Elif YILMAZ

A Master's Thesis

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# AHP-BASED EVALUATION OF THE SUITABILITY OF PUBLIC FACILITIES: THE CASE OF MELIKGAZI, KAYSERI

A THESIS
SUBMITTED TO THE DEPARTMENT OF SUSTAINABLE URBAN INFRASTRUCTURE ENGINEERING
AND THE GRADUATE SCHOOL OF ENGINEERING AND SCIENCE
OF ABDULLAH GUL UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE

By
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# SCIENTIFIC ETHICS COMPLIANCE

I hereby declare that all information in this document has been obtained in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all materials and results that are not original to this work.

Elif YILMAZ

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M.Sc. thesis titled Ahp-Based Evaluation of The Suitability of Public Facilities: The Case of Melikgazi, Kayseri has been prepared in accordance with the Thesis Writing Guidelines of the Abdullah Gül University, Graduate School of Engineering & Science.

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## ACCEPTANCE AND APPROVAL

M.Sc. thesis titled Ahp-Based Evaluation of The Suitability of Public Facilities: The Case of Melikgazi, Kayseri and prepared by Elif Yılmaz has been accepted by the jury in the Sustainable Urban Infrastructure Engineering Graduate Program at Abdullah Gül University, Graduate School of Engineering & Science.

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……….. /……….. / ………..

**(Date)**

Graduate School Dean
Prof. Dr. İrfan ALAN

# ABSTRACT

# AHP-BASED EVALUATION OF THE SUITABILITY OF PUBLIC FACILITIES: THE CASE OF MELIKGAZI, KAYSERI

Elif YILMAZ
MSc. in Sustainable Urban Infrastructure Engineering
Advisor: Assoc. Prof. Dr. Müge AKIN
March, 2024

Public facilities in urban areas, such as those for health and education, are expected to meet various humanitarian requirements. It is important to ensure that these facilities are suitable in all aspects in the urban areas. The aim of this thesis is to evaluate the suitability of public facilities proposed by zoning plans in the study area of Melikgazi District, Kayseri Province, by integrating Analytic Hierarchy Process and Geographic Information Systems. To evaluate the suitability, health facilities, green areas, kindergarten areas, primary school areas, secondary school areas, high schools and mosque areas proposed in the zoning plan were analyzed by considering the main criteria and sub-criteria determined within the scope of population density, transportation facilities and technical infrastructure services. The criteria were reclassified with Geographic Information Systems using the Analytic Hierarchy Process to calculate weight values for the Weighted Overlay and Weighted Sum analyses. The analyses identified non-suitable areas, suitable areas, and very high suitable areas. The study area was evaluated comparatively for each public facility using Weighted Overlay and Weighted Sum analyses to identify areas with suitable results and those in need of new public facilities. The results indicate that the primary school and mosque areas have suitable results, but other public facilities are still needed in areas close to the center with high population density.

*Keywords: Public Facilities, Suitability, Geographic Information Systems, Analytic Hierarchy Process*

# ÖZET

# KAMU TESİSLERİNİN UYGUNLUĞUNUN AHP TABANLI DEĞERLENDİRİLMESİ: KAYSERİ MELİKGAZİ ÖRNEĞİ

Elif YILMAZ
Sürdürülebilir Kentsel Altyapı Mühendisliği Anabilim Dalı Yüksek Lisans
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Mart-2024

