives and the slogan about form following function, there was considerably more form than life in the great majority of modernism’s projects” (2013, p.42).

After the 1950s and 1960s, the cities began resisting these formal theories and top-down planning methods. According to Batty (2019), cities (and many other kinds of the social system—the economy, for example) came to be thought of as more like organisms than machines. He continues his argument as “biology thus began to replace physics as the dominant metaphor and the notion that cities largely evolve rather than being planned in any sense, took hold” (p.vi). Handling urban design characters as organismic changed the top-down design fashion to a bottom-up evolving paradigm.

In the early 1950’s ‘situationist thinking’ began in Paris, which was developed by a group of anti-art intellectuals and students “devoted themselves to dérives: to drifting through the city for days, weeks, even months at a time, looking for what they called the city’s psychogeography” (Marcus, 1982, p.4). As the center figure of situationists, Guy Debord created an experiential walking map of the city of Paris under the title ‘The Naked City’ in 1957 by using images and relation stripes between those images (See figure 5). ‘The plan of Paris is cut up and divided into 19 sections that are randomly placed back together. The users of the map choose their own route through the city by using a series of arrows that link parts of the city together’ (Walsh, 2013). For him, this map is not a collection of images, but a social relationship between people, mediated by images (Debord, 2021). According to situationists, a city’s functioning could only be analyzed and derived from social relationships between people on the streets.

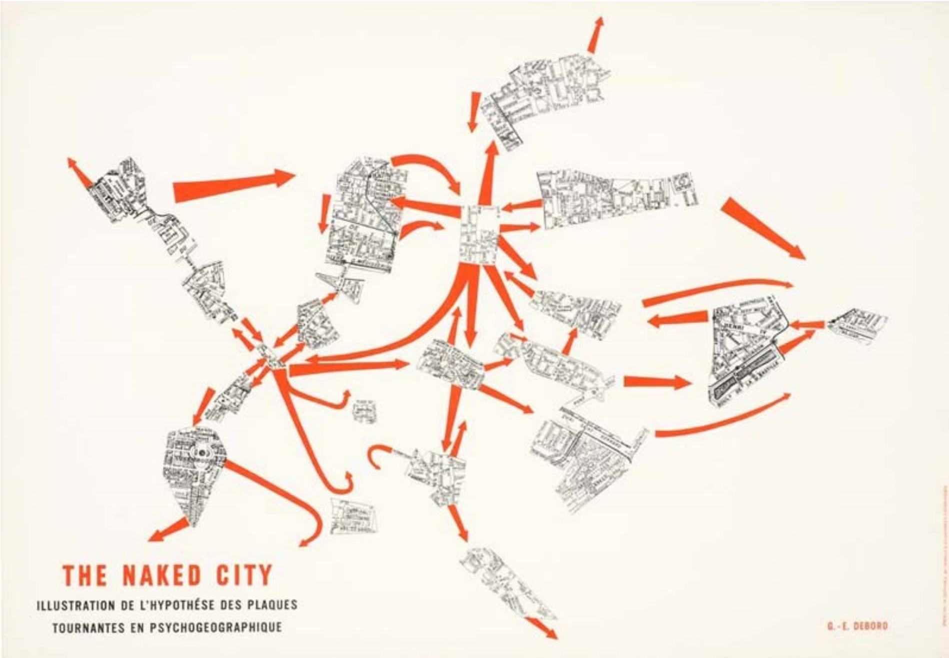


Figure 5. The Naked City Map of the city of Paris by Guy Debord (Walsh 2013).

Kevin Lynch as an architect focused on space than city life that he dealt with how users of the city read, navigate in, and experience the city (Gehl and Svarre, 2013). According to Lynch (1960), spatial understanding of the city is influenced by the organization of structural elements, such as paths, districts, nodes, edges and landmarks. For him, these urban design characters are the parameters that form the image of the city. For example, he claims that "paths with clear and well-known origins and destinations had stronger identities, helped tie the city together, and gave the observer a sense of his bearings whenever he crossed them" (Lynch, 1960, p.54).

In her book, The Life and Death of American Cities (1961), journalist and urban activist Jane Jacobs attacks previous understanding of city planning and gentrification. She is against decentralist urban design approaches such as Ebenezer Howard's Garden City (1898), Daniel Burnham's City Beautiful Movement (1890-1900), and Le Corbusier's Radiant City (1933). "Jacobs criticized dividing the city into residential, recreational and commercial areas, modernistic divisions that in her view destroyed social life and the city's complex connective strength" (Gehl and Svarre, 2013, p.51). She believes in a lively dense street with both its users, including stranger encounters and pure watchers, which is the key to a sustainable urban life. According to her, a city without streets is the slums of the future and a city without a public realm is impossible (Carchman et al., 2016). She finds any kind of segregation, ostracism, violation of private life, and grouping in colonies is dangerous. Her opposition relies on her argument that a successful city neighborhood should have three main qualities: (i) There should be clear demarcation and balance between public space and private space, (ii) there must be eyes on the street for safety, (iii) and sidewalks must have users on it continuously as possible for liveliness. According to Jacobs (Carchman et al., 2016, 1:08:38):

> The car is not supreme. The people who walk on the sidewalk are what make the city. It is not hard to understand that producing and consuming automobiles might seem important to the management of Ford and Chrysler and General Motors. However, it is hard to understand why the production and consumption of automobiles should be the purpose of life for all the rest of us.

Until now, Jacobs’s arguments have influenced and inspired many other urban researchers and city planners. Jan Gehl (as cited in Sim, 2019) puts that The New York School continued the approach of Jane Jacobs with the Public Spaces Project, led by William H. Whyte. Moreover, the Berkeley School in California has studied human-centered architecture and urban planning for many years. Gehl (as cited in Sim, 2019), continues that the invaluable contributions of Christopher Alexander, Donald Appleyard, Claire Cooper Marcus, Allan Jacobs, and Peter Bosselmann in this field should not be overlooked.

Sung and Lee (2015) indicated that walking activity is associated with Jacobs' six conditions for urban vitality, including land use mix, density, block size, building age, accessibility, and border vacuums. Perrone (2019) looks at Jane Jacobs's reconstruction of the way a city works regarding self-organization and ethical aspects (trust and respect for diversity). She employs Jacobs's early works on cities, in particular, a chapter she wrote in a book titled ‘Downtown Is for People’ (Whyte Jr, 1958), to outline a proper Jacobsian Street-Level approach (SLa) substantiated by an ethical-cognitive component. Dovey and Pafka (2020) criticize that Jacob’s description of the ‘need for concentration’, ‘mixed primary uses’ and ‘small blocks’, as three key factors of how cities work, has now become part of mainstream urban design theory and it is over-simplified. According to them, Jacobs’s point was “rather than reducing urban principles to numeric formulae, the city should be understood as organized complexity” (2020, p.95).

Walkable urban networks or built environments designed for pedestrians are only meaningful when they are used. Use refers to the relationship of purpose between human activities and the objects of the built environment that facilitate the activities (Kropf, 2017). This is a two-way (interdependent) relationship between activities and the built environment. Kropf (2017) suggests three sets of tools to deal with urban spatial structures: (i) all places are worthy of our attention, (ii) sequence of analysis, comparison, and synthesis, (iii) sequence of description, evaluation, and design. While measuring walkability, places that look the least promising that might have the most to offer as long as is it seen as worthy of the researcher’s attention. Different urban spatial structures, such as urban and newly developed urban neighborhoods, should be analyzed with key aspects of urban design. Today, Jacob’s key aspects ‘need for concentration’ stand for urban density, ‘mixed primary uses’ stand for land-use mix, and ‘small blocks’ stand for accessibility. According to Dovey and Pafka, “walkability is a set of capacities of any given neighborhood that is embodied in urban design in three main ways, which are the densities (concentrations) of buildings and people; the mix of different functions and attractions; and the access networks we use to navigate between them” (2020, p.94).

We should compare and compile the measurement results in terms of walkability major / sub-factors. Kropf suggests that, “we should be able to investigate and speak about the characteristics of different places in a non-normative way and then move on to why we think the places do or do not work – for particular purposes in particular circumstances” (2017, p.8). This suggestion is also adaptable for investigating factors determine the walkability of a place. Researchers should examine the internal relationships and the synergies between the variables of a walkable built environment.

CHAPTER 3

THEORETHICAL FRAMEWORK OF THE STUDY

Since walking is accepted as a planned healthy urban behavior, using a behavioral theory seems appropriate. Orstad et al. (2017) reports that 55.3% of the reviewed papers on walkability (47 of 85 studies) applied a theory or theoretical framework. Ecological model of active living provides a framework for integrating other theories such as the Theory of Planned Behavior (TPB) (Ajzen, 1991), which this dissertation focuses on in one aspect. On the other hand, walkability is a multi-disciplinary research field connecting geographic and social theories. Walkability is the result of dynamic set of urban relationships rather than a cluster of things in a neighborhood. With this feature, walkability will be evaluated with the Assemblage Theory (Deleuze and Guattari, 1987) complimentary to TPB. Moreover, walkability as a travelling mode of choice is related with the congruence between functionings and capabilities. The Subjective Value Theory (Fancello, Congiu, and Tsoukiàs, 2020) links the travelling mode of choice with the Capability Approach (Sen, 2009). This dissertation adapts this approach for making comparative decisions for walkability.

3.1 The Theory of Planned Behavior

Fishbein and Ajzen developed the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior together (Ajzen 1991; Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975; 2010). They showed that “it is critical to have a high degree of correspondence between measures of attitude, norm, perceived control, intention, and behavior in terms of action, target, context, and time" (Montaño and Kasprzyk, 2015, p.97). Figure 6 shows the Theory of Planned Behavioral Model with its predictors and background factors. The Theory of Planned Behavior (TPB) is a highly used theory for behavioral studies. Between 1985 and 2019, ecology and sustainability-related 71 papers were published using the TPB (Ajzen, n.d.).

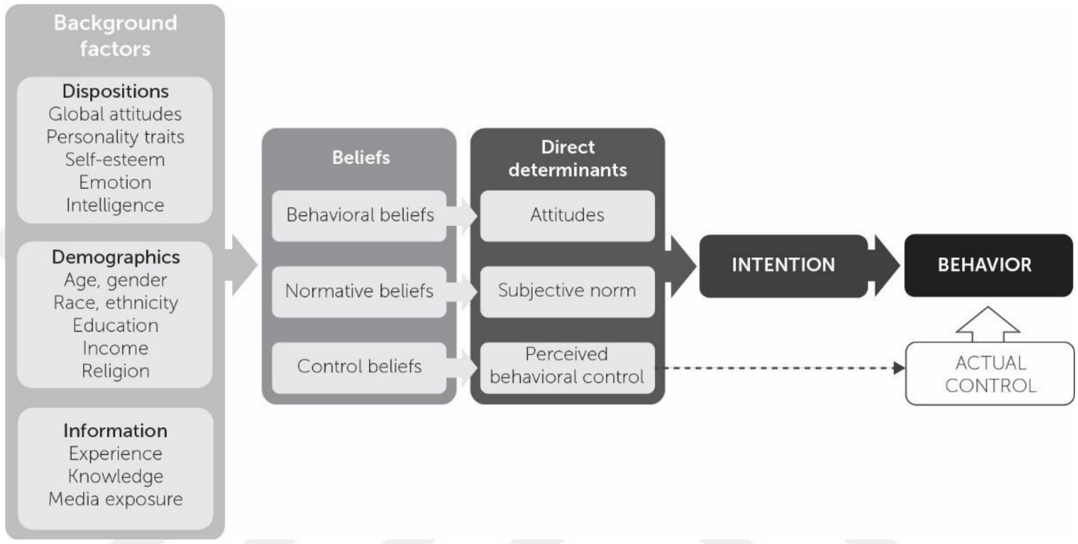


Figure 6. Theory of Planned Behavior Model (Adapted from Ajzen, 1991).

TPB was also used in walkability studies. A few papers added some predictors for walking intention and behavior. Ferreira et al. (2016) enlarged TPB by adding an emotional impact on walking intention and behavior. Seles and Afacan (2019) aimed to broaden TPB by including healthy urban performance attributes of the residential neighborhoods as an additional predictor for walking behavior. Recognizing the demand for a reliable subjective instrument to gather information on walking to occupational activities on the neighborhood scale, Al-Saraify and Grierson (2019) developed an approach following reliable techniques in the design of questionnaires including the analysis of currently available instruments, interviews with the potential case study participants, and the use of the TPB.

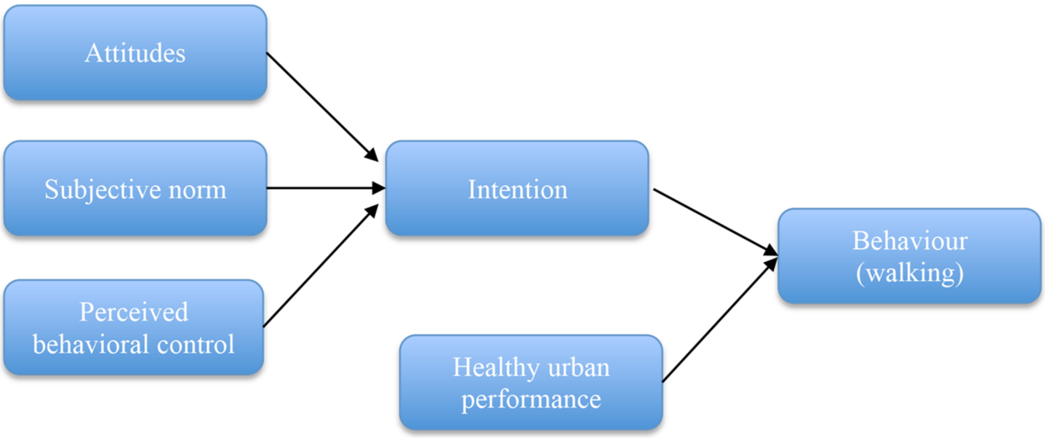


Figure 7. The hypothesized structural equation model (Seles and Afacan, 2019)

In the preliminary study related to this dissertation, walkability parameters of a residential neighborhood identified as healthy urban performance and its direct and indirect effect on walking behavior was investigated (Seles and Afacan, 2019). Figure 7 above shows the broadened Theory of Planned Behavioral Model with its predictors. Intention is the central factor for performing a behavior in TPB; in this case walking. Although, three predictors of intention factor, which are attitudes, subjective norms and perceived behavioral control, were examined statistically, this theory highlights the effect of perceived behavior control. ‘According to TPB, perceived control plays an important role and could have a direct impact to predict behavioral achievement, particularly when behavior is perceived as difficult’ (Seles and Afacan, 2019, p.45). Moreover, subjective norms, which are perceived social pressure to perform or not to perform the behavior, and perceived behavioral control, which is the perception of ability to perform or not to perform the behavior, are both related with premise determinants such as dispositions, demographics, and information.

The preliminary study results (Seles and Afacan, 2019) proved that the built environment walkability parameters are strongly correlated with walking behavior than walking intention factor. “Healthy urban performance variables were associated with lower levels of walking behavior, if their relationship was mediated through intention” (Seles and Afacan, 2019, p.49). Therefore, objective parameters of walkability (healthy urban performance) and subjective evaluations of the neighborhood residents (intentions) are not directly correlated. Besides, many studies show the strong direct relationship between walking behavior and the features of the built environment (Buck et al., 2011; Cerin et al., 2017; Cerin et al., 2019; Dias et al., 2019; Frank et al., 2005; Khanal and Mateo-Babiano, 2016; Özbil et al., 2019; Saelens and Handy, 2010; Saelens et al., 2003; Shashank and Schuurman, 2019). When perception is a strong determinant for intention or even for behavior, it is worth considering in the study to compare and contrast perceived neighborhood walkability and objectively measured neighborhood walkability. Studies are available in the literature that 85 relevant peer-reviewed papers were published between years 1990 and 2015 (Orstad et al., 2017) and 21 more papers since 2015 including two systematic reviews.

On one hand, the causal relationship between the behavior and the predictors, which is a one-way linear relationship, is examining the phenomenon with one perspective. On the other hand, actually, walkability is a complex phenomenon that both our perception and the built environment, where the walking behavior is realized, create each other simultaneously. Moreover, the walkability itself is relational that consist of many parts yield to be an assemblage of things. The situation here is we need to examine it with another perspective too, which points out not only quantitative but also with a qualitative distinction.

3.2 Non-Linear Thinking and The Assemblage Theory

Communities, institutional organizations, cities, countries are dependent of human mind, where all these entities perceived as real. At the same time, they are independent of the contents of peoples' minds, where the minds are needed to be there (DeLanda, 2012). As one can understand this is a multi-level process, consist of many entities and their properties.

Many philosophers and scientists throughout the history examined this phenomenon of properties of entities. Plato (428-348 B.C.) was one of the first philosophers who worked on the properties of things. ‘Plato called them “ideas” or “forms”, properties are viewed as *universals*, i.e., as capable, (in typical cases) of being instantiated by different objects, “shared” by them, as it were; consequently, in contrast with *particulars*, or *individuals*, of being somehow at once in different places’ (Francesco and Paoletti, 2020). John Suart Mill (1806 – 1873) formulated the principles of inductive reasoning and emergentism. ‘Mill argued that the properties of some physical systems, such as those in which dynamic forces combine to produce simple motions, are subject to a law of nature he called the "Composition of Causes". According to Mill, emergent properties are not subject to this law, but instead amount to more than the sums of the properties of their parts’ (Wikipedia Contributors, 2021). Scientifically, its reverberation could be understood in the chemistry field as the mechanism of emergence. For example, two different atoms that have different properties gain very different features when they are combined as a molecule (e.g. Hydrogen [H] and Oxygen [O] atoms act as fuels in a burning process; however, combination of these two atoms, Water [H_2O] molecule act as a fire extinguisher). In the 19th century, Hegel conceptualized the idea of seamless totality (1999). According to his argument, ‘the parts of the whole cannot be reduced to the sum of the parts because the parts fuse together to form a seamless whole, a seamless totality’ (Perez de Vega, 2016). Hegel (1999, p.711) defines his relationships of exteriority concept as mechanism:

> This is what constitutes the character of a mechanism, namely that whatever relation obtains between the things combined, this relation is extraneous to them that does not concern their nature at all and even if it is accompanied by semblance of unity it remains nothing more than composition, mixture, aggregation, and the like.

In the 20th century, Gilles Deleuze and Felix Guattari identified the Assemblage Theory, which was developed as a counterpart to seamless totality concept and relationships of interiority in their book *A Thousand Plateaus: Capitalism and Schizophrenia* (1987). For Deleuze, “an assemblage, far from being a mere collection, is a dynamic coming together of disparate things that form a union for a particular co-functioning” (Perez de

Vega, 2016, p.77). He defines assemblage as a “multiplicity, which is made up of many heterogeneous terms and, which establishes liaisons, relations between them, across ages, sexes and reigns-different natures” (Deleuze and Parnet, 2007, p.69).

Deleuze gives an example of ‘war machine’ to embody this term and shows the heterogeneity of the assemblage parts (1987). War machine is the assemblage of a horse, a warrior, and a weapon. Horse enhance both the power of the warrior and the weapon in motion. DeLanda stresses that different parts of the war machine assemblage interact and the whole is not reducible to each one of the parts (2012).

Experience of the parts is important in order to mean something more as a whole rather than just being a collection (DeLanda, 2012). DeLanda argues that the human body is really an assemblage and not a seamless totality. Organs of the body interact with one another but they retain their own identity in those interactions (2012). Even they can be detached from the assemblage (e.g. body) and can be plugged into another assemblage (e.g. organ transplant).

Assemblages might have extensive or intensive properties. DeLanda (2016) explains Deleuze’s Assemblage Theory with the combination of Hegel’s seamless totality. He notices the exteriority, which is about the totality, and the parts’ properties do not explain the properties of the whole as Hegel puts it. On the other hand, interiority is about the changes; once parts joined, they cannot be separated as Deleuze puts it. Moreover, he stresses the extensive spaces such as features of the earth, like coastal lines or areas of land; on the other hand, he mentions intensive spaces where the differences occur in the intensity of properties like zones of low/high pressure or cold/warm fronts (DeLanda, 2016). He argues that there are critical points at which quantitative changes becomes qualitative and at the thresholds of intensity causing changes from quantity to quality in the spatial organization of those bodies can be understood by intensive maps (DeLanda, 2016).