Kamu tesisleri, kentsel alanda insanların sağlık ve eğitim gibi öncelikli ihtiyaçlarını karşılayan alanlar olduğu için bu tesislerin kentsel alanda pek çok açıdan uygun olması beklenmektedir. Bu tezin amacı, Kayseri İli Melikgazi İlçesinde belirlenen çalışma alanında, imar planları ile önerilmiş kamu tesislerinin uygunluğunun, Analitik Hiyerarşi Süreci ve Coğrafi Bilgi Sistemleri'nin entegre edilerek değerlendirilmesidir. Uygunluk değerlendirmesi yapabilmek için imar planında önerilmiş sağlık tesisleri, yeşil alanlar, anaokulu alanları, ilkokul alanları, ortaokul alanları, liseler ve cami alanları; nüfus yoğunluğu, ulaşım imkanları ve teknik altyapı servisleri kapsamında belirlenen ana kriterler ve alt kriterler dikkate alınarak analiz edilmiştir. Coğrafi Bilgi Sistemleri ile yeniden sınıflandırılan kriterlerin Analitik Hiyerarşi Süreci ile ağırlık değerleri hesaplanarak, Weighted Overlay ve Weighted Sum analizleri uygulanmıştır. Her iki analiz sonucunda da uygun olmayan alanlar, uygun alanlar ve çok uygun alanlar saptanmıştır. Her bir kamu tesisi için Weighted Overlay ve Weighted Sum analiz sonuçlarının karşılaştırmalı değerlendirmesi yapılarak çalışma alanında uygun sonuç veren bölgeler ve yeni kamu tesisine ihtiyaç duyan bölgeler tespit edilmiştir. Elde edilen sonuçlara göre ilkokul ve cami alanları uygun sonuç ortaya koymuşken çalışma alanının, özellikle nüfus yoğunluğunun yüksek olan merkeze yakın bölgelerinde diğer kamu tesislerine hala ihtiyaç duyduğu tespit edilmiştir.

*Anahtar kelimeler: Kamu Tesisleri, Uygunluk, Coğrafi Bilgi Sistemleri, Analitik Hiyerarşi Süreci*

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| | |
|---|---|
| GIS | Geographic Information Systems |
| AHP | Analytic Hierarchy Process |
| E | The Floor Area Ratio |
| KASKİ | Kayseri Water and Sewerage Administration |
| KCETAŞ | Kayseri and the surrounding electricity Turk Inc. |
| KAYSERİ ULAŞIM A.Ş. | Kayseri Transportation Inc. Company |
| MAKS | Spatial Address Registration System |

# Chapter 1

# Introduction

## 1.1 General

The global population is growing rapidly, leading to a reduction in the availability of urban space and hindering the development of healthy and accessible urban areas, particularly in cities. Despite economic and political considerations often taking precedence in urban planning, these plans must also prioritize meeting both the housing and basic social needs of the expanding population.

Housing remains the top priority in urban areas, with new constructions aimed at accommodating the growing population. Conversely, public facilities such as health centers, educational institutions and recreational areas, which meet the social needs of the growing population, are produced at a minimum level within the framework of legislation, although they form the backbone of urban and regional development. However, public facilities should have two main functions in cities: First, to serve the inhabitants of the city, and secondly, to protect the urban environment [1].

The effective provision and placement of these facilities have a profound impact on the quality of life, social equity, and economic development within a community. As the world becomes increasingly urbanized, the planning and management of public facilities become even more critical. To optimize these processes, Geographic Information Systems (GIS) and the Analytic Hierarchy Process (AHP) have emerged as indispensable tools in decision-making.

Geographic Information Systems (GIS) is a technology that enables the collection, analysis, and visualization of spatial data, allowing users to understand, interpret, and make informed decisions about the world around them. It combines geographic data (information tied to specific locations) with various analytical tools to provide valuable insights into spatial relationships, patterns, and trends.

The Analytic Hierarchy Process (AHP), developed by Saaty (1980), is a multi-criteria decision-making method that enables the systematic evaluation of alternatives in complex decision contexts. AHP helps in structuring the decision problem by establishing a hierarchy of criteria and sub-criteria, and it enables the determination of the relative importance of these criteria through pairwise comparisons [2]. This method is especially valuable in situations where decisions involve multiple, often conflicting, factors.

Due to the significance of public facilities and the complexities involved in their location and evaluation, the combination of GIS and AHP offers a promising approach. Therefore, this thesis utilized these methods to analyze the suitability of public facilities.