In the light of these arguments, as a phenomenon, walkability is examined through the filter of the Assemblage Theory. Walkability is an assemblage of its predictors, variables and the built environment capacities. Walkability of the neighborhood is not just a collection of walkability criteria. Even an urban neighborhood is not a thing nor a collection of things (Dovey and Pafka, 2017). For Dovey and Pafka, a city is a complex adaptive assemblage (2020). Walkability indices need to interact with one another as to yield the walkability of a neighborhood that has properties of its own; these properties are irreducible to the properties of an index. Now one can speak of walkability as a capacity, rather than its properties. DeLanda (2006, p.10) explains that with an example:

> We can distinguish, for example, the properties of a given entity from the capacities to interact with other entities. While properties are given and may be denumerable as a closed list, its capacities are not given—they may go unexercised if no entity suitable for interaction is around. (…) being part of a whole involves the exercise of a part’s capacities but it is not a constitutive property of it. In addition, given that an unexercised capacity does not affect what a component is, a part may be detached from the whole while preserving its identity.

In order to reveal those capacities of walkability, researchers propose different methods. Dovey and Pafka claim that the relationship between urban design variables and the outcome as walking behavior is non-linear. They propose reading those relationships not by a statistical and causal regression analysis but a walkability mapping method. In their series of articles that focus on residential density, functional mix, and accessibility to facilities of residential neighborhoods, rather than reducing these urban key walkability factors to an index they propose different mapping methods that reveal each examined built environment as an assemblage of different assemblages (Dovey and Pafka, 2014; 2017; 2020). For them, “non-linear thinking appropriate to understanding the city lies in the practice of mapping and diagramming” (2017, p.254). They see those diagrams and maps as the central to the discourses of spatial knowledge. In order to analyze the hidden forces within a built environment, Dovey and Pafka use mapping practice as a novel method as Deleuze (1987) suggests it.

If more dimensions, which are also parameters / factors, are added, an intensive map reveals further complexity in the behavior of matter (DeLanda, 2016). This is the nature of assemblages. DeLanda (2012) explains this phenomenon with the phase diagram of water molecule. Water molecule acts as solid (ice) under 0C° and acts as liquid (water) above this temperature, and acts as gas (vapor) above 100C°. However, this phase diagram is not constant. This is only possible under the effects of certain factors, such as heat, pressure (being at the sea level), and specific volume (DeLanda, 2016). Combination of dimensions shape the behavior of matter.

Walkability parameters are quantitative. Their emergence, their actual properties, and their effects are observable by objective measuring methods until critical thresholds of change. It indicates the balance between functions that happen to exist, which is called an 'entropy' (Dovey and Pafka, 2017). Walkability factors are also qualitative that they are relational and have a synergetic effect. According to Dovey and Pafka (2017) synergetic effects of cities that cannot be reduced to cause-effect relationships. When combinations of known factors give rise to new developed factors, they form new assemblage diagrams or maps. These maps are heterogeneous, deterritorialized and virtual (real but not actual), which shows existence of transformations, dispositions, tendencies, and capacities (DeLanda, 2016).

Walkability is a capacity, because it has the capacity to function diversely if assembled by different factors such as perception. Even the perception is an assemblage. Perception is a capacity to function diversely when assembled by information, demographics, and dispositions, which are other assemblages.

3.3 Subjective Value Theory Approach

Fancello, Congiu, and Tsoukiàs claim that majority of urban walkability studies "refer to the behavior of a standard walker with no distinction among subjective preferences or needs, thus demanding for more personalization" (2020, p.1). The preliminary study related to this dissertation (Seles and Afacan, 2019) showed that the perception affects the preferences. Therefore, this study proposes a more preference based analysis of walkability factors, which are derived from the perception of the users in residential neighborhoods of the city of Ankara.

As stated before, perception is a capacity assembled by other factors; it functions parallel with the citizen's capabilities in the urban environment. What is mentioned here as capability, actually is the 'capability approach' (Sen, 2009), which is the effective freedom of an individual to choose between different things to do or to be that he/she has reason to value (Blečić, 2015). "In this concept, a capability constitutively requires two preconditions: (i) the ability, a person's internal power, detained but not necessarily exercised, to do and to be; and (ii) the opportunity, the presence of external conditions, which make the exercise of that power possible" (Blečić, 2015, p.1). According to that approach, walkability can also be explained as an urban capability. Figure 8 shows the determinants of well-being in the capability model adapted for walkabiliy.

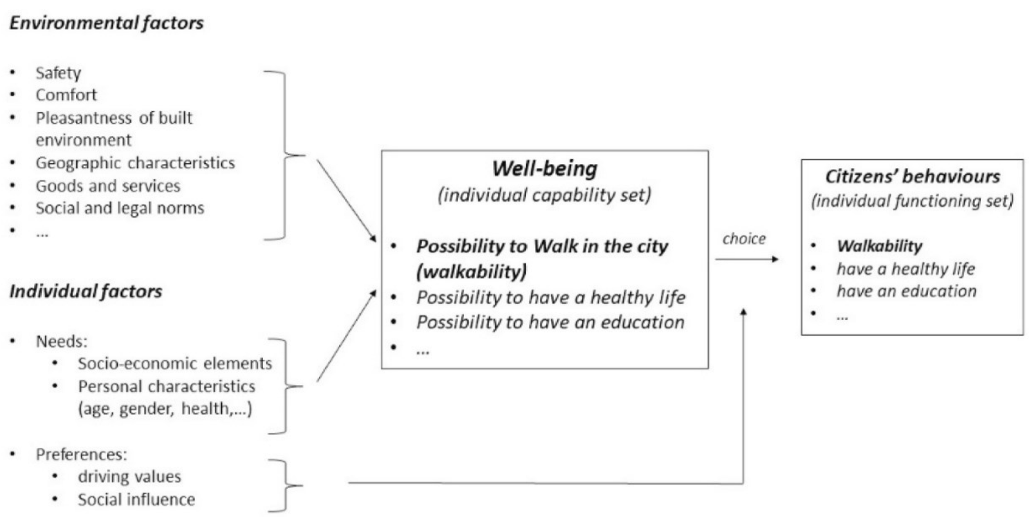


Figure 8. Capability model showing determinants of well-being with specific attention to walkability (Adapted from Fancello, Congiu, and Tsoukiàs, 2020)

To reach functionings, Robeyns (2017, p.39) identifies capabilities as a persons' opportunities and real freedoms, that he explains this with an example:

> While travelling is a functioning, the real opportunity to travel is the corresponding capability. A person why does not travel may or may not be free and able to travel; the notion of capability seeks to capture precisely the fact of whether the person could travel if she wanted to. The distinction between functionings and capabilities is between the realized and the effectively possible, in other words, between achievements, on the one hand, and freedoms or opportunities from which one can choose, on the other.

The urban and territorial factors directly affect urban capabilities. The Subjective Value Theory Approach is about "determining the values, which citizens give to urban and environmental factors that influence the walkability of places, and thus the urban capability set of citizens" (Fancello, Congiu, and Tsoukiàs, 2020, p.3). Those factors could be either environmental or individual that influence the individual capability set that affects citizens' behaviors. This approach proposes to value the functional (e.g. walkability) developed factors derived from citizens' needs and preferences rather than indexed normative factors.

In summary, Assemblage Theory points out that the predictors of walking behavior in the Planned Behavior Theory model are actually assemblages that need to be addressed. The model structure of the Subjective Value Theory Approach also bears similarities with the Theory of Planned Behavior. There are similarities between the urban capacities of Assemblage Theory and the urban capabilities of Subjective Value Theory Approach that links the theory of freedom of choice to multi-criteria decision-making (MCDM) methods.

CHAPTER 4

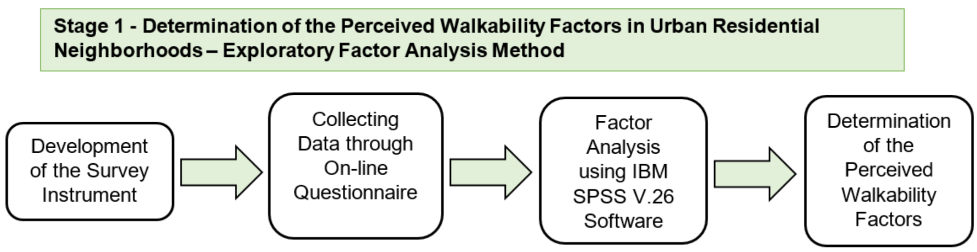
METHODOLOGY

It is not possible to say that there are universal factors of walkability when considering perception. “There is no consensus about the criteria that should be considered in an analysis tool due to context embedded factors and to the diversity of city users” (Fancello, Congiu, and Tsoukiàs, p.2). Background factors such as dispositions (consisting global attitudes, personality traits, self-esteem, emotion, intelligence), demographics and previous information (consisting experience, knowledge, media exposure) affect control beliefs that affect perception (Ajzen, 1991). These background factors might also differ in different geographic locations and different cultures, or different regions in a single geographic location such as urban and newly developed urban residential neighborhoods of a city. However, these variable factors can be investigated, demonstrated and compared with each other for better understanding of walkability. According to the objectives of the study stated before (Sub Chapter 1.2, p.15), a mixed-method was used within three analysis stages.

The three key design aspects of walkability were used for the first stage of the study to focus on, which are the urban density, the urban mixed-use, and the urban accessibility. Dovey and Pafka (2020) state that these three key urban design aspects are highly resistant to change once the city develops, while the other factors such as traffic safety, surveillance, parking, experience, green space, and community (Zuniga-Teran, 2017) are equally important too. Using these key aspects and in search of developed factors derived from the case study areas, the perceived walkability factors were determined by Exploratory Factor Analysis (EFA) method. The data required to perform the EFA were obtained by developing a survey instrument. When the perceived walkability factors were determined, their validity were tested on two selected urban residential neighborhood main streets by ranking their walkability preference values.

On the second stage of the analysis, first, the tree of fundamental parameters of walkability was formed based on the determined perceived walkability factors. Then the measured parameter values of the case streets were analyzed by using a Multi-Criteria Decision-Making (MCDM) method (Visual PROMETHEE) in order to rank their walkability preference.

On the last stage of the analysis, the relation of walkability of case streets and the neighborhoods they are attached to were investigated by mapping techniques. Mappable ones among the tree of fundamental walkability parameters and their applicability were determined. Walkability measuring scales and calculation methods were determined for the case areas. Then the quality thresholds of walkability (the parameters) are calculated through web mapping platforms and GIS tools. Last but not the least, separate street walking quality maps are resulted by using a GIS software (QGIS 3.18). Multi –criteria weighted-overlay analysis method was used to superimpose all the resulted maps to form final evaluation of walkability maps. Figure 9 shows all study stages and substeps with tools of analysis.



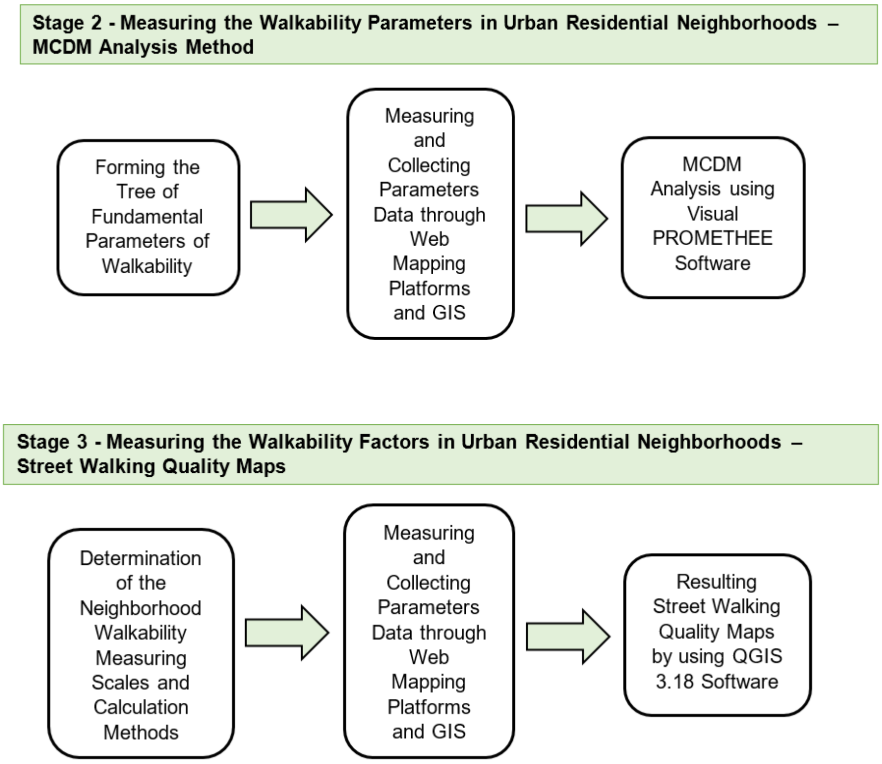


Figure 9. The relationship between the stages of the study and their related data collecting instruments (Drawn by the author, 2021).

4.1 Selection of the Site

In the late 19th century, Ankara was a small size city and far from urbanization. Between 1932 and 1938, Hermann Jansen designed the first urban city center of Ankara. He firstly proposed the walkable character of the city of Ankara as the pedestrian road network. It was made possible by the design of green spaces in the city center at that time. ‘The green space structure proposed by him consists of natural and artificial water surfaces, greenways of different widths, and sports fields of different sizes, parks, and vegetable gardens connected by greenways. It has also functioned the same green area structure as an alternative pedestrian road network to vehicle roads, providing pedestrian access from the gardens of the residences to schools, sports fields, the city center, the Ministries site and the airport’ (Burat, 2011). Figure 10 presents one of his designs on the green extension of a street in Ankara. However, the green roads were not realized as it is in the city plans of Jansen. After the 1960s, all is lost to land speculation and left in the archives (Burat, 2011).

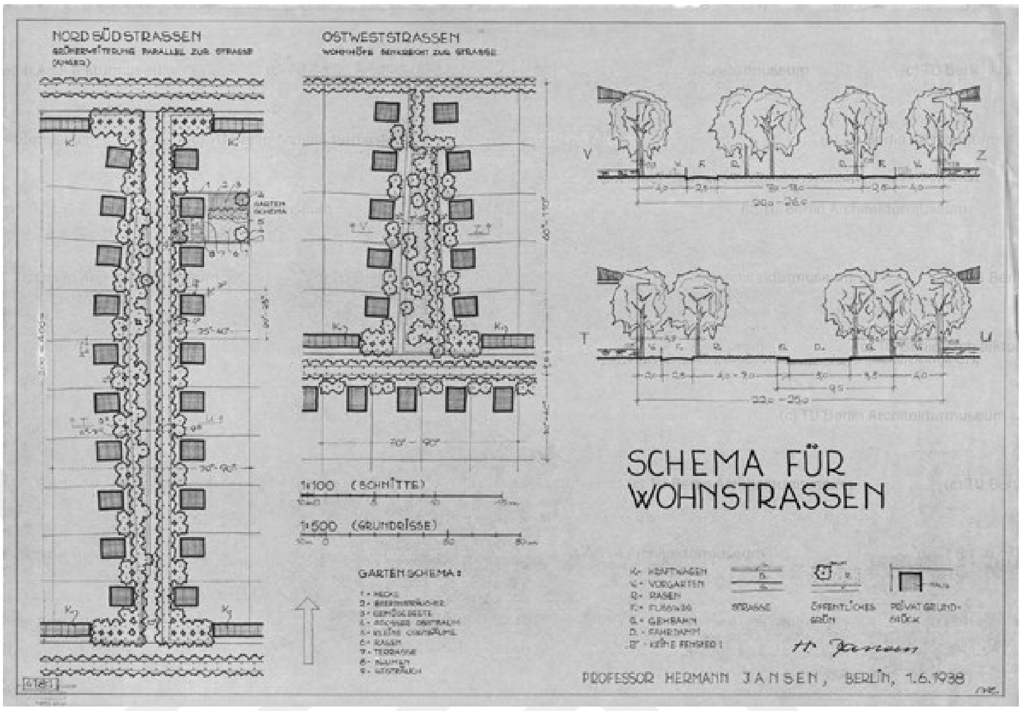


Figure 10. Jansen's plans of a green extension parallel to a north-south oriented street and a living courtyard perpendicular to an east-west oriented street in Ankara. Source: Berlin Technical University Architecture Museum (Burat, 2011).

Case study sites are chosen among main streets of the residential neighborhoods of Ankara, Turkey. Those sites are chosen for their different urban design characters. The main purpose of selecting these neighborhoods is to compare the walkability of two urban residential neighborhoods close to and far from the city center.

The first case study site, Güvenlik Street, was chosen from the most popular urban residential neighborhood area in Ankara, which was Ayrancı Neighborhood of Çankaya District. The planning history of Ayrancı Neighborhood went back to the early 1950s, when radical urban transformations occurred in Ankara based on Jansen master plan with the founding of Republic in 1923 (Aslanoğlu, 2001).

Until the 1950s, Ayrancı Neighborhood had a character far from an urban context, where the land was covered with vineyards. Alyanak and Başgül states that the down end part of Güvenlik Street was a neighborhood called Tatar District, where eight Tatar families made a living by feeding cows and selling their milk to embassies (2020) (See Figure 11). There were one-story houses with two bedrooms (Aslanoğlu, 2001). After the founding of the Republic of Turkey in 1923, Ankara became urbanized, and its population increased rapidly. Şumnu (2014) stated that in 1950s, the built environment in Ayranci evolved from a few number of detached houses to mass-produced apartment houses.

Figure 11. Early 1960s. On the left of the photo, the house of Ankara MP Doğan Bey (now the corner of Meneviş and Yaylagül streets). The road in front of the house is now Güvenlik Street, which was a stream in the early days (Alyanak and Başgül, 2020).

This neighborhood was selected as the survey area for several reasons. First reason is its neighborhood design type, which consists of residential block of apartments with housing backyard arrangements (Karaibrahimoğlu, 2006). Although Çankaya District Municipality does not have an extensive initiative focused on improving active travel (walking and biking) in Ayrancı

Neighborhood, the common use of these housing backyards, their connections to sidewalk, street and land use system are coherent (Seles and Afacan, 2019). Second reason is the urban quality of the housing blocks in this residential neighborhood have similar characteristics regarding horizontal and vertical rhythms, locations of windows and doors, garden walls, materials and color, which strongly affect comfort and safety of the walkability. Shops and services are available at street level, under the apartment blocks on almost every street in the neighborhood. Thirdly, it is one of the oldest, densest and most populous in terms of residential living. It is a neighborhood adjacent to Grand National Assembly of Turkey. A very popular shopping street, Tunalı Hilmi, exists within ten-fifteen minutes walking distance, and Ayrancı is within approximately fifteen-twenty minutes walking distance to the city center, Kızılay. Finally, residents in this neighborhood could experience more urban facilities compared to other suburban, enclosed or cluster housing neighborhoods (such as different vehicular and pedestrian traffic patterns, access points to public transport, pedestrian facilities, access to cultural centers, residential green areas, shops, cafes and restaurants) (See Figure 12 and Figure 13).

Figure 12. Views from the Güvenlik Street and a typical street view (at the right bottom corner) in Ayrancı. (Photos taken by the author, between 2018 and 2020)

Figure 13. View from the Güvenlik Street in Ayrancı. (Photo taken by the author, 2018)

While a new suburban neighborhood is being formed, it is natural to propose a livable urban environment to those living in the city center. Less denser and greener areas, easier transportation and a more walkable pedestrian network, more access to social and commercial services can be listed among these promises. For comparison, the second case study site, 2432nd Street (Recently renamed as Doğan Taşdelen Boulevard), was chosen from one of the first newly developed urban residential neighborhood areas in Ankara, which was Çayyolu Neighborhood of Çankaya District. Before being named as Çayyolu Neighborhood this area was Kutuğun Village, which was a typical Anatolian village until the 1990s. It has developed after the 1990s as a suburban neighborhood. However, it gained more urban characteristics soon and has become one of the most luxurious newly developed urban districts of Ankara today (Wikipedia contributors, 2020). Çayyolu is located in the southwestern part of Ankara and 17 km away from the city center (Aksel and İmamoğlu, 2020). The residential development of Çayyolu started with the Çayyolu Mass Housing Plan by the Ankara 1990 Metropolitan Master Plan and the Metropolitan Municipality of Ankara (Erişen, 2003; Gültekin, 2015) (See Figure 14).