## 1.2 Purpose and Scope

The 3194 numbered Zoning Law Spatial Plans Construction Regulation defines public facilities area as a general term for facilities built by the public or private sector to meet the cultural, social, and recreational needs of individuals and society. These facilities include educational, health, religious, cultural, and administrative facilities, indoor and outdoor sports facilities, parks, playgrounds, squares, recreation areas, open and green areas. The aim is to improve the quality of life with a healthy environment. The locations and sizes of these areas are determined and planned in zoning plans by taking into account the geographical, geological, and demographic characteristics of the cities, while considering the public interest.

To ensure the most appropriate proposal of public facility areas in city zoning plans, the Regulation on The Making of Spatial Plans establishes a set of standards and walking distances (Table 1.1).

**Table 1.1 The standards and walking distances of the Regulation on The Making of Spatial Plans**

| PUBLIC FACILITY | POPULATION GROUP (person) | | | | | | | | WALKING DISTANCE (m) |
|---|---|---|---|---|---|---|---|---|---|
| | 0 - 75.000 | | 75.001- 150.000 | | 150.001 - 500.000 | | 501.000 + | | |
| | m²/person | Minimum Unit Area (m²) | m²/person | Minimum Unit Area (m²) | m²/person | Minimum Unit Area (m²) | m²/person | Minimum Unit Area (m²) | |
| Health Facility Area | 1,50 | 750-2.000 | 1,50 | 750-2.000 | 1,50 | 750-2.000 | 1,60 | 750-2.000 | 500 |
| Green Area | 10,00 | — | 10,00 | — | 10,00 | — | 10,00 | — | 500 |
| Kindergarten Area | 0,50 | 1.500-3.000 | 0,50 | 1.500-3.000 | 0,60 | 1.500-3.000 | 0,60 | 2.000-4.000 | 500 |
| Primary School Area | 2,00 | 5.000-8.000 | 2,00 | 5.000-8.000 | 2,00 | 5.000-8.000 | 2,00 | 5.000-8.000 | 500 |
| Secondary School Area | 2,00 | 6.000-10.000 | 2,00 | 6.000-10.000 | 2,00 | 6.000-10.000 | 2,00 | 6.000-10.000 | 1000 |
| High School Area | 2,00 | 6.000-10.000 | 2,00 | 6.000-10.000 | 2,00 | 6.000-10.000 | 2,00 | 6.000-10.000 | 2500 |
| Mosque Area | 0,50 | 1.000 | 0,50 | 1.000 | 0,75 | 1.000 | 0,75 | 1.000 | 250 |

The table shows coefficients for calculating the per capita area of public facilities, with minimum required areas indicated in square meters. For instance, to calculate the required health facilities area for a region with a population of 150,000, the following method is used:

$$population \times coefficient(m^2/person) = the\ total\ required\ health\ facility\ area \quad \textbf{(1.1)}$$

$$\frac{the\ total\ required\ health\ facility\ area}{minimum\ unit\ area\ (m^2)} = number\ of\ health\ facilities \quad \textbf{(1.2)}$$

$$150.000 \times 1{,}50 = 225.000\ m^2\ the\ total\ required\ health\ facility\ area\ for\ region$$

$$\frac{225.000\ m^2}{750\ m^2} = 300\ units$$

or

$$\frac{225.000\ m^2}{2000\ m^2} = 112.5\ units$$

or

$$\frac{225.000\ m^2}{5000\ m^2} = 45\ units$$

The number of health facilities will vary based on the preferred minimum unit area, as demonstrated in the example. Thus, the spatial distribution of these areas in the region is more crucial than the size of the area and the number of facilities. To ensure that public facilities meet the needs of residents, walking distances have been determined to achieve an appropriate spatial distribution. As the Table 1.1 shows, a walking distance of 500 meters was also preferred as relatively more convenient.

However, determining the suitability of public facilities cannot rely solely on size, number, or walking distance. Other factors, such as high population density, availability of transport and technical infrastructure services, are also very important in terms of suitability. Therefore, this thesis conducted research on public facility areas determined by zoning plans.