Figure 14. On the left, a view of Çayyolu in 1990. The green area (field) visible in the back is the residential area of Konutkent-2. The buildings that appear in the distance are also MESA Koru residential blocks. On the right, a view of the same area in 2006. ("Geçmiş zaman olur ki…" 2006)

In the district, there are branches of many famous trademarks, schools, banks, shopping centers, cafes and restaurants, green areas as well as mainly gated communities, multi-story residential blocks, row houses and villa-type residential detached houses with gardens. Factors such as the opening of private universities like Bilkent University on the Eskişehir Road since 1984 and the realization of the Koru Housing Project by Mesa™ Construction Company between 1985 and 2004 contributed to the expansion of Çayyolu district and city of Ankara in the western direction.

Today, Çayyolu is a very popular and dense newly developed urban residential neighborhood. Most of the housing are gated communities and do not have shops at the ground level of the apartments. Shops, restaurants, and other facilities are in non-residential buildings mainly and they are within approximately ten-fifteen minutes' walking distance. Most of the residential buildings are not adjacent to main street and separated by walls and greenery. On 2432nd Street, the distance between intersections is generally long (more than 120m); however, sidewalks are wide and mostly close to greenery, which strongly affect the walkability of the neighborhood (See Figure 15 and Figure 16). The location was chosen because of its newly developed urban qualities of the housing blocks in this residential neighborhood.

Figure 15. Views from the 2432nd Street and a typical street view (at the right bottom corner) in Çayyolu. (Photos taken by the author, 2020)

Figure 16. View from the 2432nd Street in Çayyolu. (Photo taken by the author, 2020)

4.2 The Participants

Three hundred and sixty one (361) Turkish people participated in the study voluntarily (193 participants in Ayrancı Neighborhood and 168 participants in Çayyolu Neighborhood). Due to the conditions of COVID-19 pandemics, the participants enrolled in the study by an online survey system (Google Forums – See Appendix B). Same questions were asked for both of the neighborhood residents. The participant selection operationalized with the help of Çankaya Municipality, neighborhood mukhtars (The head of local government of a neighborhood or a village in Turkey), Provost Office of Bilkent University, and on-line social media channels of non-governmental organizations (NGOs) (e.g., Lavarlaa, Ankara Apartments, Ankara Cımbızcısı, Anthology Ankara, Çayyolu City Council, Ayrancı Neighborhood Assembly, etc.). A graphical poster was designed in order to take attention of the neighborhood residents and to direct to the walkability survey (See Appendix F). The posters were hung on visible spots of public and commercial establishments. The Bilkent University Ethical Committee (See Appendix A) has given ethical permission for the previous study (Seles and Afacan, 2019) related to this dissertation. The participants enrolled in the study after they saw the informed consent, stating the purposes of the study, their involvement, risks, and emergency procedures. They are also informed about the confidentiality of the study and their right to terminate their participation in the study at any time (See Appendix B). According to the survey's demographic results, 40.9 percent of the participants (highest value) live more than 10 years in Ayrancı Neighborhood and 44 percent of the participants (highest value) live more than 10 years in Çayyolu Neighborhood.

4.3 Instruments

Three instruments (walkability questionnaire, MCDM analysis tool, and Geographic Information Systems tool) are introduced to find answers to the research questions and for testing the hypotheses in this dissertation.

4.3.1 Developing the Survey

Çayyolu Neighborhood is introduced as the additional case area for this study as an example of a newly developed urban neighborhood far from the city center. In this stage of the dissertation, a revised questionnaire was developed upon the preliminary study's questionnaire (Seles and Afacan, 2019), and it was used to understand users' perception of their neighborhood walkability and their routines as pedestrians in both urban case study areas (Ayrancı and Çayyolu Neighborhoods). Therefore, the questionnaire was designed with including sub-parts to understand user profile, in addition to items focusing on density, mixed-use, and accessibility in urban and newly developed urban neighborhoods of the city of Ankara (See Appendix B). Moreover, since the participants filled out this online questionnaire, it was accepted that they did not have any biases in this regard. First, the unstructured items in the questionnaire were adapted from the Neighborhood Environment Walkability Scale (NEWS) questionnaire developed by Saelens et al. (2003) and developed later by Cerin et al. (2006) to find out information about what the participants perceive about their neighborhood. Second, the preliminary study's walking behavior questionnaire (Seles and Afacan, 2019) was adopted (only healthy urban performance items in line with the NEWS) based on the Theory of Planned Behavior questionnaire guideline introduced by Ajzen (n.d.). The author also adds some items in order to question the perceived effects of the COVID-19 pandemics on walking behavior as a conttirbution. A few items come from Jane Jacobs' (1961) urban vitality approach. For analyzing the three key walkability attributes later, perceived urban density, perceived urban mix-use, and perceived urban accessibility (DMA) data collected by this (Likert-scale close-ended questionnaire) method Table 1 shows the references that the questionnaire items are related to.

The study identified the uninformative and irrelevant survey items among 34 walkability items regarding the responses of participants from Ayrancı Neighborhood (n= 193) and Çayyolu Neighborhood (n=168) in Ankara, Turkey. Due to the conditions of COVID-19 pandemics, the data was collected through an online survey by using Google Forms between the dates of 23.08.2020 and 06.12.2020.

Table 1. Perceived Urban DMA Walkability Questionnaire Items and Their References (drawn by the author, 2021).

Perceived Urban DMA[1] Questionnaire for Walking in the Neighborhood		
Construct (34 Items)	**Item ID**	**Item Reference**
Density (D,12 Items), Mixed-Use (M,10 Items), Accessibility (A,12 Items)	D1, D5, D8, D12, M5, A5	Covid 19 Health Issue - added by the author
	D2, D3, D4	Cerin et al., 2006; Saelens et al., 2003
	D6	Cerin et al., 2006; Jacobs, 1961; Saelens et al., 2003
	D7, D9, D10	Jacobs, 1961
	D11, M7, M8	Cerin et al., 2006; Jacobs, 1961; Saelens et al., 2003; Zuniga-Teran et al., 2016
	M1, M2, M3, M4, M6, M9, M10, A1, A2, A3, A4, A6, A7, A8, A,9, A10, A11, A12	Cerin et al., 2006; Saelens et al., 2003; Zuniga-Teran et al., 2016

4.3.2 Choosing the MCDM Analysis Method

In this research's case, decision problem is to choose a better street in terms of walkability multiple parameters, which is a ranking problem. "An outranking relation is defined in the set of alternatives such that alternative *a* outranks alternative *b* if there are enough arguments to decide that *a* is at least as good as *b*, while there is no essential reason to refute that statement" (Harputlugil et al., 2011, p.11). For analysis of the walkability multi parameters, Preference Ranking Organization METHod for Enrichment Evaluation (PROMETHEE) was chosen for the method. Because, it is based on pairwise comparison and it only requires indifference and preference thresholds; moreover, input effort is quite low compared to other outranking methods (Ishizaka and Nemery, 2013). Visual PROMETHEE is the upgraded user-friendly software version of this method, which is combining the

[1] Density, Mixed-Use, and Accessibility

PROMETHEE and GAIA methods with visual representations, used as a tool for this study.

4.3.3 A Layer in the Map: The Street

Researchers represent or measure their walkability parameters through mapping techniques. Those deterritorialized and virtual maps show the existence of dispositions, tendencies, and capacities of the urban environment on a visual basis. Mainly other web mapping platforms or Geographical Information Systems (GIS) are used for these analyses.

Those mapping software are used for creating many layers, such as nodes, lines or polygons. For example, those items might work as attributes of a street. Nodes might point commercial amenities, intersections, focal points of a street depending on the scale or objectives of the measurement. A line might represent the axis of a street or a polygon might represent the area of that same street. As for choosing an MCDM analysis method, there is not a universal way of representing walkability attributes on a map either.

Some of the studies propose showing key walkability aspects, depending on the objectives or scale of the case study, on cadastral layers. Those studies try to analyze walkability through weighing those lot and blocks. For example, Dovey and Pafka (2014; 2017; 2020) used such a method to show building and population density or mixed-use in their work (See Figure 17 and Figure 18).

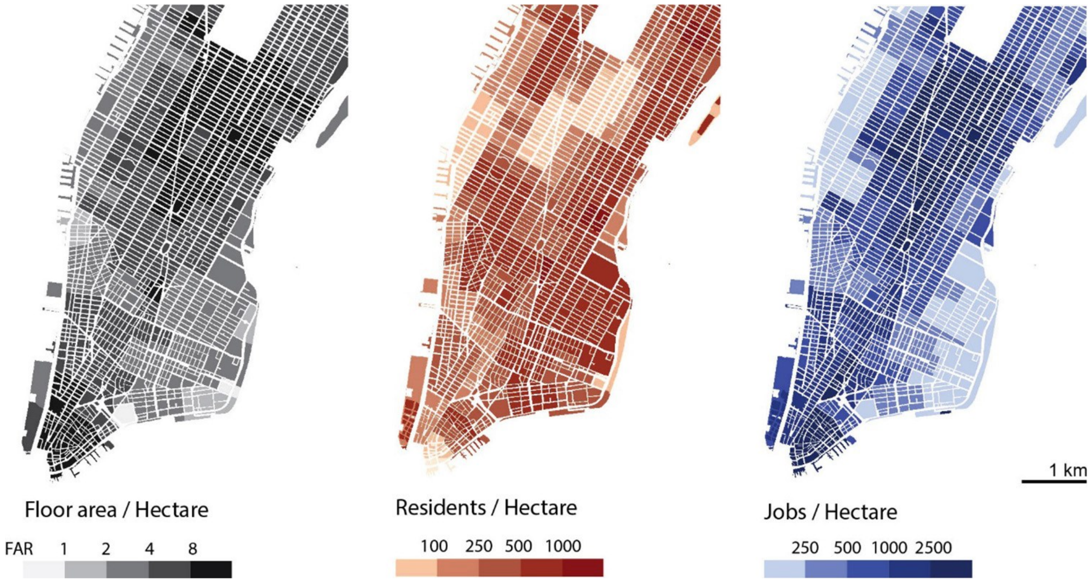


Figure 17. Building and Population Density Maps (Dovey and Pafka, 2020).

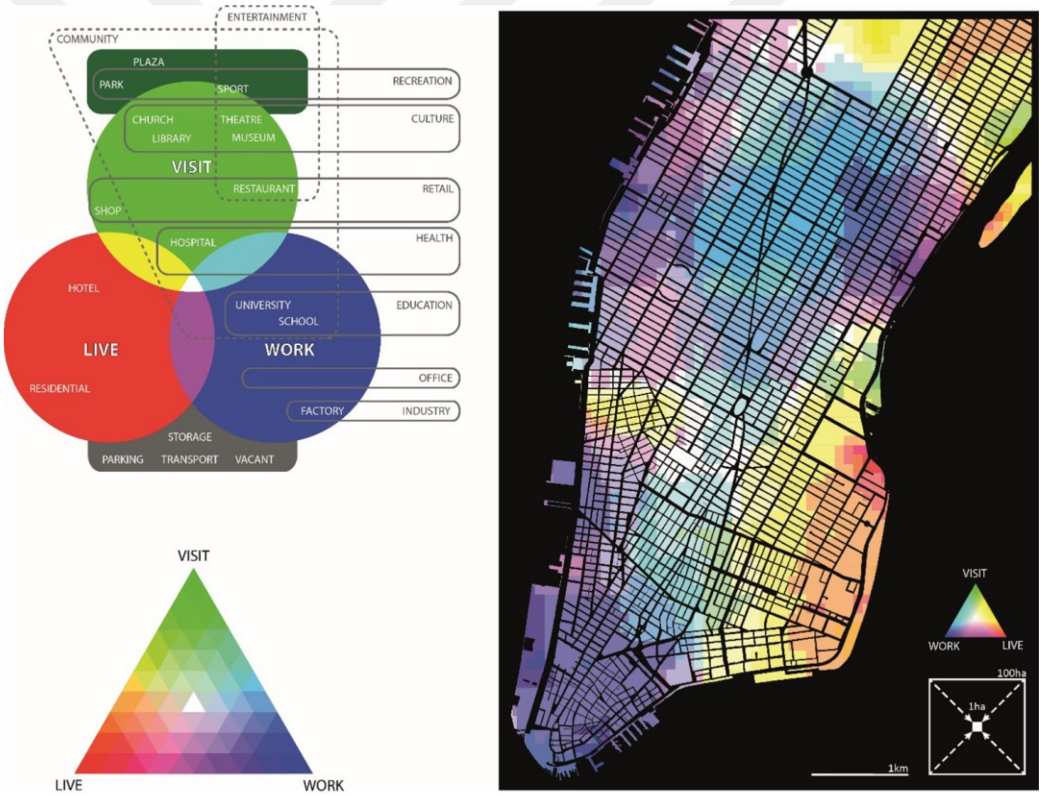


Figure 18. The Walkable Live/Work/Visit Mixed-use Map (Dovey and Pafka, 2020).

On the other hand, some other researches proposed representing walkability parameters on street layers rather than lot and blocks. Those studies try to analyze walkability through weighing only the streets (Akkar Ercan and Belge, 2016; Blečić et al., 2015; Doğan, 2021; Fancello, Congiu, and Tsoukiàs, 2020; Manzolli, Oliveira, and Neto, 2021; Ortega et al., 2020; Özer and Kubat, 2015; Talavera-Garcia and Soria-Lara, 2015) (See Figure 19 and Figure 20).

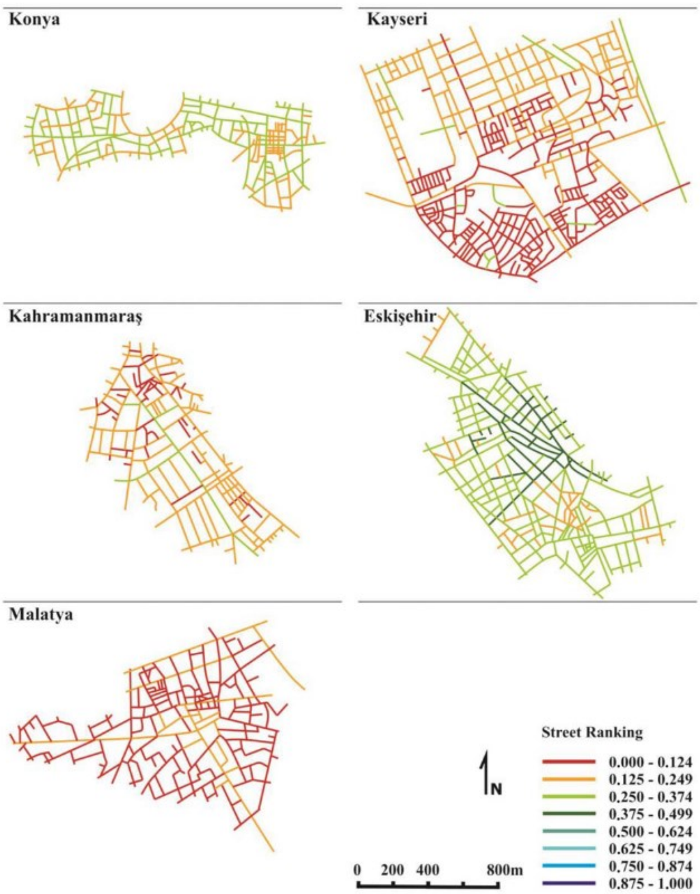


Figure 19. Street Connection Density Maps (Doğan, 2021).

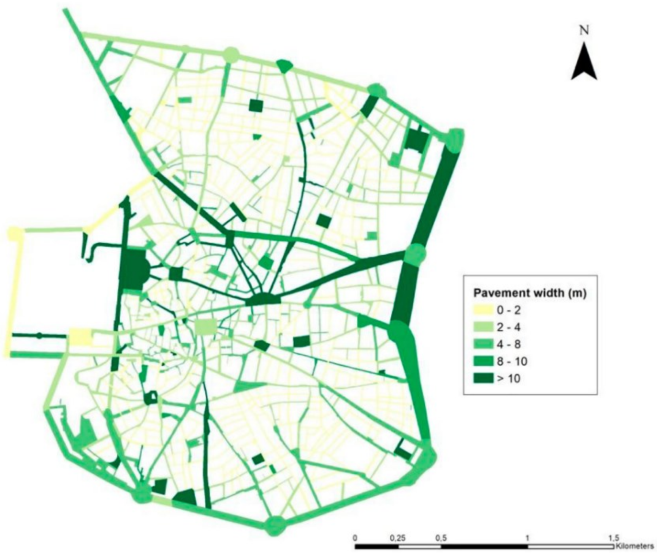


Figure 20. Pavement Width Map (Ortega et al., 2020).

Considering the scale of the case areas of this study, it was found appropriate to value street layers for analyzing the walkability parameters in this study. The QGIS 3.18 (n.d.) software was considered as a tool that supports viewing, editing, and analyzing geospatial data. Because it is a free of charge and open source GIS software used by researchers and mapping engineers all over the world. Moreover, the multi-criteria weighted-overlay analysis was used to allocate the suitability of areas based on the walkability parameters.

However, our biggest shortcoming in this regard was the lack of inadequacy of urban development databases in Turkey at all. For example, the reason why many publications are available on walkability in Australia is that the data generating units of municipalities or government agencies are constantly updating wide variety of data on the urban design of the cities in Australia (Adams et al., 2014; Badland et al., 2013; Cowie et al., 2016; Foster et al., 2015; Grasser et al., 2017; Mavoa et al., 2018; Mayne et al., 2013; Ryan et al., 2016; Saghapour and Moridpour, 2019).

CHAPTER 5

RESULTS

5.1 Stage I: Exploratory Factor Analysis

This phase of the study finds an answer to Research Question 1 in this dissertation. The Exploratory Factor Analysis (EFA) was used to measure the strength of the correlations among perceived walkability items based on urban Density, Mix, and Access in the survey. The same questions were asked to the participants in both neighborhoods. It was examined under which factors the answers were clustered. The similarities and differences between the perceived walkability factors for both neighborhoods are shown.

5.1.1 Refinement of the Survey Instrument

The items were eliminated based on two refinement factors in order to carry out an effective data analysis: (a) floor and/or ceiling effects and (b) the strength of correlation scores. In the study, the participants' responses were coded using 7-point agreement likert scale: (1) 'Totally Agree, (2) 'Agree', (3) 'Somewhat Agree', (4) 'Neither Agree nor Disagree', (5) 'Somewhat Disagree', (6) 'Disagree' and (7) 'Totally Disagree'. When the instrument is relatively unstructured, a floor and/or ceiling effect can occur if response means for each item are higher and/or lower than they should be and may pile up against these extreme scores (Krathwohl, 1998). In order to prevent the instrument decay, the items with a mean score lower than 1.50 and greater than 4.50 required to be deleted to eliminate the floor and/or ceiling effect in a 1-to 5 likert scale survey (Afacan, 2008). As adapted for the 1 to 7 likert scale, the frequency distributions of the survey reveal as mean scores that were no lower than 2.10 or greater than 6.30; so that no items were excluded for both two neighborhood surveys.

When the common variance values of the items were examined, no determined factor was below 0.30; whereas correlation coefficients lower than 0.30 have a weak relation and are not preferred (Argyrous, 2005). So, no item was excluded from the analysis of both two-neighborhood survey data within this respect.

5.1.2 Determination of the Perceived Walkability Factors in Urban and Newly Developed Urban Residential Neighborhoods of Ankara

The ratings of the participants on 34 items were analyzed by using the IBM's Statistical Package for the Social Sciences (SPSS) program version 26. First, the answers given to the negative survey questions (D5, D8, D10, M2, M5, M10, A6, A8, and A11) were re-encoded in the SPSS program (See Appendix B). Then, KMO (Keiser-Meyer-Olkin) value and Bartlett's test were used to control whether factor analysis could be performed on 34 observation items of the Walkability Scale.

Since the KMO value is 0.81 (> 0.71), the sample size is sufficient (n=193), and the Bartlett's test Chi-Square value is 3008,154 and the degree of freedom is 561 and the original correlation matrix is the same as the identity matrix is rejected, the factor of the scale was considered suitable (p=0.00, p<0.05) for carrying out the analysis for Güvenlik Street of Ayrancı Neighborhood survey.

On the other hand, the KMO value is 0.766 (> 0.71), the sample size is sufficient (n=168), and the Bartlett's test Chi-Square value is 2140,484 and the degree of freedom is 465 and the original correlation matrix is the same as the identity matrix is rejected, the factor of the scale was considered suitable ($p=0.00$, $p<0.05$) for carrying out the analysis for 2432nd Street of Çayyolu Neighborhood survey. Both results show that the exploratory factor analysis could be performed on 34 observation items of the walkability scale on both two-neighborhood surveys.

If the eigenvalues and factor loadings are taken into account when deciding the number of factors, it is seen that the scale has nine factors in the analysis of Ayrancı Neighborhood survey and eight factors in the analysis of Çayyolu Neighborhood survey. Those factors with an eigenvalue greater than one (EVG1) in the scale can be seen when looking at the total explained variance.

Varimax rotation method is the most frequently preferred method in exploratory factor analysis (Argyrous, 2005; Karaman, 2015). With this method, a rotated component matrix created and the items' factor loading values examined sequentially. To be able to say that an item measures a structure or a factor well, the value of this factor load must be 0.30 or above (Karaman, 2015). It can be deduced that it measures the structure at a moderate level for an item with a factor load of 0.30-0.50, and a high level for an item with a factor load higher than 0.50 (positive or negative) (Kline, 1994). In both two surveys, it was clear that some items, which have factor loading values over 0.5, are grouped under definite components showing that those items are highly correlated with those components.

When an item gives a factor load to more than one factor, the difference between the two factors should be at least 0.1 (Stevens, 2002). In Ayrancı survey, some items (M7, and A11) were linked to three factors at the same time with a difference in factor loading values was less than 0.1, so they were excluded from the list and exploratory factor analysis was repeated with the remaining 32 items (See Appendix B). For a factor to be stable, it must consist of at least three items and have high factor loadings (Ford et al., 1986; Hogarthy et al; 2005; Maccallum et al., 1999). The study removed four factors that include less than three items (Factors 5, 6, 8, and 9) to avoid a poor correlation structure, which resulted a final decision of five factors out of nine.

Therefore, five factors were obtained for Ayrancı survey and these factors explain 51% of the total variance. This scale is a five-dimensional structure with 1% eigenvalue and 4.77% variance that explains 51% of the total variance, i.e. 32 items have 51.005% variances in common, so that they are correlated highly with 5 common themes that were indicated in Table 2 and each theme was considered as a factor scale.

Table 2. Summary of Rotated Factors for Güvenlik Street of Ayrancı Neighborhood.

Factor	Scale	Eigenvalue	% of Variance	Cumulative %
1	Route Safety in a Residential Neighborhood	7,437	23,239	23,239
2	Route Comfort	3,203	10,010	33,250
3	Route Characteristics	2,205	6,892	40,141
4	Route Accessibility	1,950	6,094	46,235
5	Route Attractiveness	1,527	4,770	51,005

Although a factor is usually identified according to the item with the highest factor loading (Argyrous, 2005), the names were given to the five factors regarding the items with the common characteristics. Appendix C gives the detailed list of the five factors with their corresponding items and the factor loadings for each item under each factor for Güvenlik Street of Ayrancı Neighborhood.

In Çayyolu survey, some items (D8, M10, and A7) were linked to three factors at the same time with a difference in factor loading values was less than 0.1, so they were excluded from the list and exploratory factor analysis was repeated with the remaining 31 items (See Appendix B). Moreover, according to the stability requirements of the factor mentioned above, the study also removed last three factors that include less than three items (Factors 6, 7, and 8) to avoid a poor correlation structure, which resulted a final decision of five factors out of eight.

Accordingly, again five factors were obtained for Çayyolu survey as for Ayrancı survey and these factors explain 50.7% of the total variance. This scale is a five-dimensional structure with 1% eigenvalue and 5.01% variance that explains 50.7% of the total variance, i.e. 31 items have 51.739% variances in common, so that they are correlated highly with 5 common themes that were indicated in Table 3 and each theme was considered as a factor scale.

Table 3. Summary of Rotated Factors for 2432nd Street of Çayyolu Neighborhood.

Factor	Factor Name	Eigenvalue	% of Variance	Cumulative %
1	Route Safety in a Residential Neighborhood	6,529	21,060	21,060
2	Route Characteristics	2,989	9,643	30,703
3	Route Comfort	2,754	8,882	39,585
4	Route Accessibility	1,903	6,139	45,724
5	Route Attractiveness	1,554	5,014	50,739

Although a factor is usually identified according to the item with the highest factor loading (Argyrous, 2005), the names were given to the five factors regarding the items with the common characteristics. Appendix D gives the detailed list of the five factors with their corresponding items and the factor loadings for each item under each factor for 2432nd Street of Çayyolu Neighborhood. Nomenclature of the perceived factors and their relation to questionnaire items are discussed at the sixth chapter.

5.2 Stage II: MCDM Implementation in Urban and Newly Developed Urban Residential Neighborhoods of Ankara

This phase of the study finds answers to Research Question 2 and research Question 3 in this dissertation. In order to perform the Multi-Criteria Decision-Making (MCDM) analysis for ranking the walkability preference of the case streets, developed parameters compatible with the perceived walkability factors were selected. Their relation was shown on a diagram. Then, those selected parameters are measured for gathering geospatial data to perform the MCDM analysis.

5.2.1 Selecting the Relevant Walkability Parameters

The main objective of the decision-aid process described as the walkability of selected streets. Then, main factors for developing the analysis were outlined. Four main factors were defined: (i) route safety in a residential neighborhood, (ii) route comfort, (iii) route characteristics, and (iv) route accessibility.

According the exploratory factor analysis, five factors were determined for both case neighborhoods. However, the fifth factor, ‘the attractiveness’ is decided to rank under the ‘route characteristics’ factor as a sub factor category with ‘the aesthetics’ sub factor category.

The parameters, where the quality thresholds of walkability are calculated, were selected among the recent studies’ parameter lists (Fancello, Congiu, and Tsoukiàs, 2020; Manzolli, Oliveira, and Neto, 2021; Ortega et al., 2020; Talavera-Garcia and Soria-Lara, 2015; Zuniga-Teran et al., 2016) in relevance to the executed exploratory factor analysis. Those parameters not only selected for the decision-aid process, but also for their mappable characteristics. Figure 21 presents the perceived items, the main factors, the sub-factor categories, and the parameters of the decision-aid process.

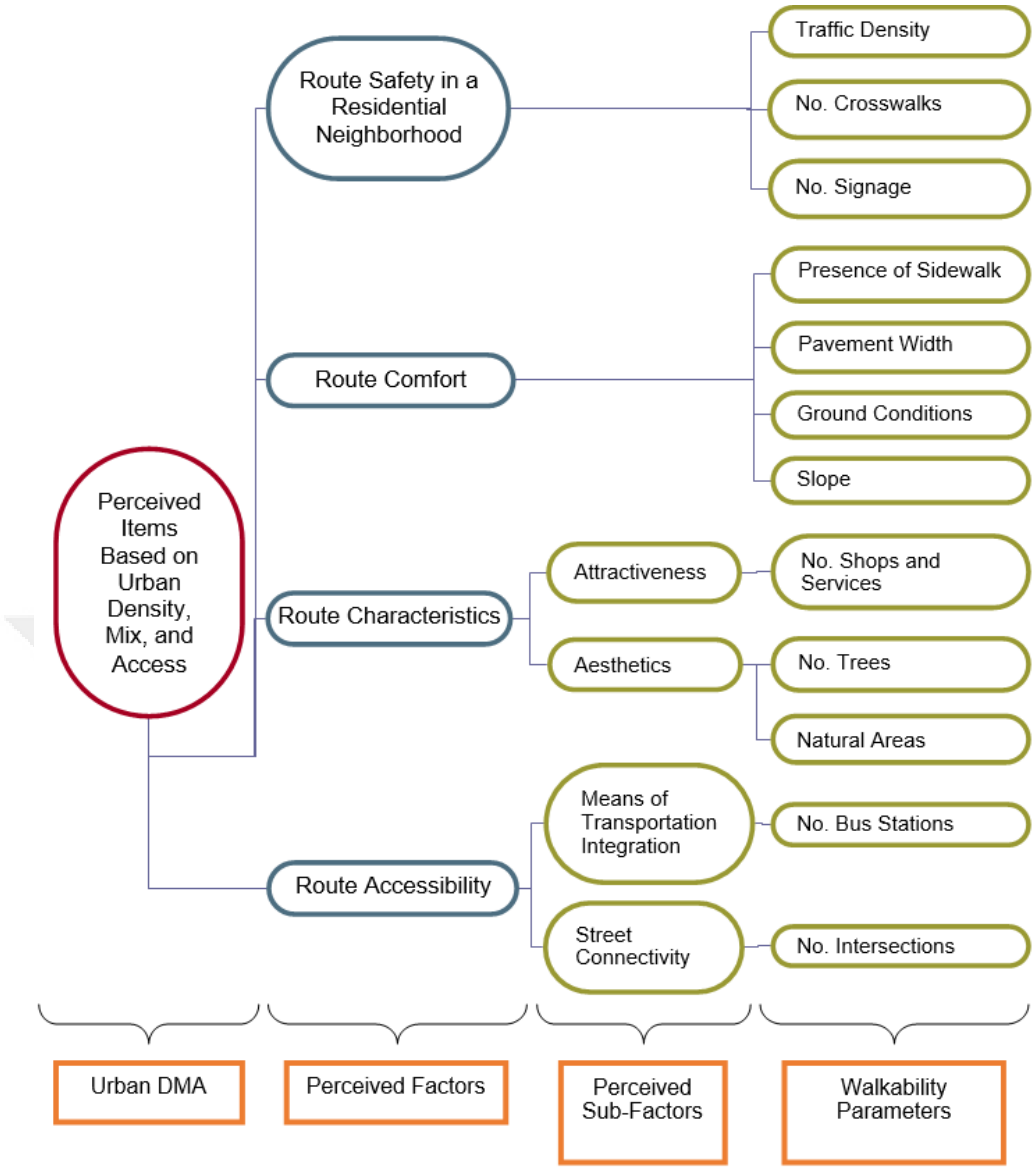


Figure 21. The Tree of Fundamental Parameters of Neighborhood Walkability (Drawn by the author, 2021).

5.2.2 Calculating the Walkability Parameters

The selected parameters were obtained and measured with various objective tools such as web mapping platforms and GIS software. A prevalent search was conducted to obtain the consistent and up-to-date data. The process was divided into acquiring raw data from web mapping platforms, processing it if necessary, then applying GIS software for visualization, and finally obtaining the usable data. Table 4 presents the selected parameters by name, description, measurement scale (quantitative or qualitative), and data source.

Table 4. Summary of Parameters (Adapted from Manzolli, Oliveira, and Neto, 2021)

Ref.	Criteria	Description	Unit	Source
w1	Vehicle Traffic Flow	Pedestrians' sense of safety while walking in the neighborhood, due to the presence of high vehicle traffic flow	High / Medium / Low	Google Street View
w2	No. Crosswalks	Number of crosswalks on the route	(# / km)	Google Street View
w3	No. Signage	Pedestrians' sense of safety due to the presence of signage (traffic signs, lights, and information posts)	(# / km)	Google Street View
w4	Presence of Sidewalk	Presence of sidewalk on the route	Y / N	Google Street View
w5	Ground Conditions	Quality of project, construction, and maintanance of the pavement	Good / Medium / Bad	Google Street View
w6	Pavement Width	Effective pavement width for walking	Wide / Medium / Narrow / Inexistent	QGIS (3.18)
w7	Slope	Inclination of the street	High / Medium / Flat	QGIS (3.18)
w8	No. Shops and Services	Number of shops and services on the route (bakeries, markets, pharmacies, restaurants, bars, etc.)	(# / m)	Google Street View
w9	No.Trees	Number of trees in the route area	(# / m²)	Google Street View
w10	Natural Areas	Presence of natural areas (parks, squares) in the route area	Y / N	Open Street Map
w11	No. Bus Stations	Number of bus stops on the route	(# / m)	Open Street Map
w12	No. Intersections	Number of intersections on the route	High / Medium / Low	Open Street Map

The quality thresholds of walkability (the parameters) are calculated by various tools and methods indicated below:

- **Traffic Density (W1):** This criterion measures the pedestrians' sense of safety related to the presence of high vehicle traffic flow. To assess it, data concerning the number of traffic congestions during rush hours (Between 8–11 a.m. and between 5–8 p.m.), provided by Google Maps Typical Traffic Flow, were analyzed. The qualitative scale represents the following measurements: High (if at least more than 75% of vehicle traffic flow data reported daily in a given period of time is traffic congestion), Medium (if at least 75% to 50% of vehicle traffic flow data reported daily in a given period of time is traffic congestion), Low (if less than 50% of vehicle traffic flow data reported daily in a given period of time is traffic congestion).

- **Number of Crosswalks (W2):** This quantitative criterion measures the pedestrians' sense of safety related to the number of crosswalks on the route per kilometer. Google Street View (n.d.) was used as an evaluation tool to measure the number of crosswalks. The data were divided by the length of each selected streets in order to normalize the results.

- **Number of Signage (W3):** This quantitative criterion measures the pedestrians' sense of safety due to the number of signage (e.g., traffic signs, traffic lights, and information posts) on the route per kilometer. To determine it, Google Street View was used as an evaluation tool to measure the number of signage. The data were divided by the length of each selected streets in order to normalize the results. (For Güvenlik street: 8 Traffic Lights, None Traffic Signs, and 28 Info Posts for pedestrians; for 2432nd Street: 10 Traffic Lights, 9 Traffic Signs, and 20 Info Posts for pedestrians).

- **Presence of Sidewalk (W4):** This binary qualitative criterion measures the pedestrians' sense of comfort and describes the presence or absence of pedestrian sidewalks for both of the selected streets. Google Street View was used as an evaluation tool to observe the existence of pavement.

• **Pavement Width (W5):** This quantitative criterion measures the pedestrians' sense of comfort related to the width dimension of the pavement. Jan Gehl (1987) designates personal interact distances as: (i) Intimate distance 0–0.45m, (ii) personal distance 0.45–1.37m, (iii) social distance 1.37–3.65m, and (iv) public distance 3.65m. On the other hand, in the conditions of COVID-19 pandemics, Glover believes that ideally the citizens of a city should be 'co-present' in public space (rather than using the term 'social distancing'), which means "occupying the same physical space at the same time but remain aloof or disinterested to stay unknown to each other intentionally" (2021, p.2). QGIS 3.18 (n.d.) software was used as an evaluation tool to measure the width of the pavements considering this criterion. The pavement layer is intersected with the street polygons layer and the area is computed. This value corresponds to the two pavements, and then it is divided by 2. This research assumes that the pavement resembles a parallelogram; therefore, the area was divided by the length of the street, to get an average width. The qualitative scale represents the following measurements: Wide (if the average width of pavement is more than 3.65m), Medium (if the average width of pavement is in between 1.37–3.65m), and Narrow (if the average width of pavement is equal or less than 1.37m, and Inexistent (if there is no pavement).

• **Ground Conditions (W6):** This qualitative criterion measures the pedestrians' sense of comfort related to the quality of the project, construction, and pavement maintenance. Google Street View was used to assess the sidewalk conditions.

• **Slope (W7):** This qualitative criterion evaluates the inclination of the route's pavement. To assess it, open data provided by the Google Earth Pro software concerning the inclination of the streets were used. The altitude value was added to the points corresponding to the ends of the street axes, and this information was attached to the line layer. The slope was then calculated as the difference in altitude divided by length. Finally, the mean value was obtained for each street. According to the code on *Accessibility Guide*, “any ramp gradient should be less than 1:12 (8%)” (Ministry of Family, Labor and Social Services of Turkey, General Directorate of Disabled and Elderly Services, 2021, p.23). The qualitative scale represents the following measurements: High (if the average slope of pavement is equal or more than 8%), Medium (if the average slope of pavement is in between 8%–6%), and Flat (if the average slope of pavement is less than 6%).

- **Number of Shops and Services (W8):** This criterion measures the attractiveness of the street by the number of commercial establishments (e.g., restaurants, cafes, bars or similar establishments, bakeries, pharmacies, markets, cinemas, theatres, etc.), public establishments (e.g., hospitals, police stations, post offices, etc.), and public amenities (e.g., playgrounds, museums, libraries, etc.) on each street per kilometer. To determine it, Google Street View was used as an evaluation tool to measure the number of shops and services. The data were divided by the length of each selected street to normalize the results. (For Güvenlik street: 139 commercial establishments, 11 public establishments, and 1 public amenity exist; for 2432nd Street: 91 commercial establishments, 1 public establishment, and 3 public amenities exist).

- **Number of Trees (W9):** This criterion measures the aesthetics of the street by number of trees on each street, divided by the route area. The trees adjacent to or on the pavements counted only. 2432nd street is a two way street and the trees in the median part of the street, where there was no pavement, were excluded. Google Street View was used as a support tool to assess and manipulate the data.

- **Presence of Natural Areas (W10):** This binary qualitative criterion (if they do exist or not in the route area) measures the aesthetics of the street by the presence of natural areas (mainly parks and squares) in the selected streets. To determine it, Open Street Map (n.d.) was used as a support tool.

- **Number of Bus Stops (W11):** This quantitative criterion measures means of transportation integration by showing the presence of bus stops on the route. To determine it, the data were divided by the length of each selected streets in order to normalize the results. Open Street Map (n.d.) was used as a support tool.

- **Number of Intersections (W12):** This quantitative criterion measures street connectivity by the number of intersections on the route per kilometer. Open Street Map (n.d.) was used as an evaluation tool to measure the number of intersections. The data were divided by the length of each selected streets in order to normalize the results. "Jane Jacobs suggested a maximum block length of about 120m to ensure an effective pedestrian network" (Dovey and Pafka, 2020, p.57). In this context, the qualitative scale represents the following measurements: High (if number of intersections are more than 27 in 1600mt), Medium (if number of intersections are in between 13 and 27 in 1600mt), and Low (if number of intersections are equal or less than 13 in 1600mt).

The walkability parameter calculation results for Güvenlik Street and 2432nd Street are listed in Table 5. The data obtained from these calculations were used in Multi-Criteria Decision-Making analysis for the ranking of both case streets.

Table 5. Data acquired to perform the MCDM study.

Ref.	Güvenlik Street - Ayrancı Neighborhood	2432nd Street - Çayyolu Neighborhood
w1	High	Medium
w2	0,625	6,25

Table 5. (Cont'd)

Ref.	Güvenlik Street - Ayrancı Neighborhood	2432nd Street - Çayyolu Neighborhood
w3	22,5	24,37
w4	Y	Y
w5	Medium	Good
w6	Medium	Wide
w7	Medium	Flat
w8	94,37	59,37
w9	0,03	0,03
w10	Y	Y
w11	3,12	3,12
w12	Medium	Medium

5.2.3 Representing the Visual PROMETHEE

In this chapter, the outcomes of the MCDM analysis is presented and discussed. The PROMETHEE II method was selected as the supporting tool to assess the case streets' walkability ranking and applied in this work. For all data used, the weights are equal and the preference functions for all parameters are set up as "Usual" (see Appendix E). This step was taken in order to avoid any discrepancy in the results. Nevertheless, some decision makers could perform the analysis, varying the preference functions and weights in order to design different analysis scenarios. The study outcomes are presented in three visualizations: ranking flow table, PROMETHEE Diamond, and PROMETHEE Rainbow. Table 6 presented below introduces the positive, negative, and complete outranking flow scores of the analysis.

Table 6. The PROMETHEE **complete** flow table results for the case study.

Ranking	Action	φ	$\varphi+$	$\varphi-$
1	2432nd Street	0,4167	0,5	0,0833
2	Güvenlik Street	-0,4167	0,0833	0,5

Figure 22 presents the PROMETHEE Diamond representation of the results. In the visualization, the points in the ($\varphi+$, $\varphi-$) plane represent each of the alternatives analyzed. The plane is angled at 45º degrees so that the vertical dimension (green-red axis) corresponds to the φ net flow.