The aim of this research is to analyze the suitability of proposed public facilities in zoning plan and develop a methodology for integrating GIS and AHP into public facility suitability analysis. The developed methodology will be applied to a case study, and the results will be analyzed. Based on the findings, suggestions will be provided for improving public facility planning and management.

## 1.3 Study Area

Kayseri is a city located in the Central Anatolia Region of the Republic of Turkey, between the latitudes of 37°45'N and 38°18'N and the longitudes of 34°56'E and 36°58'E (Figure 1.1). It has an area of 16,975 $km^2$ and a population of 1,441,523 people, with an elevation of 1071 m.


**Figure 1.1 The map of Kayseri Province**

The Melikgazi Municipality is both the central and most populous district of Kayseri Province, covering an area of 600 square kilometers and a population of 594,344 people (Figure 1.2).

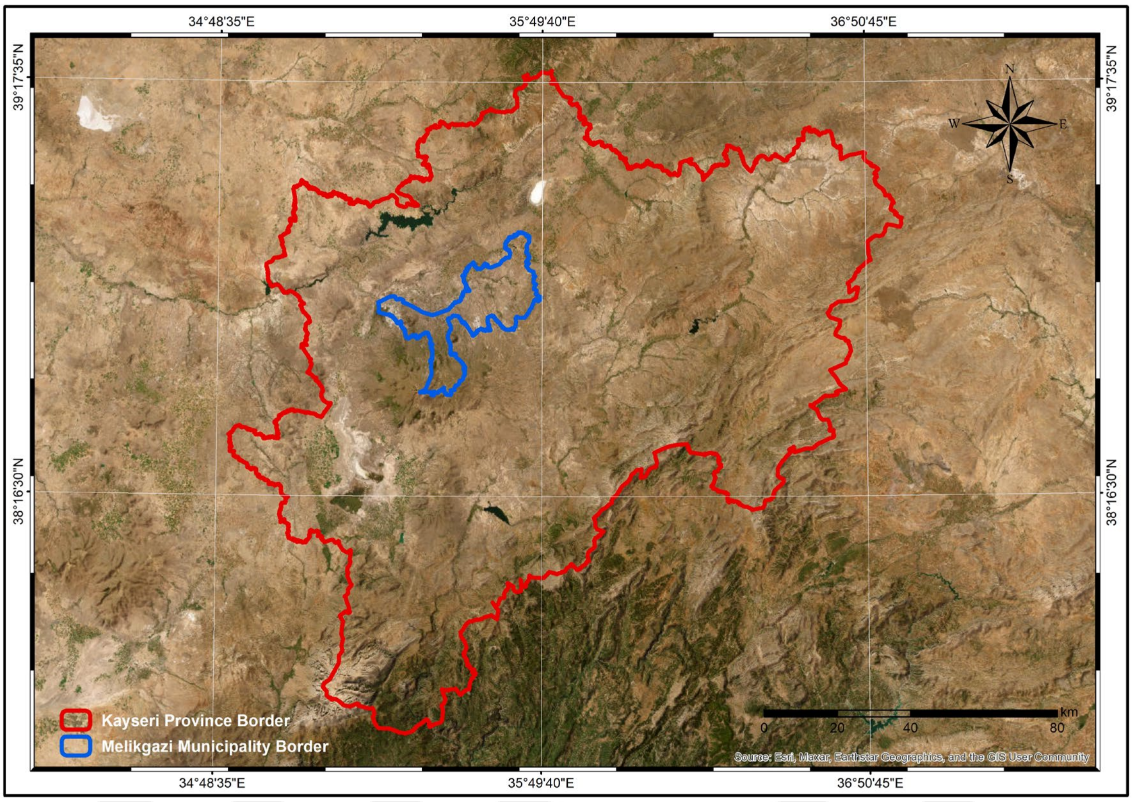



**Figure 1.2 The map of Melikgazi Municipality**

The study area is situated in the city center and covers seven neighborhoods within the borders of Melikgazi Municipality (Figure 1.3, Figure 1.4). It is surrounded by main roads, 70 meters to the west and 50 meters to the north, south, and east, which form the primary transportation network of the city. Furthermore, the tram line that originates from the western part of the city and passes through the city center divides into two directions within the boundaries of the study area and continues on the north-eastern and south-eastern lines.