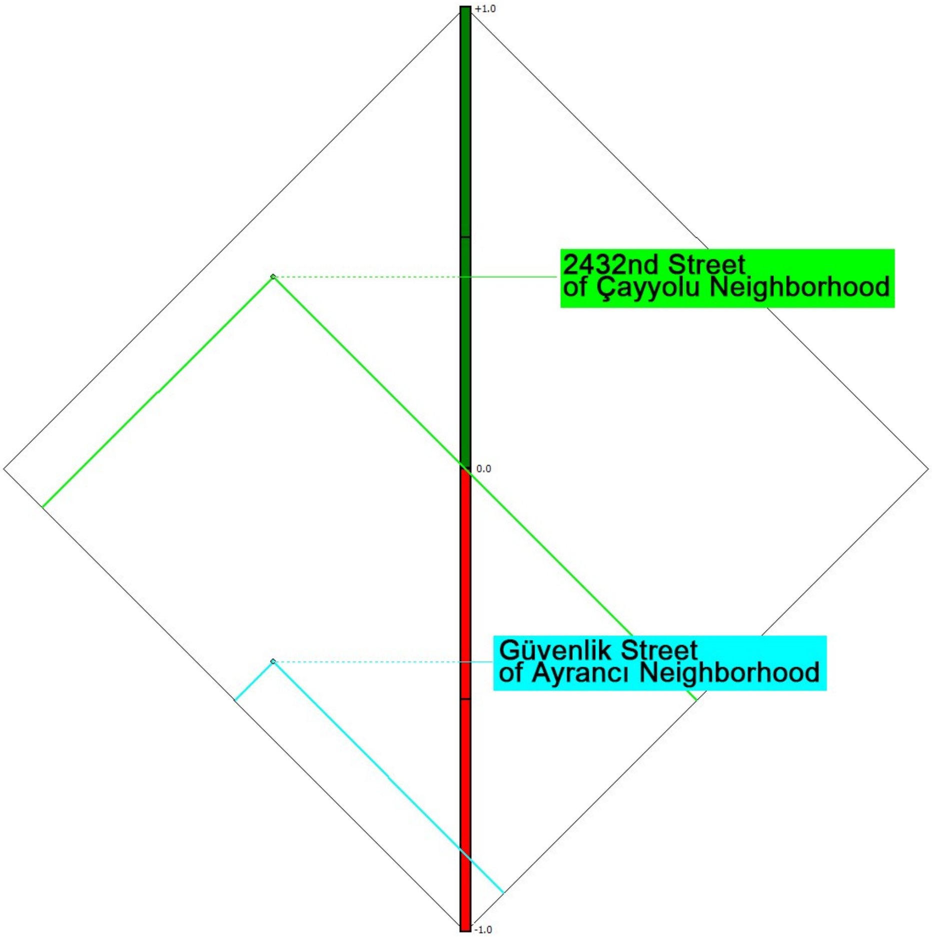


Figure 22. PROMETHEE Diamond representation of the case study's results.

The cone drawn for each alternative represents the outranking or incomparability relationships between the alternatives. If the cone overlaps another one, it means that the overlapping cone is preferred. Intersecting cones correspond to alternatives that cannot be compared. For instance, the '2432nd Street of Çayyolu Neighborhood' (Green cone) alternative is preferred to 'Güvenlik Street of Ayrancı Neighborhood' (Blue cone), which is the poorest alternative. Their comparison is clear and no incomparability in this representation.

Figure 23 displays the PROMETHEE Rainbow representation of the results. This type of visualization enables the decision maker to notice the strengths and weaknesses of an alternative. Each bar has different colored slices that represent the different parameters of the alternatives. The slices are proportional to the contribution of each criterion (flow value times the weight of the criterion) to the φ net flow score of the action. The bar's upper end corresponds to good parameters evaluation, while the lower end corresponds to weaknesses. For instance, the alternative '2432nd Street' presents 11 strengths and only 1 weakness. On the other hand, 'Güvenlik Street' presents six weaknesses and six strengths. The results concerning strengths and weaknesses of the best alternative (2432nd Street) and the poor alternative (Güvenlik Street) are discussed later in the Chapter 6.

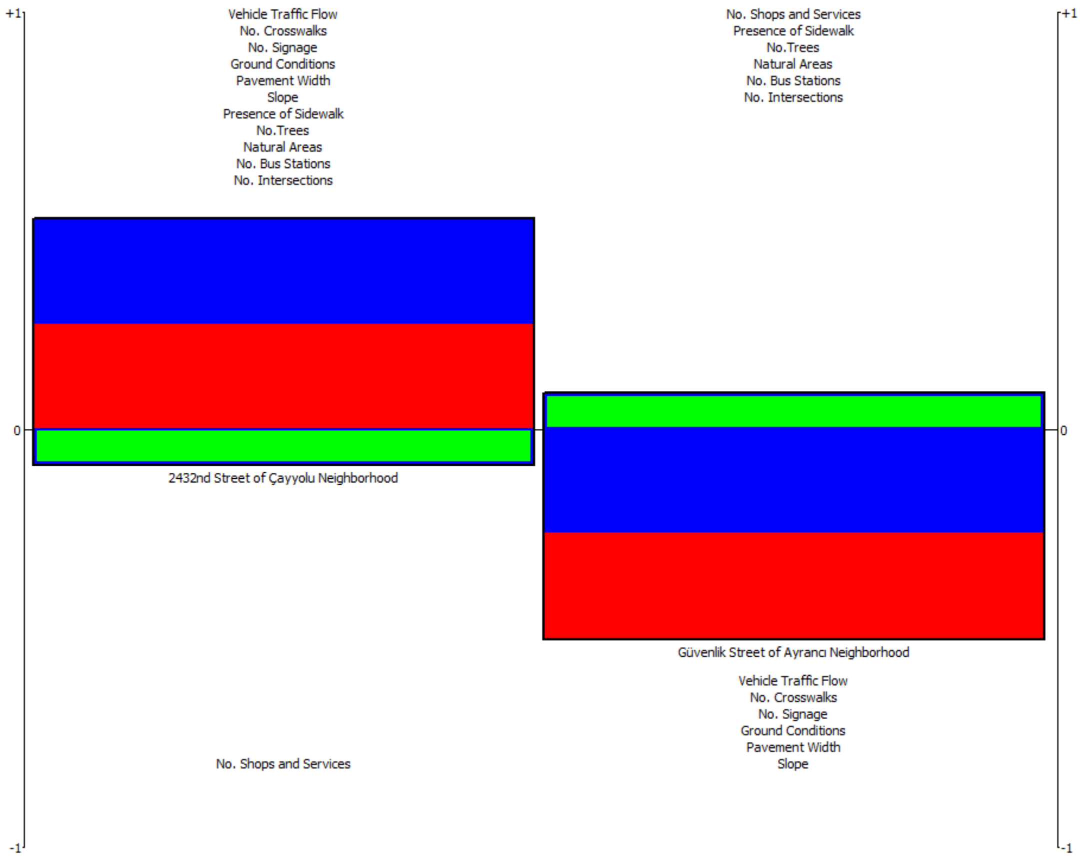


Figure 23. PROMETHEE Rainbow representation of the case study's results.

5.3 Stage III: Resulting Street Walking Quality Maps

This phase of the study finds an answer to Research Question 4 in this dissertation. Mapping techniques were used in order to see if there are any similarities/differences of walkability values between the case neighborhoods and their main streets. Streetwalking quality maps are formed based on four mappable walkability parameters. Then, all those criteria maps were transformed into raster images as walkability maps to compare the walkability values of both cases of urban residential neighborhoods.

For resulting street walking quality maps, first, the walkability study scale was determined. 400m was considered as a buffer walking distance scale. It is a distance, which the majority, including young children and the elderly, could walk in 5 to 10 minutes (Duncan et al., 2011; Hinckson et al., 2017; Steinmetz-Wood and Kestens, 2015). The street routes considered as the center axis lines of the measurement. However, the total lengths of Güvenlik Street of Ayrancı Neighborhood and 2432nd Street of Çayyolu Neighborhood, which are the case study areas, are different from each other. The proposal of this study is to accept the Güvenlik Street length, which is the shortest total length between the two streets, as the study limit distance for the 2432nd Street too. In order to determine the total area to be measured, length of Güvenlik Street, which is 1600m, was taken as the basis measure and three virtual circles with a diameter of 400m were intersected on this axis. Google Earth Pro application was used for this. Same method was used for 2432nd Street too (See Figure 24 and Figure 25).

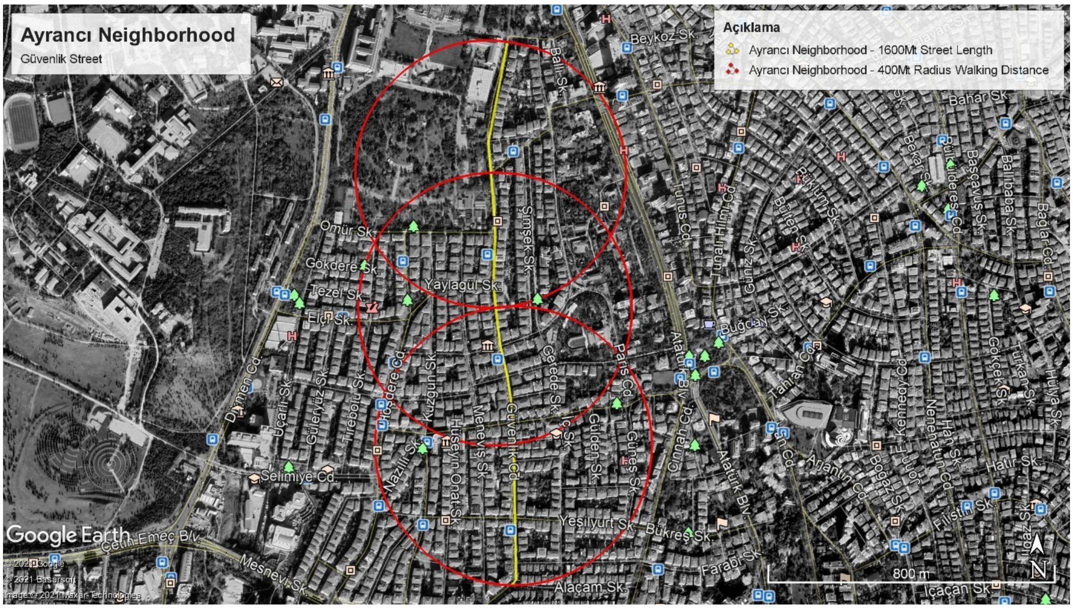


Figure 24. Display of 400m diameter virtual walking limits for Güvenlik Street (Google Earth Pro).

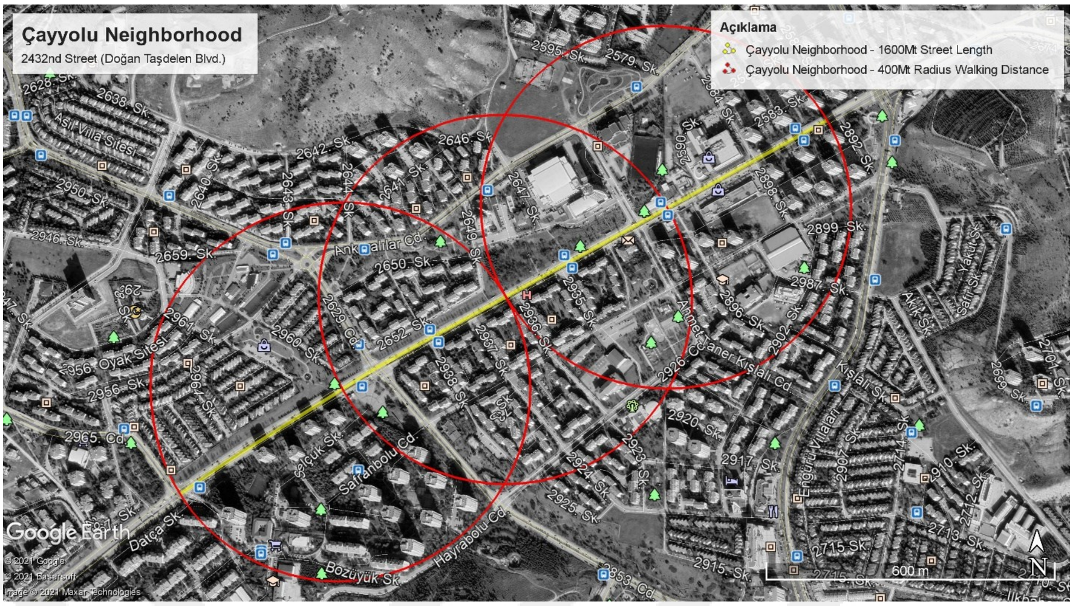


Figure 25. Display of 400m diameter virtual walking limits for 2432nd Street (Google Earth Pro).

These virtual circle boundaries do not actually indicate the actual walkable distance. Because street and building block layouts actually change these 5-minute walking distances. To measure this, web-based Pedestrian Catch (White and Kimm, 2016) application was used. This application creates a map data by making a 2D simulation of real walkable distances depending on the time and walking speed. Accordingly, the center points of the three virtual circles were marked on both streets in the Pedestrian Catch application. Walking limit data were generated by setting the walking speed as the average adult human walking speed of 1.33m/s, the walking time as 5 minutes, and the offset buffer as 25m (See Figure 26 and Figure 27). In the diagrams, the first border around the focal points (the yellow dots) represents a 1-minute walk, the second border a 3-minute walk, and the last border a 5-minute walk.

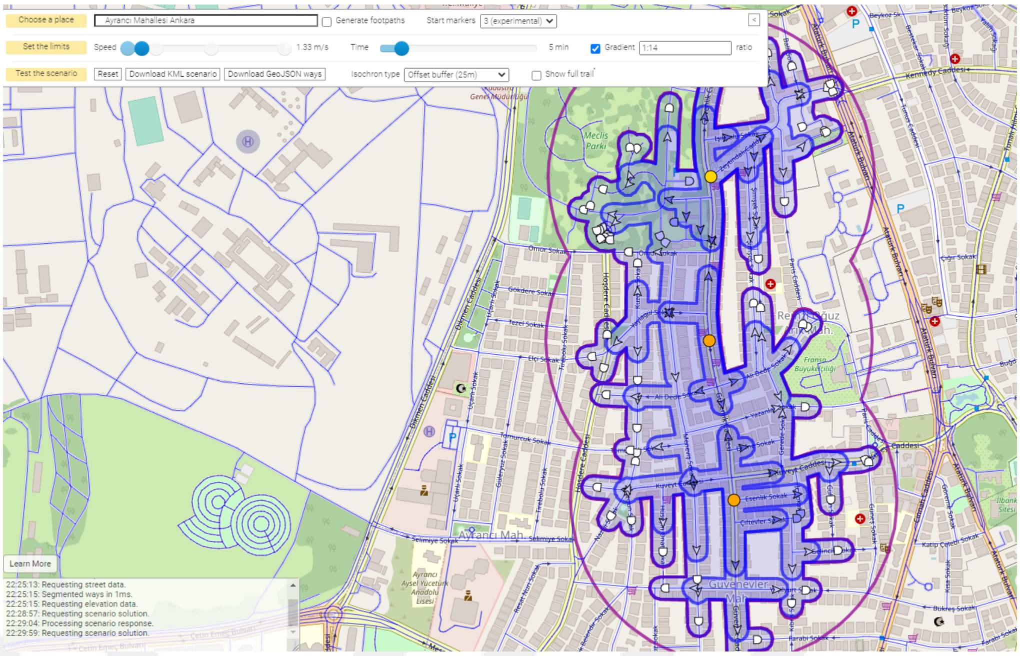


Figure 26. Display of actual walking limits of 5 minutes for Güvenlik Street prepared with Pedestrian Catch (White and Kim, 2016).

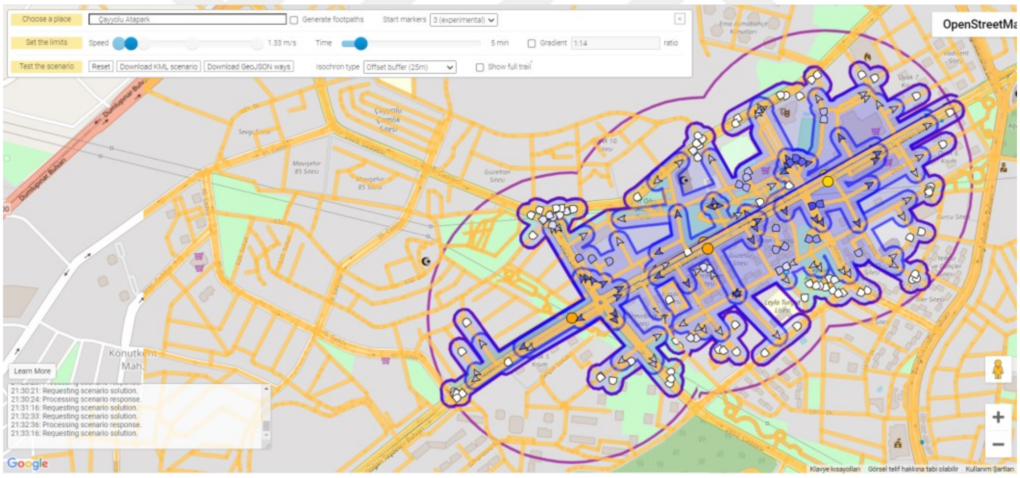


Figure 27. Display of actual walking limits of 5 minutes for 2432nd Street prepared with Pedestrian Catch (White and Kim, 2016).

The street walking quality maps showing the changing values of walkability parameters (Traffic density map, pavement width map, number of facilities by street length map, and number of intersections by street length map) are prepared with QGIS software (Version 3.18). The walkability parameters data were obtained by various digitalized geospatial sources. Although there are 12 walkability parameters in the list, some factors have been discarded for a variety of reasons. For example, binary parameters were excluded starting with the sentence “presence of...” (W4 and W10), because its data have no use in the mapping software. The number of signage and crosswalks (W2 and W3) were thought to be related to the number of intersections parameter as a route design characteristic and eliminated. Ground conditions (W5) and the number of trees (W9) have not been included, since they are not available in the GIS layer. Slope (W7) data of case streets were obtained through Google Earth Pro software. However, the neighborhood slope data were not available in the GIS layer either. The number of bus stops (W11) data was only meaningful on Güvenlik Street and 2432nd Street, since there were no bus stops on the smaller streets in the case neighborhoods other than those main streets. Therefore, this parameter was discarded too.

For visualizing the obtained data, each street was drawn as polygons, and each ranking value was colored separately. All vector polygons were then transformed into 1m by 1m resolution raster images for walkability parameter maps by using QGIS (Version 3.18) software. For a final evaluation of the walkability of the case neighborhoods, all parameters raster image maps were superimposed by using QGIS (Version 3.18) software.

In the ranking of parameters (1 to 3), as indicated in Table 7, 1 point was accepted as the most positive value for the traffic density. The denser the traffic, the slower it is. Slow traffic flow is safer for the pedestrians; hence, it is more preferable for the walkability of the residential neighborhood (See Figure 28 and Figure 29).

Table 7. Ranking Scale for Traffic Density.

Traffic Density				
Value	**Points**	**Value Range**	**Unit**	**Color**
High	1	>3609	No. Incidents	
Medium	2	1804-3609	No. Incidents	
Low	3	<1804	No. Incidents	

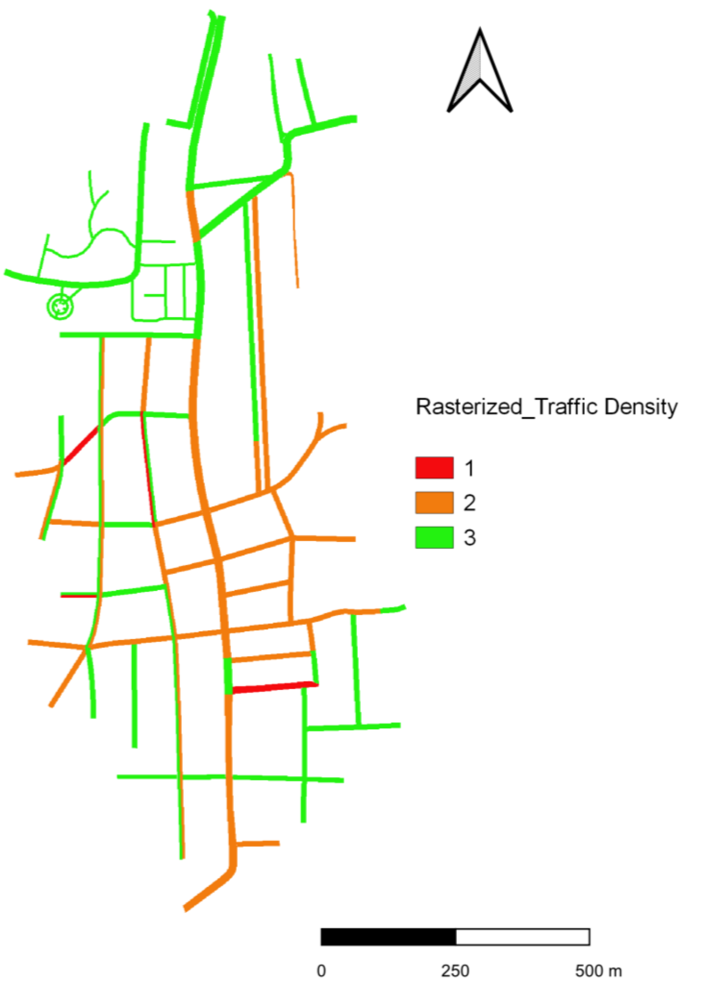


Figure 28. Traffic Density Map of Ayrancı Neighborhood (Drawn by the author).

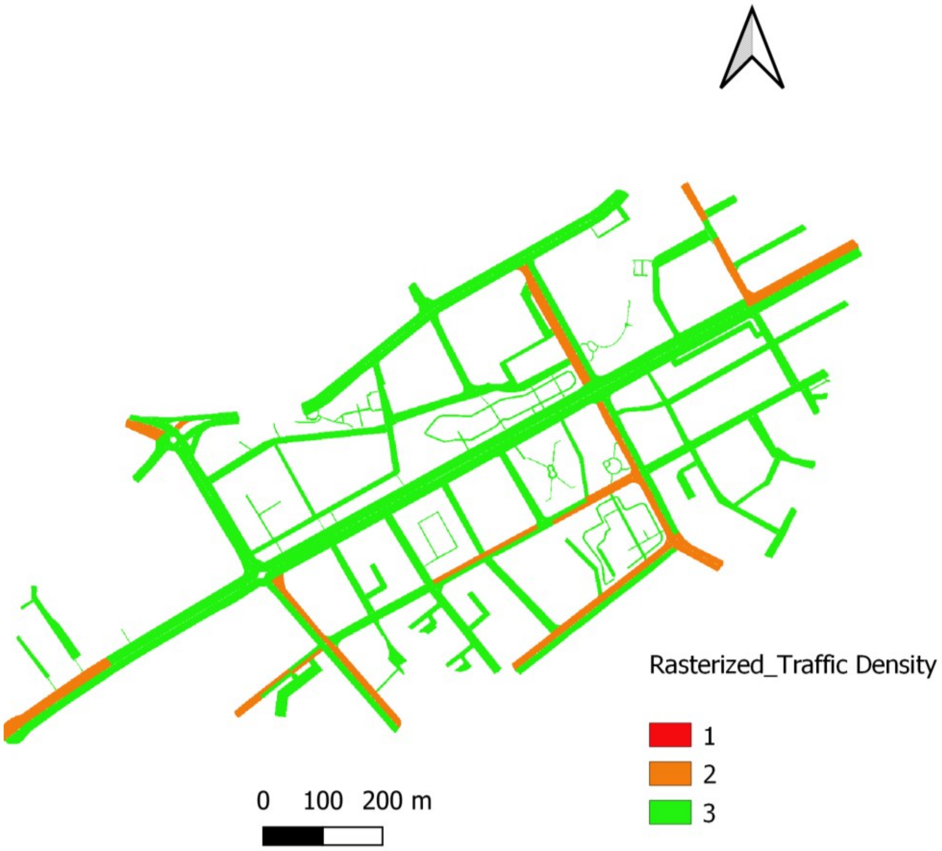


Figure 29. Traffic Density Map of Çayyolu Neighborhood (Drawn by the author).

In the ranking of parameters (1 to 3), as indicated in Table 8, 1 point was accepted as the most positive value for the pavement width as indicated in Table 8. The wider the pavement, the healthier and the more comfortable for co-presence of the pedestrians in the conditions of COVID-19 pandemics. Wider pavement is preferable for the walkability of the residential neighborhood (See Figure 30 and Figure 31).

Table 8. Ranking Scale for Pavement Width.

Pavement Width				
Value	**Points**	**Value Range**	**Unit**	**Color**
Wide	1	>3,65	m	
Medium	2	1,37-3,65	m	
Narrow	3	<1,37	m	

Figure 30. Pavement Width Map of Ayrancı Neighborhood (Drawn by the author).

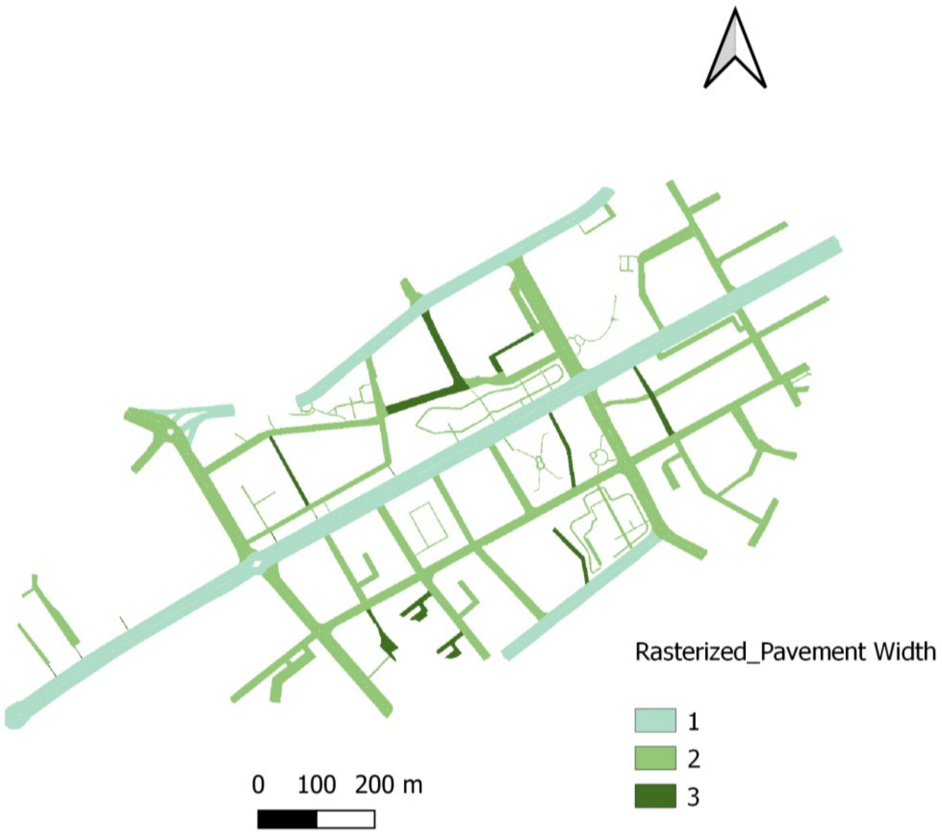


Figure 31. Pavement Width Map of Çayyolu Neighborhood (Drawn by the author).

In the ranking of parameters (1 to 3), as indicated in Table 9, 1 point was accepted as the most positive value for the number of shops and services (See table 9). The more the number of commercial establishments and public amenities at an accessible distance, the more reason for the residents to go out for a walk in the neighborhood (See Figure 32 and Figure 33).

Table 9. Ranking Scale for Number of Shops and Services.

Number of Shops and Services				
Value	**Points**	**Value Range**	**Unit**	**Color**
High	1	>70	Shops/km	
Moderate	2	70_30	Shops/km	
Low	3	<30	Shops/km	

Figure 32. Number of Shops and Services Map of Ayrancı Neighborhood (Drawn by the author).

Figure 33. Number of Shops and Services Map of Çayyolu Neighborhood (Drawn by the author).

In the ranking of parameters (1 to 3), as indicated in Table 10, 1 point was accepted as the most positive value for the number of intersections per case street length. 120m was accepted as the maximum block length measure to ensure an effective pedestrian network. All the case street lengths were divided into 120m, 90m, and 60m block lengths to obtain value ranges for each street. The more intersections, the more accessible and permeable the residential neighborhood is. More permeability is preferable for walkability (See Figure 34 and Figure 35).

Table 10. Ranking Scale for Intersections.

Number of Intersections				
Value	**Points**	**Value Range**	**Unit**	**Color**
High	1	>27	Inters./1600m	
Medium	2	27_13	Inters./1600m	
Low	3	<13	Inters./1600m	

Figure 34. Number of Intersections Map of Ayrancı Neighborhood (Drawn by the author).

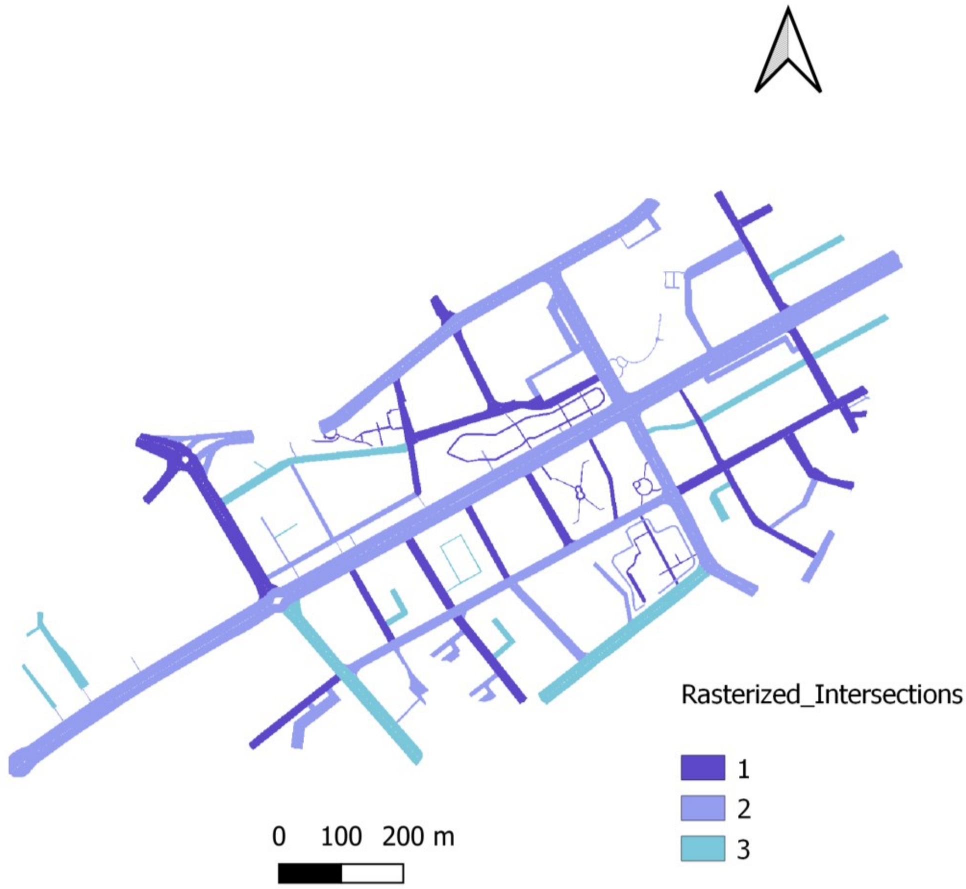


Figure 35. Number of Intersections Map of Çayyolu Neighborhood (Drawn by the author).

For the overall evaluation of the walkability of the case neighborhoods, multi-criteria weighted overlay analysis was done by using QGIS (Version 3.18) software.

All walkability parameters (The traffic density, the pavement width, the number of shops and services, and the number of intersections) are weighted equally (multiplied by 0.25). and their maps are superimposed. Figure 38 shows the raster calculations screen in QGIS (Version 3.18) software. In the ranking parameters (1.5 to 2.75), 1.5 point was accepted as the most positive value for the walkability of the neighborhood as indicated in Table 11. As a result, the new overlay maps reveal the suitable walkable portions of the neighborhoods (See Figure 36 and Figure 37).

Table 11. Ranking Scale for Multi Criteria Overlay Analysis for Walkability.

Multi Criteria Overlay Analysis			
Value	**Points**	**Unit**	**Color**
Excellent	1,5	points/m²	
Very Good	1,75	points/m²	
Good	2	points/m²	
Average	2,25	points/m²	
Poor	2,5	points/m²	
Very Poor	2,75	points/m²	

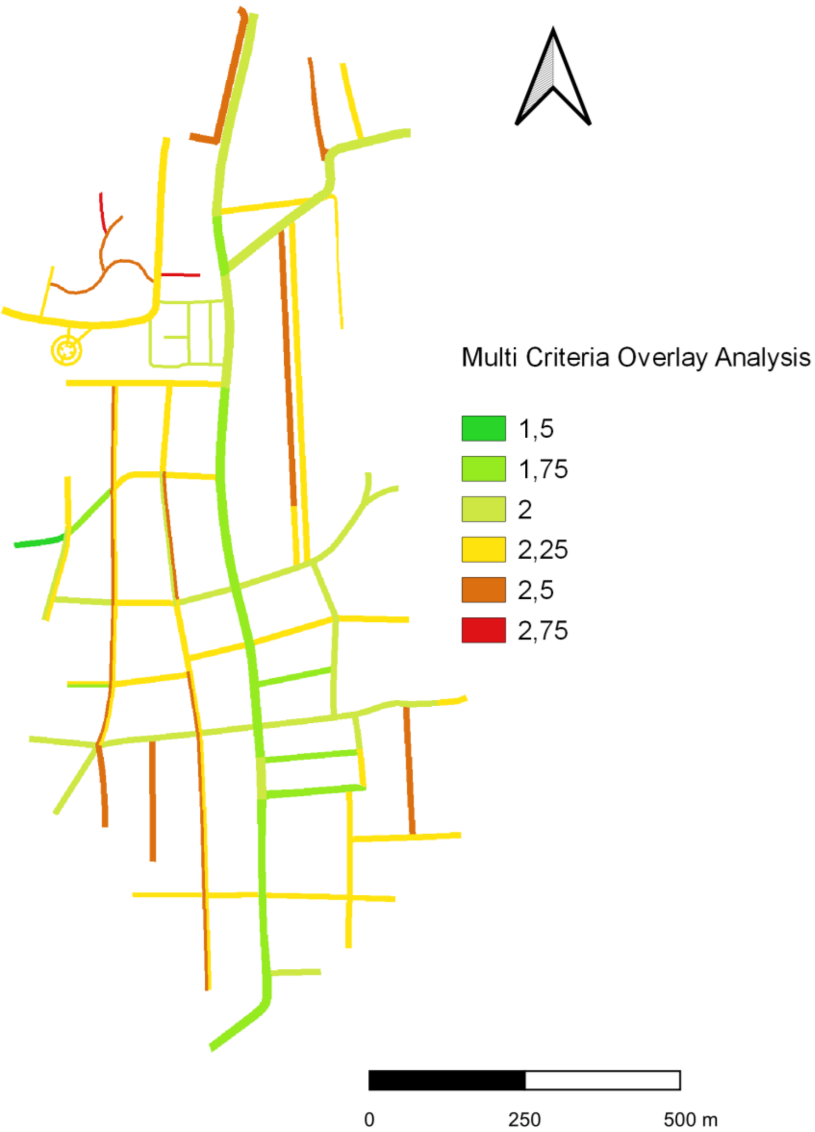


Figure 36. Multi Criteria Overlay Walkability Analysis Map of Ayrancı Neighborhood (Drawn by the author).

Figure 37. Multi Criteria Overlay Walkability Analysis Map of Çayyolu Neighborhood (Drawn by the author).

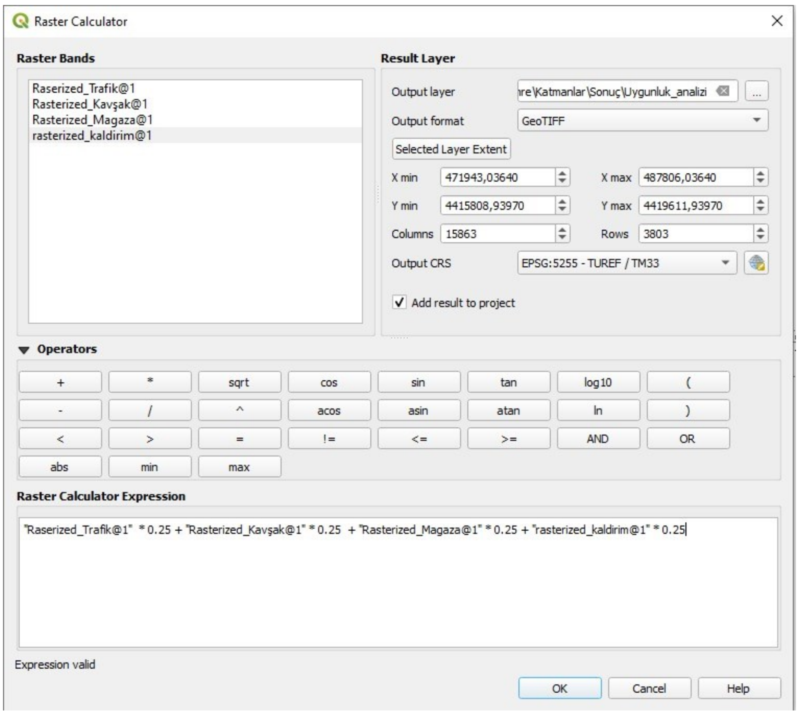


Figure 38. Screenshot of Raster Calculator Tool in QGIS (Version 3.18) Software.

CHAPTER 6

DISCUSSION: COMPARATIVE ANALYSIS OF PERCEIVED AND OBJECTIVELY MEASURED WALKABILITY

6.1 Methodological Discussion

The results of the preliminary study (Seles and Afacan, 2019) showed that subjective norms with perceived behavioral control had indirect effects and the healthy urban performance had independent and direct effects on walking behavior. It was worth considering in the study to analyze perceived neighborhood walkability and objectively measured walkability.

A bottom-up approach for analyzing the walkability of the residential neighborhoods looks appropriate. The perceived walkability factors showed that the citizens gave value to urban and environmental factors that influence the walkability of places, thus the set of urban citizens' capability (Fancello, Congiu, and Tsoukiàs, 2020). In addition, walkability should not be seen as an index where objectively determined criteria come together. Walkability should be seen as an integrity and urban capacity that creates its own variable parameters according to perceived conditions. In this way, it can open the door to more creative analysis and local solutions such as enhancers and impediments to walking in the city. The assemblage of key urban walkability attributes (Density, Mix, and Access) interacted with one another to yield the perceived walkability factors that have properties of their own (developed walkability parameters); these properties are irreducible to the properties of an index. Because Exploratory Factor Analysis showed that perceived walkability factors are relational and contextual. A combination of known factors gave rise to new perceived factors that form new assemblage diagrams and maps. These maps are heterogeneous, deterritorialized, and virtual, which shows the existence of transformations, dispositions, and capacities (DeLanda, 2016). The developed perceived walkability parameters derived from the exploratory factor analysis provided fruitful results for both MCDM Analysis and Multi-Criteria Overlay Walkability Maps.

6.2 Perceived Design Factors

This study puts the necessity of developed perceived factors for walkability derived from the neighborhood residents. The unstructured urban Density, Mixed-use, and Accessibility questionnaire items were assembled and with the exploratory factor analysis, perceived factors of the case areas were identified.

For the road safety factor, if a neighborhood provides a healthy and pleasant environment for walking, the user perceives it as a safe place. Because safety is a contextual parameter. If that neighborhood provides alternative routes and if it is hard to get lost, it supports the safety feeling. For example, if the lighting is inadequate for a road at night, knowing that there is an alternative route for reaching a target increases the perceived sense of security. For a vital neighborhood, the buildings being close to the street and providing various services like cafes, markets, restaurants, and cultural venues is necessary. Moreover, that means surveillance and feeling safe by being watched by others at day and night time at street level as Jane Jacobs puts it (1961). The survey items grouped under this factor show that this nomenclature is correct.

For the route comfort factor, the presence of the sidewalk and its width are important parameters. In the conditions of COVID-19 pandemics, people prefer wider sidewalks and open spaces for a healthier walking experience while keeping the physical distance. Barbarossa claims that “the challenge is to guarantee a new ‘right to the city’, which encompasses essential services, as well as a different way of life that is adapted to the new health crisis” (2020, p.2). Rather than being socially distant, users should have a vital pedestrian flow yet co-present in public space, which means occupying the same sidewalk at the same time, but remain apart (Glover, 2021). A sidewalk should provide this for a pleasant and safe walk in terms of health and vitality. According to these arguments, the survey items grouped under this factor show that this nomenclature is correct.

For the route characteristics factor, availability of mixed-use of residence, work, education, shopping, and entertainment facilities are important. Residential neighborhoods whether in the city center or not, urban characteristics, which provide social and cultural venues for a vital public life motivate people for walking. Jane Jacobs (1961) was saying in the 1960s, “downtown is for people”. However, when we look at the case neighborhoods today, Çayyolu Neighborhood has urban characteristics although it is far from the city center and its main street is more walkable than Güvenlik Street at the city center. The survey items grouped under this factor show that this nomenclature is correct.