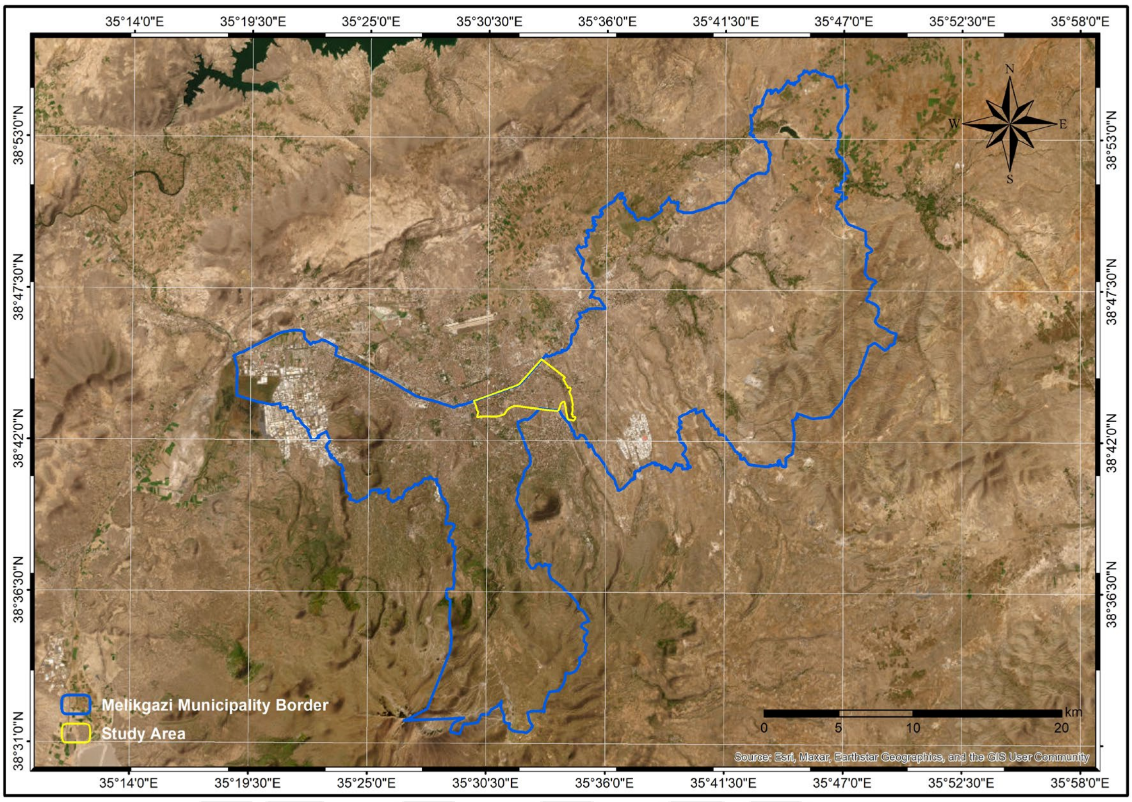



**Figure 1.3 Location of the study area within the borders of Melikgazi Municipality**


**Figure 1.4 The map of the study area**

The residential areas within the study area have been a popular choice for over two decades due to their proximity to the city center, transportation facilities, and public buildings. The city's development area has expanded from the center to the east, enabling the establishment of popular shopping malls over the last 20 years. This expansion has also led to the improvement of infrastructure facilities and transportation networks, the reduction of slum settlements, and the opening of new construction sites. The construction in the western part, closest to the city center, is almost complete, while the eastern part is still under development (Figure 1.5).