For the route accessibility factor, permeability and number of intersections are important parameters. Although the existence of traffic signs and pedestrian crossings are related to safety, these signs also indicate the existence of intersections. Users perceive their neighborhood as more walkable if they reach their target more quickly (Frank et al., 2005). Permeability provides the users to know their environment better and perceive their neighborhood as more walkable (Koohsari et al., 2014). Covid 19 pandemics conditions, unfortunately, direct people to more automobile usage and online shopping if they perceive the environment less permeable to reach their needs. Hence, the survey items grouped under this factor show that this nomenclature is correct.

For the route attractiveness factor, availability of mixed-use of residence, work, education, shopping, and entertainment facilities are parts of urban characteristics of a neighborhood also. Hence, this factor was thought of as a sub-factor of walkability under route characteristics. The survey items grouped under this factor show that this nomenclature is also correct.

The findings in Stage 1 of the study showing that the perceived walkability factors are almost similar for urban and for newly developed urban case neighborhoods. However, while the “route comfort” factor has a higher eigenvalue (3,203) for Güvenlik Street, and it has a lower value (2,754) for 2432nd Street. A pleasant and safe walk in terms of health and providing vitality at the same time seems to gain more importance in terms of the urban users’ perception of walkability in Güvenlik Street. Decision-makers and city planners can make an improvement in the comfort of the route by considering the importance of the perception of this factor.

Moreover, while the “route characteristics” factor has a higher eigenvalue (2,989) for 2432nd Street, and it has a lower eigenvalue (2,205) for Güvenlik Street. Availability of mixed-use of residence, work, education, shopping, and entertainment facilities seem to gain more importance in terms of the urban users’ perception of walkability in 2432nd Street. Decision-makers and city planners can make improvements in attractiveness and aesthetics of the route by considering the importance of the perception of this factor. This is a significant difference between the perceived walkability factors for urban and newly developed urban neighborhoods; therefore, Hypothesis 1 is supported.

Jane Jacobs’ (1961) conditions for urban vitality, including land use mix, density, small block size, building age, accessibility, and attractiveness are objective parameters for a walkable built environment (Dovey and Pafka, 2020). Generally, urban neighborhoods seem more advantageous for obtaining these parameters rather than newly developed urban areas in that manner. A comparative analysis was done for the case areas of this study. The Multi-Criteria Decision-Making analysis findings in Stage 2 of the study showing that the newly developed urban 2432nd Street in Çayyolu

Neighborhood is much preferable for a walkable environment than the urban Güvenlik Street in Ayrancı Neighborhood. The reason is especially the main axis where 2432nd Street exists has been urbanized since the 90s till today and gated housing enclaves are shifted to the far south-west of the Çayyolu Neighborhood. Although the number of shops and amenities is less than Güvenlik Street, 2432nd Street meets more objective walkability parameters, including the vehicle traffic flow, the number of crosswalks, the number of signage, the ground conditions, the pavement width, and the slope.

Jane Jacobs' (1961) approach to urban vitality is still valuable for a healthier urban life and the wellbeing of people even in the conditions of COVID-19 pandemics. According to Glover, "limiting mobility, restricting people to isolate at home, and keeping them from seeing their family and friends in person can have damaging health consequences, for meaningful social ties and the support they provide boost our wellbeing in tremendous ways" (2020, p.3). People should walk outside, co-present and interact with each other, and reach services that are within 15-20 minutes walking distance in a healthy, safe, and accessible way. City planners and decision-makers should make inclusive improvements considering the vulnerable groups with an awareness of age and ability effect on walkability. Because, pandemics and lock-downs prevented the co-presence of senior adults, young children, and people with disabilities walking outside with the rest of the neighborhood population.

6.3 Objectively Measured Design Parameters

Moreover, the perceived walkability factors are also assemblages that have properties of their own. These properties are the developed walkability parameters that can be measured objectively. New perceived walkability factors are significantly related to measured walkability parameters; therefore, Hypothesis 2 of the study is supported.

The walkability parameter maps of the neighborhoods in 5 minutes walking buffer area around the case street axes represent a significant difference in terms of the number of shops and services. In Çayyolu Neighborhood, it is disadvantageous to have a poor number of services and amenities when you get farther from 2432nd Street. On the contrary, the shops and services are well spread with higher quantity around Ayrancı Neighborhood.

The traffic density data were retrieved from Google Maps for the traffic density maps. 'The speed-density relationship is linear with a negative slope; therefore, as the density increases the speed of the roadway decreases' (Wikipedia, 2021, May 29). As represented in the maps, low density means faster traffic flow and results in less safety for the pedestrians. Hence, Ayrancı Neighborhood around Güvenlik Street is preferable in terms of safety parameter of walkability. However, denser traffic causes more exhaust gas emissions, which threatens a healthy walking experience. In comparison, the intersection maps and pavement width maps of both case neighborhoods show no significant difference.

In street scale, there is a strong relation between Multi-criteria Decision-Making (MCDM) analysis results and walkability parameter maps. In neighborhood scale, the multiple walkability weighted criteria overlay maps represent different characteristics when case neighborhoods are compared. Although the slope of Güvenlik Street is disadvantageous compared to 2432nd Street, other parameter maps of Ayrancı Neighborhood represent a more walkable environment than Çayyolu Neighborhood. Hence, Hypothesis 3 is not supported. This indicates that sometimes popular and vital-looking streets mask the actual vitality and walkability of the residential neighborhoods settled around those main streets.

CHAPTER 7

CONCLUSION

In conclusion, first, a summary of the research is presented to remind the main points. Next, the contributions of the study are listed in detail. Moreover, a guideline for analyzing a walkable residential neighborhood is suggested in this part. Then, the limitations of the research about the methods and tools used are explained. Finally, further research is recommended to highlight possible contributions to the dissertation.

7.1 Summary of the Dissertation

From the second half of the 20th century, public and urban research gained momentum. Because the effects of global warming and intense population growth in cities have adversely affected urban life and moved away from being sustainable. At this point, the concepts of active transportation methods and the walkability of cities have become a popular topic of interest in these public studies and urban planning.

In a defined context, this study evaluates the design factors of the walkability of residential neighborhoods. The study focuses on both the urban residential neighborhoods and the newly developed urban residential neighborhoods. Because it wonders the effect of user's perception and routines on walkability, design factors in different urban settings. In relation with research questions "How do urban key design aspects (Density, Mixed-use, and Accessibility) influence the perception of walkability in an urban and a newly developed urban residential neighborhood in a metropolitan city?", "Can there be a set of developed parameters and attributes for an urban main street in a residential neighborhood based on the idea of perceived walkability as an urban capacity?", and "What is the relationship between perceived and measured walkability in an urban and a newly developed urban residential neighborhood in a metropolitan city?" have been answered in a different context. Perceived walkability factors by diverse users for urban and newly developed urban residential neighborhoods of the city of Ankara were explored and their walkability factor differences and similarities were compared.

The literature review examined the conditional and contextual factors of walkability requiring multiple analyzing methods. Methodological characteristics of the studies on walkability are investigated in detail. The study structure was formed in relevance to these characteristics.

Fieldworks, observations, and questionnaires are primary sources of the study in addition to obtained data from related institutions. In the scope of field studies, extensive and intensive surveys are completed to define the structural conditions of the site, to analyze the main streets and surrounding residential neighborhoods, to evaluate user's profiles and their walkability perceptions. A questionnaire based on the key walkability attributes (including urban DMA items) was implemented in case study areas to get perceptions of pedestrians in Ayrancı Neighborhood and Çayyolu Neighborhood of Ankara, Turkey. Those perceived walkability factors are obtained and identified by using the Exploratory Factor Analysis tool (SPSS, Version 26).

The relationships between perceived walkability factors and a set of developed walkability parameters were investigated. The selected urban and newly developed urban streets from highest to poorest quality, based on the developed walkability parameters were ranked by using a Multi-Criteria Decision Making analysis tool (Visual PROMETHEE).

At last but not the least, a set of walking quality maps for both of the selected urban and newly developed urban neighborhoods of the city of Ankara based on the selected walkability parameters were provided by using a Geographical Information Systems (GIS) spatial analysis tool (QGIS, Version 3.18).

Because of these sets of analyses the effect of user's perception and routines on walkability design factors in Ayrancı Neighborhood and Çayyolu Neighborhood were compared and their developed parameters were measured, tested, and represented on walkability maps.

7.2 The Contributions of the Study

The main objective and contribution of this study to the literature in this field is to propose a mixed method for analyzing the walkability of urban and newly developed urban residential neighborhoods in a metropolitan city. None of the studies combined the Exploratory Factor Analysis, MCDM Analysis, and the Multi-Criteria Overlay Walkability Maps as a mixed walkability analyzing method before.

The study also documented the urban and newly developed urban neighborhoods of Ankara in terms of walkability characteristics. Although there is a lack of inadequacy of urban development databases in Turkey at all, most of the walkability parameters data were produced specifically for this study for the case neighborhoods.

This dissertation is one of the academic researches that contribute to the creation and transformation of sustainable, healthy, slow, and inclusive cities that member countries should fulfill as part of the United Nations' contingency plan to combat global warming. Lastly, this study nonetheless argues that the results of the qualitative and quantitative analysis show potential as an innovative exploratory analysis tool for further researches and implications. Based on the qualitative and quantitative results, this study suggests some walkability analysis guidelines as presented in Table 12, that will lead to better design solutions for city planners and decision-makers and will be helpful to develop a walkable residential neighborhood.

Table 12. Guidelines for Analyzing a Walkable Residential Neighborhood.

Guidelines	
1.	The analysis should examine the internal relationships and the synergies between the variables of a walkable built environment.
2.	The analysis should compare and compile walkability major / sub-factors through relevant literature.
3.	The analysis should consider walkability as an assemblage and seek for perceived walkability factors.
4.	The analysis should weight perceived walkability factors in terms of user preferences.
5.	The analysis should consider developed walkability parameters based on perceived walkability factors first for the objective measuring.
6.	The analysis should enable the decision-maker to notice the strengths and weaknesses of a street in the selected study area in terms of developed walkability parameters.
7.	The analysis should consider the actual walkable distance rather than a virtual one for objective measuring.
8.	The analysis should determine the value range for all the perceived wakability parameters in order to rank.
9.	The analysis should accept at least a neighborhood scale rather than a street scale for comparison.
10.	The analysis should compare the walkability multi-criteria decision-making results with the walkability multi-criteria weighted overlay map results.
11.	The analysis should show all the mappable walkability parameters seperately for comparison of selected case areas.
12.	The analysis should overlay multiple walkability parameter maps for obtaining and comparing most suitable areas for walkability.
13.	The analysis should enable city planners and the decision-makers generate improvements and implications evaluating the perceived walkability factors for existing residential neighborhoods.
14.	The analysis should enable city planners and the decision-makers generate improvements and implications evaluating the MCDM analysis results and multi-criteria overlay weighted walkability maps.

7.3 The Limitations of the Study and Suggestions for Further Research

Beyond the potential of the mixed methodology and the analytical tool developed in this study, it nonetheless has some limitations and drawbacks. The first one is that in Exploratory Factor Analysis, five factors were obtained for the Ayrancı survey and these factors explain 51% of the total variance. Moreover, again five factors were obtained for the Çayyolu survey as for the Ayrancı survey and these factors explain 50.7% of the total variance. However, these percentages have the least acceptable values. These factors are expected to explain more of the total variance. A further study can improve this by changing the walkability items in the survey instrument or eliminate more factor variables for a stronger explanation. Limited time and resources for the study did not allow repeating the survey.

One of the other limitations of the study was the conditions of COVID-19 pandemics. The questionnaire was online. Getting the attention of the residents and persuading them to attend was challenging. On the other hand, Google Street View was used as a geospatial data source. During the economic conditions of the pandemics, some of the shops and services were shut down the business or replaced in 2021. However, in Google Maps most recent street views are dated back to 2020.

As an another drawback, the fact that there are only male and female options under gender information in the demographic questions of the survey. This situation caused complaints by those who wanted to answer outside of these categories. This should be taken into account in further academic studies in terms of inclusiveness.

With the completed study, a mixed walkability analysis method has been established. Therefore, there could be further studies that can be performed using this method. The study was focusing on urban and newly developed urban neighborhoods as case areas. However, a further study comparing urban design characteristics and perceived walkability factors with other neighborhoods that have a different design characteristics and possible different perceptions of walkability (e.g. suburban neighborhoods with detached houses and gated community residences).

For all data of developed walkability parameters used in MCDM implementation and Multi-Criteria Overlay Mapping, the weights were equal. Before performing these methods, a further research could set up another survey and ask expert groups such as architects, city planners, and government officials to weight those parameters according to their importance.

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Appendix A - The Ethical Permission for the Preliminary Walkability Study Related to This Dissertation by the Bilkent University Ethical Committee

Bilkent Üniversitesi
Akademik İşler Rektör Yardımcılığı

Tarih : 30 Temmuz 2018

Gönderilen : Emre Seles

Tez Danışmanı : Yasemin Afacan

Gönderen : Fatma Taşkın
İnsan Araştırmaları Etik Kurulu Başkanı

Konu : *"The role of ..."* çalışması etik kurul onayı

Üniversitemiz İnsan Araştırmaları Etik Kurulu, 30 Temmuz 2018 tarihli görüşme sonucu, *"The Role of Healthy Urban Performance on Walkability: Broadening the Theory of Planned Behaviour"* isimli çalışmanız kapsamında yapmayı önerdiğiniz etkinlik için etik onay vermiş bulunmaktadır. Onay, ekte verilmiş olan çalışma önerisi, çalışma yürütücüleri, ve bilgilendirme formu için geçerlidir.

Bu onay, yapmayı önerdiğiniz çalışmanın genel bilim etiği açısından bir değerlendirmesine karşı gelmektedir. Çalışmanızda, kurulumuzun değerlendirmesi dışında kalabilen özel etik ve yasal sınırlamalara uymakla ayrıca yükümlüsünüz.

Etik Kurul Üyeleri:

Ünvan / İsim	Bölüm / Uzmanlık	İmza
1. Doç.Dr. Fatma Taşkın	İktisat	
2. Prof.Dr. Erdal Onar	Hukuk	
3. Prof.Dr. Haldun Özaktaş	Elektrik ve Elektronik Müh.	
4. Doç.Dr. Işık Yuluğ	Moleküler Biyoloji ve Genetik	
5. Yrd.Doç.Dr. Gül Günaydın	Psikoloji	
Yd.1.Doç.Dr. Çiğdem Gündüz Demir	Bilgisayar Mühendisliği	(yedek üye)
Yd.2. Yrd.Doç.Dr. A.Barış Özbilen	Hukuk	(yedek üye)

Kurul karar/toplantı No: 2018_07_30_03

Bilkent Üniversitesi, 06800 Bilkent, Ankara • Telefon: (312) 290 12 13 • (312) 290 12 14 • Faks: (312) 266 41 52

Appendix B - The Survey Instrument

English Version of the Survey:

You are invited to participate in a survey on the walkability of your neighborhood.

The aim of this study is to gain knowledge about the perceived walkability of the neighborhoods through subjective evaluations of the residents.

Information for Participants

Research Title: Perceived Walkability in Residential Neighborhoods

You are invited to participate in a survey on the walkability of your neighborhood. Before making a decision, it is important to understand why this research was conducted and what it will include. Please take the time to read the information below and talk to others if you wish. Consider if there is anything unclear or if you want more information.

What is the purpose of the project?

The aim of this study is to gain knowledge about the perceived walkability of the neighborhoods through subjective evaluations of the residents. This survey study is specific to two neighborhoods in Çankaya District in Ankara. It is a survey focusing on Güvenlik Street in Ayrancı Neighborhood and 2432nd Street in Çayyolu Neighborhood. If you do not live in these neighborhoods, you may not take the survey.

Why was I chosen?

You have been asked to attend because you are a local resident who can give an idea of the walkability of your neighborhood mentioned above.

Do I have to attend?

Participation in this study is voluntary, so please do not feel obligated to participate. You will not face any penalties for refusing to participate, and you may withdraw at any stage of the study.

What should I do?

If you agree to participate in the survey, you will be asked to fill out the questionnaire reporting your subjective judgments about walking in your neighborhood.
If necessary, take a walk around your neighborhood before filling the questionnaire. You will also be asked to answer demographic questions and questions about your neighborhood.

The survey takes about 15 minutes; but since there is no time limit, you can use as much time as you want. The survey language is Turkish.

Are there any downsides to participating?

There is no predictable disadvantage for your participation. If you are unhappy or have more doubts at any stage of the survey, please address your concerns first to the researcher by sending an e-mail (emre.seles@bilkent.edu.tr) to the researcher. You also have the right to leave the survey at any time.

Will all my information be kept confidential?

All information collected will be treated in accordance with the Annotated Model Grant Agreement of the European Commission (AGA) and ethical research guidelines and principles, and the data will be kept strictly confidential and anonymized before being presented in any study.

What will happen to the results of the research study?

Collected data will be analyzed by SPSS and other statistical analysis programs. The results of these analyzes can be published in doctoral dissertation, conference reports and / or journal articles; however, all information will be kept strictly confidential and anonymized. Your data will be stored in a secure system. If you would like a copy of the published thesis or article, please contact the researcher.

Will I be paid to participate in the research?

No, you will not be paid.

Where and how can survey questions be answered?

You can access and answer survey questions from anywhere with an internet connection.

Who can be contacted for more information?

Name and Contact Information of the Researcher: Interior Architect Emre SELES (emre.seles@bilkent.edu.tr)

On-line Survey Link:
https://forms.gle/SCBYD4nWLLtpPXiz9

Date:
Participant Number:

Demographic Information

Place of Residence (District / Street):

Ayrancı / Güvenlik Street ☐
Çayyolu / 2432nd Street ☐

Period of Residence (in Years):

Less than 1 year ☐
1-5 years ☐
5-10 years ☐
More than 10 years ☐

Age Group:

17 or younger ☐
18-20 ☐
21-29 ☐
30-39 ☐
40-49 ☐
50-59 ☐
60-69 ☐
70 or older ☐

Sex:
Male ☐
Female ☐

Education Degree:

Primary School ☐
Middle School ☐
High School or Equivalent ☐
Bachelor ☐
Graduate ☐

Personal Monthly Income Level:

0TL - 999TL ☐
1.000TL - 1.999TL ☐
2.000TL - 4.999TL ☐
5.000TL - 9.999TL ☐
10.000TL - 14.999TL ☐
15.000TL - 19.999TL ☐
20.000TL - 29.999TL ☐
30.000TL and above ☐

Car Ownership:

I Own a Car ☐
I Do Not Own a Car ☐

Marital Status:

Single ☐
Married ☐
Widow ☐

Perceived Urban DMA* Walkability Questionnaire									
Construct (34 Items)	**Item**		**Scale**						
			Totally Agree						**Totally Disagree**
Density (D, 12 Items)	D1	I find it positive for my health to walk at least 30 minutes 5 times a week in my neighborhood.	1	2	3	4	5	6	7
	D2	I find it pleasant to walk at least 30 minutes 5 times a week in my neighborhood.	1	2	3	4	5	6	7
	D3	I find it safe to walk at least 30 minutes 5 times a week in my neighborhood.	1	2	3	4	5	6	7
	D4	The crowded streets of my neighborhood makes me feel safe while walking.	1	2	3	4	5	6	7
	D5	I find the crowded streets of my neighborhood risky for my health while walking.	1	2	3	4	5	6	7
	D6	I prefer crowded hours for a pleasant walk in my neighborhood.	1	2	3	4	5	6	7
	D7	The liveliness in my neighborhood motivates me to walk.	1	2	3	4	5	6	7
	D8	In my neighborhood, I prefer walking in secluded hours, considering the social distance.	1	2	3	4	5	6	7

	D9	I find it advantageous for walking, that my neighborhood is in the downtown.	1	2	3	4	5	6	7
	D10	I find it advantageous for walking, that my neighborhood is far from the city center (suburb).	1	2	3	4	5	6	7
	D11	Knowing that I was seen by others while walking in my neighborhood makes me feel safe.	1	2	3	4	5	6	7
	D12	Being in social distance and wearing a mask while walking in my neighborhood decrease my motivation for walking.	1	2	3	4	5	6	7
Mixed-Use (M, 10 Items)	M1	I prefer to walk in my neighborhood for shopping.	1	2	3	4	5	6	7
	M2	Instead of walking, I use automobile to go to work.	1	2	3	4	5	6	7
	M3	I can go to school on foot.	1	2	3	4	5	6	7
	M4	In my neighborhood, I can reach work, school and shopping on foot.	1	2	3	4	5	6	7
	M5	Instead of visiting the shops in my neighborhood, I prefer on-line shopping for my health.	1	2	3	4	5	6	7

	M6	In my neighborhood, I can reach social and cultural venues (cafe, bar, restaurant, museum, art gallery, etc.) on foot.	1	2	3	4	5	6	7
	M7	I think that the mixed-use of residence, work, shopping and entertainment places in my neighborhood increases the vitality.	1	2	3	4	5	6	7
	M8	The mixed-use of residence, work, shopping and entertainment places in my neighborhood motivates me for walking.	1	2	3	4	5	6	7
	M9	In my neighborhood, I can meet more than one basic need by walking at different times during the day.	1	2	3	4	5	6	7
	M10	As long as there is an automobile, it is not a problem for me that the places of residence, work, shopping and entertainment are far from each other in my neighborhood.	1	2	3	4	5	6	7
Accessibility (A, 12 Items)	A1	In my neighborhood, the sidewalks are designed for walking.	1	2	3	4	5	6	7
	A2	In my neighborhood, the distance between intersections is generally short (90m).	1	2	3	4	5	6	7
	A3	There are many alternative routes in my neighborhood to get from one place to another on foot.	1	2	3	4	5	6	7
	A4	There are pedestrian crossings / traffic signs that make it easier to cross crowded streets in my neighborhood.	1	2	3	4	5	6	7

	A5	The sidewalks in my neighborhood are wide enough for a social distance walk.	1	2	3	4	5	6	7
	A6	I think it makes walking difficult because most streets in my neighborhood are uphill.	1	2	3	4	5	6	7
	A7	The buildings in my neighborhood are close to the street.	1	2	3	4	5	6	7
	A8	It is easy to get lost while walking in my neighborhood.	1	2	3	4	5	6	7
	A9	Green areas are easily accessible on foot from my house.	1	2	3	4	5	6	7
	A10	There is enough artificial or natural canopy (trees, arcade, etc.) to walk comfortably in my neighborhood.	1	2	3	4	5	6	7
	A11	There are obstacles in my neighborhood that make it difficult to walk on the street (trees, parked cars, narrow pavement, rough surface, etc.).	1	2	3	4	5	6	7
	A12	There are clear signs to help me find my way around my neighborhood while walking.	1	2	3	4	5	6	7

Table 1. List of constructs and their corresponding items (Adapted from Cerin et al., 2006; Jacobs, 1961; Saelens et al., 2003; and Zuniga-Teran et al., 2016)

*Density, Mixed-Use, Accessibility.

Turkish Version of the Survey:

Mahallenizin yürünebilirliği hakkında bir ankete katılmaya davetlisiniz.

Bu çalışmanın amacı, mahalle sakinlerinin öznel değerlendirmeleri yoluyla mahallelerin algılanan yürünebilirliği hakkında bilgi edinmektir.

Katılımcılar için Bilgiler

Araştırma Başlığı: Konut Mahallelerinde Algılanan Yürünebilirlik

Mahallenizin yürünebilirliği hakkında bir ankete katılmaya davetlisiniz. Bir karar vermeden önce, bu araştırmanın neden yapıldığını ve neleri içereceğini anlamak önemlidir. Lütfen aşağıdaki bilgileri okumak için zaman ayırın ve isterseniz başkalarıyla konuşun. Belirsiz bir şey olup olmadığını veya daha fazla bilgi isteyip istemediğinizi düşünün.

Projenin amacı nedir?

Bu çalışmanın amacı, mahalle sakinlerinin öznel değerlendirmeleri yoluyla mahallelerin algılanan yürünebilirliği hakkında bilgi edinmektir. Bu anket çalışması Ankara ili Çankaya İlçesi'ndeki iki mahalleye özeldir. Ayrancı Mahallesi Güvenlik Caddesi ve Çayyolu Mahallesi 2432. Cadde'ye odaklanan bir ankettir. Bu mahallelerde yaşamıyorsanız ankete katılmayabilirsiniz.

Neden seçildim?

Yukarıda belirtilen mahallenizin yürünebilirliği hakkında fikir verebilecek yerel bir sakin olduğunuz için katılmanız istendi.

Katılmak zorunda mıyım?

Bu çalışmaya katılım isteğe bağlıdır, bu nedenle lütfen kendinizi katılmak zorunda hissetmeyin. Katılmayı reddetmeniz durumunda herhangi bir ceza ile karşılaşmazsınız ve çalışmanın herhangi bir aşamasında geri çekilebilirsiniz.

Ne yapmalıyım?

Ankete katılmayı kabul ederseniz, mahallenizde yürümekle ilgili öznel yargılarınızı bildiren anketi doldurmanız istenecektir.
Gerekirse anketi doldurmadan önce mahallenizde dolaşın. Ayrıca demografik soruları ve mahallenizle ilgili soruları yanıtlamanız istenecektir.

Anket yaklaşık 15 dakika sürer; ancak süre sınırı olmadığı için istediğiniz kadar zaman kullanabilirsiniz. Anket dili Türkçe'dir.

Katılmanın herhangi bir dezavantajı var mı?

Katılımınız için öngörülebilir bir dezavantaj yoktur. Anketin herhangi bir aşamasında memnun değilseniz veya daha fazla şüpheniz varsa, lütfen araştırmacıya bir e-posta (emre.seles@bilkent.edu.tr) göndererek endişelerinizi öncelikle araştırmacıya iletin. Ayrıca istediğiniz zaman anketten ayrılma hakkına da sahipsiniz.

Tüm bilgilerim gizli tutulacak mı?

Toplanan tüm bilgiler, Avrupa Komisyonu'nun (AGA) Açıklamalı Model Hibe Sözleşmesine ve etik araştırma yönergeleri ve ilkelerine uygun olarak işlenecek ve veriler herhangi bir çalışmada sunulmadan önce kesinlikle gizli tutulacak ve anonim hale getirilecektir.

Araştırma çalışmasının sonuçlarına ne olacak?

Toplanan veriler SPSS ve diğer istatistiksel analiz programları tarafından analiz edilecektir. Bu analizlerin sonuçları doktora tezi, konferans raporları ve/veya dergi makalelerinde yayınlanabilir; ancak, tüm bilgiler kesinlikle gizli tutulacak ve anonim hale getirilecektir. Verileriniz güvenli bir sistemde saklanacaktır. Yayımlanmış tez veya makalenin bir kopyasını isterseniz, lütfen araştırmacı ile iletişime geçiniz.

Araştırmaya katılmak için bana ödeme yapılacak mı?

Hayır, size ödeme yapılmayacaktır.

Anket soruları nerede ve nasıl yanıtlanabilir?

Anket sorularına internet bağlantısı olan her yerden ulaşabilir ve cevaplayabilirsiniz.

Daha fazla bilgi için kiminle iletişime geçilebilir?

Araştırmacının Adı ve İletişim Bilgileri: İç Mimar Emre SELES (emre.seles@bilkent.edu.tr)

Çevrimiçi Anket Bağlantısı:
https://forms.gle/SCBYD4nWLLtpPXiz9

Tarih:
Katılımcı Numarası:

Demografik Bilgiler

İkâmet Yeri (Mahalle / Cadde):

Ayrancı / Güvenlik Caddesi ☐
Çayyolu / 2432. Cadde ☐

İkâmet Süresi (Yıl Olarak):

1 yıldan az ☐
1-5 yıl arası ☐
5-10 yıl arası ☐
10 yıldan fazla ☐

Yaş Grubu:

17 veya daha genç ☐
18-20 ☐
21-29 ☐
30-39 ☐
40-49 ☐

50-59 ☐
60-69 ☐
70 veya üstü ☐

Cinsiyet:
Erkek ☐
Kadın ☐

Eğitim Derecesi:

İlkokul ☐
Ortaokul ☐
Lise ya da Dengi Okul ☐
Yüksekokul / Üniversite ☐
Lisansüstü ☐

Kişisel Aylık Gelir Düzeyi:

0TL - 999TL ☐
1.000TL - 1.999TL ☐
2.000TL - 4.999TL ☐
5.000TL - 9.999TL ☐
10.000TL - 14.999TL ☐
15.000TL - 19.999TL ☐
20.000TL - 29.999TL ☐
30.000TL ve üzeri ☐

Otomobil Sahipliği:

Otomobilim Var ☐
Otomobilim Yok ☐

Medeni Hali:

Bekâr ☐
Evli ☐
Dul ☐

Yürünebilirlik için Algılanan Kentsel YKU* Anketi									
Oluşumlar (34 Madde)	Maddeler		Ölçek						
			Kesinlikle Katılıyo-rum						Kesinlikle Katılmıyo-rum
Yoğunluk (Y, 12 Madde)	Y1	Mahallemde haftada 5 kez, en az 30 dakika yürümeyi sağlığım için olumlu bulurum.	1	2	3	4	5	6	7
	Y2	Mahallemde haftada 5 kez, en az 30 dakika yürümeyi keyifli bulurum.	1	2	3	4	5	6	7
	Y3	Mahallemde haftada 5 kez, en az 30 dakika yürümeyi güvenli bulurum.	1	2	3	4	5	6	7
	Y4	Mahallemin cadde ve sokaklarının kalabalık oluşu yürürken kendimi güvende hissettirir.	1	2	3	4	5	6	7
	Y5	Yürürken, mahallemin cadde ve sokaklarının kalabalık oluşunu sağlığım açısından riskli bulurum.	1	2	3	4	5	6	7
	Y6	Mahallemde keyifli bir yürüyüş için kalabalık saatleri tercih ederim.	1	2	3	4	5	6	7
	Y7	Mahallemdeki canlılık, yürüyüş için beni motive eder.	1	2	3	4	5	6	7
	Y8	Mahallemde, sosyal mesafeyi gözeterek, tenha saatlerde yürümeyi tercih ederim.	1	2	3	4	5	6	7

	Y9	Mahallemin şehir merkezinde oluşunu yürüyüş için avantajlı bulurum.	1	2	3	4	5	6	7
	Y10	Mahallemin şehir merkezinden uzak (banliyöde) oluşunu yürüyüş için avantajlı bulurum.	1	2	3	4	5	6	7
	Y11	Mahallemde yürürken başkaları tarafından görüldüğümü bilmek kendimi güvende hissettirir.	1	2	3	4	5	6	7
	Y12	Mahallemde yürürken sosyal mesafeli olmak ve maske takmak yürüyüş için motivasyonumu azaltır.	1	2	3	4	5	6	7
Karma-Kullanım (K, 10 Madde)	K1	Alışveriş için mahallemde yürümeyi tercih ederim.	1	2	3	4	5	6	7
	K2	İşe gitmek için yürümek yerine otomobil kullanırım.	1	2	3	4	5	6	7
	K3	Yürüyerek okula gidebilirim.	1	2	3	4	5	6	7
	K4	Mahallemde işe, okula ve alışverişe yürüyerek ulaşabilirim.	1	2	3	4	5	6	7
	K5	Mahallemdeki dükkanları ziyaret etmek yerine sağlığım açısından on-line alışverişi tercih ederim.	1	2	3	4	5	6	7

	K6	Mahallemde sosyal ve kültürel mekânlara (cafe, bar, restoran, müze, sanat galerisi vs.) yürüyerek ulaşabilirim.	1	2	3	4	5	6	7
	K7	Mahallemde konut, çalışma, alışveriş ve eğlence mekânlarının bir arada olmasının canlılığı artırdığını düşünüyorum.	1	2	3	4	5	6	7
	K8	Mahallemde konut, çalışma, alışveriş ve eğlence mekânlarının bir arada olması yürüyüş için beni motive eder.	1	2	3	4	5	6	7
	K9	Mahallemde, gün içinde, farklı saatlerde yürüyerek, birden fazla temel ihtiyacımı karşılayabilirim.	1	2	3	4	5	6	7
	K10	Otomobil olduğu sürece, mahallemde konut, çalışma, alışveriş ve eğlence mekânlarının birbirinden uzak olması benim için bir problem değil.	1	2	3	4	5	6	7
Ulaşılabilirlik (U, 12 Madde)	U1	Mahallemde kaldırımlar yürüyüş için uygun tasarlanmıştır.	1	2	3	4	5	6	7
	U2	Mahallemde kavşaklar arasındaki mesafe genelde kısadır (90m).	1	2	3	4	5	6	7
	U3	Mahallemde bir yerden diğer bir yere yürüyerek ulaşmak için birçok alternatif rota vardır.	1	2	3	4	5	6	7
	U4	Mahallemdeki kalabalık caddeleri / sokakları geçmeyi kolaylaştıran yaya geçitleri / trafik işaretleri var.	1	2	3	4	5	6	7

	U5	Mahallemdeki kaldırımlar, sosyal mesafeli bir yürüyüş için uygun genişliktedir.	1	2	3	4	5	6	7
	U6	Mahallemdeki çoğu cadde ve sokak yokuş olduğu için yürümeyi zorlaştırdığını düşünüyorum.	1	2	3	4	5	6	7
	U7	Mahallemdeki binalar caddeye / sokağa yakındır.	1	2	3	4	5	6	7
	U8	Mahallemde yürürken kaybolmak kolaydır.	1	2	3	4	5	6	7
	U9	Evimden yeşil alanlara yürüyerek kolayca ulaşılabilir.	1	2	3	4	5	6	7
	U10	Mahallemde rahat yürüyebilmek için yeterince yapay veya doğal gölgelik (kanopi, ağaç vs.) var.	1	2	3	4	5	6	7
	U11	Mahallemde yürümeyi zorlaştıran (ağaç, park etmiş otomobiller, dar kaldırım, bozuk satıh vb.) engeller bulunuyor.	1	2	3	4	5	6	7
	U12	Mahallemde yürürken yolumu bulmama yardımcı olacak açık işaretler / tabelalar var.	1	2	3	4	5	6	7

Tablo 2. Oluşumların ve ilgili başlıkların listesi (Cerin et al., 2006; Jacobs, 1961; Saelens et al., 2003; ve Zuniga-Teran et al., 2016'dan uyarlanmıştır)

*Yoğunluk, Karma-Kullanım, Ulaşılabilirlik.

Appendix C - The Detailed List of the 5 Factors with Their Corresponding Items and the Factor Loadings of Güvenlik Street in Ayrancı Neighborhood

Factor 1 – Road Safety in a Vital Residential Neighborhood

D1 – I find it positive for my health to walk at least 30 minutes 5 times a week in my neighborhood (0.795).

D2 – I find it pleasant to walk at least 30 minutes 5 times a week in my neighborhood (0.789).

(A8) – It is easy to get lost while walking in my neighborhood (0.722).

M6 – In my neighborhood, I can reach social and cultural venues (cafe, bar, restaurant, museum, art gallery, etc.) on foot (0.665).

A7 – The buildings in my neighborhood are close to the street (0.664).

M9 – In my neighborhood, I can meet more than one basic need by walking at different times during the day (0.651).

D3 – I find it safe to walk at least 30 minutes 5 times a week in my neighborhood (0.630).

A3 – There are many alternative routes in my neighborhood to get from one place to another on foot (0.511).

Factor 2 – Route Comfort

(D8) – In my neighborhood, I prefer walking in secluded hours, considering the social distance (0.791).

D7 – The liveliness in my neighborhood motivates me to walk (0.746).

(D5) – I find the crowded streets of my neighborhood risky for my health while walking (0.652).

D6 – I prefer crowded hours for a pleasant walk in my neighborhood (0.583).

D4 – The crowded streets of my neighborhood makes me feel safe while walking (0.519).

Factor 3 – Route Characteristics

(D10) – I find it advantageous for walking, that my neighborhood is far from the city center (suburb) (0.771).

D9 – I find it advantageous for walking, that my neighborhood is in the downtown (0.645).

M8 – The mixed-use of residence, work, shopping and entertainment places in my neighborhood motivates me for walking (0.587).

(M10) – As long as there is an automobile, it is not a problem for me that the places of residence, work, shopping and entertainment are far from each other in my neighborhood (0.539).

Factor 4 – Route Accessibility

A1 – In my neighborhood, the sidewalks are designed for walking (0.768).

A5 – The sidewalks in my neighborhood are wide enough for a social distance walk (0.695).

A12 – There are clear signs to help me find my way around my neighborhood while walking (0.615).

A4 – There are pedestrian crossings / traffic signs that make it easier to cross crowded streets in my neighborhood (0.601).

Factor 5 – Route Attractiveness

M3 – I can go to school on foot (0.785).

M4 – In my neighborhood, I can reach work, school and shopping on foot (0.732).

(M2) – Instead of walking, I use automobile to go to work (0.571).

Note: Reverse coded items are written in parenthesis.

Appendix D - The Detailed List of the 5 Factors with Their Corresponding Items and the Factor Loadings of 2432nd Street in Çayyolu Neighborhood

Factor 1 – Road Safety in a Vital Residential Neighborhood

D2 – I find it pleasant to walk at least 30 minutes 5 times a week in my neighborhood (0.844).

D1 – I find it positive for my health to walk at least 30 minutes 5 times a week in my neighborhood (0.820).

D3 – I find it safe to walk at least 30 minutes 5 times a week in my neighborhood (0.685).

(A8) – It is easy to get lost while walking in my neighborhood (0.604).

(D10) – I find it advantageous for walking, that my neighborhood is far from the city center (suburb) (0.579).

Factor 2 – Route Characteristics

M9 – In my neighborhood, I can meet more than one basic need by walking at different times during the day (0.780).

M7 – I think that the mixed-use of residence, work, shopping and entertainment places in my neighborhood increases the vitality (0.736).

M6 – In my neighborhood, I can reach social and cultural venues (cafe, bar, restaurant, museum, art gallery, etc.) on foot (0.715).

M8 – The mixed-use of residence, work, shopping and entertainment places in my neighborhood motivates me for walking (0.682).

A3 – There are many alternative routes in my neighborhood to get from one place to another on foot (0.550).

M1 – I prefer to walk in my neighborhood for shopping (0.504).

Factor 3 – Route Comfort

D7 – The liveliness in my neighborhood motivates me to walk (0.825).

D6 – I prefer crowded hours for a pleasant walk in my neighborhood (0.738).

D4 – The crowded streets of my neighborhood makes me feel safe while walking (0.737).

Factor 4 – Route Accessibility

(D5) – I find the crowded streets of my neighborhood risky for my health while walking (0.593).

(M5) – Instead of visiting the shops in my neighborhood, I prefer on-line shopping for my health (0.561).

(M2) – Instead of walking, I use automobile to go to work (0.550).

D9 – I find it advantageous for walking, that my neighborhood is in the downtown (0.522).

Factor 5 – Route Attractiveness

M4 – In my neighborhood, I can reach work, school and shopping on foot (0.704).

M3 – I can go to school on foot (0.674).

A12 – There are clear signs to help me find my way around my neighborhood while walking (0.523).

Note: Reverse coded items are written in parenthesis.

Appendix E – The Visual PROMETHEE Dataset Interface Window

Street Walkability	Vehicle Traffi...	No. Crosswalks	No. Signage	Presence of ...	Ground Con...	Pavement W...	Slope	No. Shops a...	No.Trees	Natural Areas	No. Bus Stati...	No. Intersec...
Unit	3-point HML	# / km	# / km	y/n	3-point GMB	4-point WMNI	3-point HMF	# / m	# / m²	y/n	# / m	3-point HML
Cluster/Group												
Preferences												
Min/Max	max	max	max	max	min	min	max	max	max	max	max	min
Weight	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Preference Fn.	Usual	Usual	Usual	Usual	Usual	Usual	Usual	Usual	Usual	Usual	Usual	Usual
Thresholds	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute
- Q: Indifference	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
- P: Preference	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
- S: Gaussian	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Statistics												
Minimum	1,00	0,63	22,50	1,00	1,00	1,00	2,00	59,37	0,03	1,00	3,12	2,00
Maximum	2,00	6,25	24,37	1,00	2,00	2,00	3,00	94,37	0,03	1,00	3,12	2,00
Average	1,50	3,44	23,43	1,00	1,50	1,50	2,50	76,87	0,03	1,00	3,12	2,00
Standard Dev.	0,50	2,81	0,93	0,00	0,50	0,50	0,50	17,50	0,00	0,00	0,00	0,00
Evaluations												
Güvenlik Street o...	High	0,63	22,50	yes	Medium	Medium	Medium	94,37	0,03	yes	3,12	Medium
2432nd Street of...	Medium	6,25	24,37	yes	Good	Wide	Flat	59,37	0,03	yes	3,12	Medium

Appendix F – Poster Design for Promoting the Walkability Survey

Figure 1. Poster design made by the author.