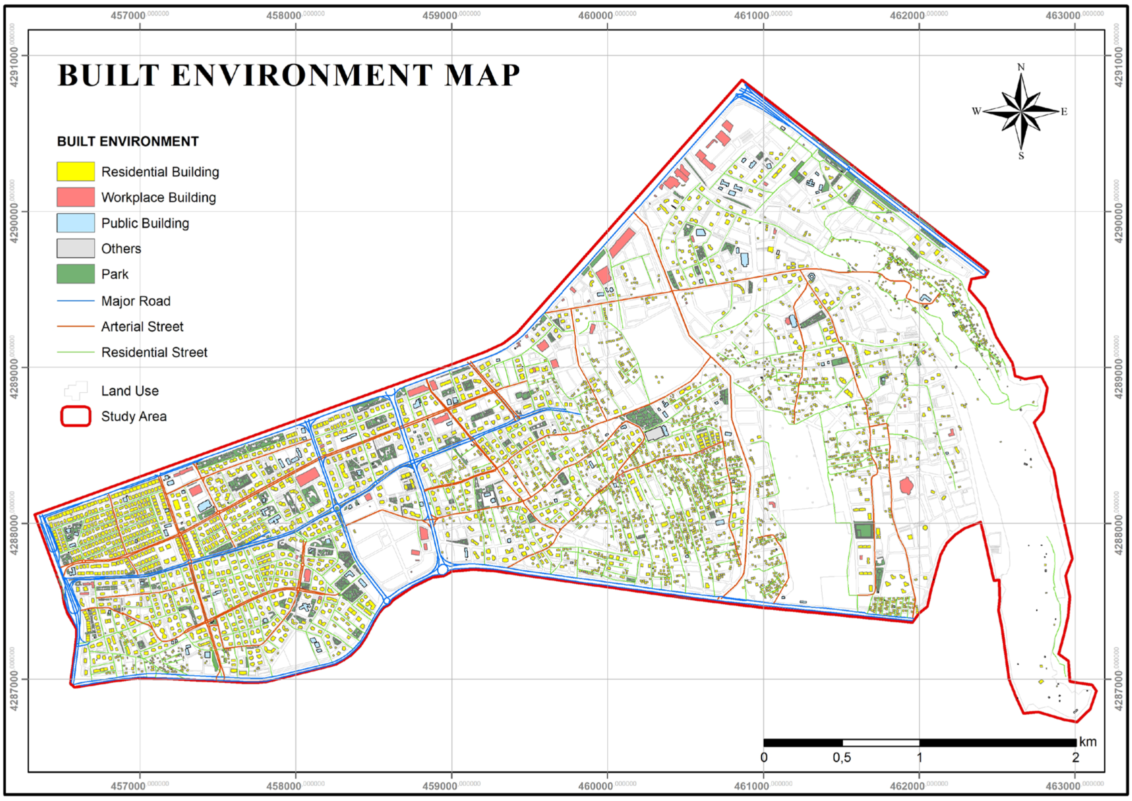



**Figure 1.5 The built environment map of study area**

The area of the city has a high population density and daily mobility. It is popular among the city's residents, with some areas already developed and others still under construction. These conditions make it suitable for evaluating public facilities.

## 1.4 Methodology

The study presents a methodology for assessing the suitability of public facilities and integrating GIS and AHP in public facility suitability evaluation as seen in Figure 1.6.

The first step was to analyze the existing literature on public facilities, Geographical Information Systems (GIS), the Analytical Hierarchy Process (AHP) and how they relate to each other.

The study area's most appropriate criteria and required data were determined by compiling the literature review results. The relevant criteria and data were collected from various institutions and organizations in different formats. The data was analyzed using ArcMap desktop application, based on geographical information systems. It was processed by separating and grouping the data, and the database was established by converting it into shapefiles with TUREF 36M coordinate system. Spatial analyses of the determined criteria in the study area produced information maps and thematic maps, thanks to the established database.

Weight values were calculated by applying the Analytic Hierarchy Process (AHP) to the criteria to perform the suitability analysis.

Weighted overlay and weighted sum analyses were performed using geographical information systems to produce suitability maps for public facilities. The results are presented and discussed.

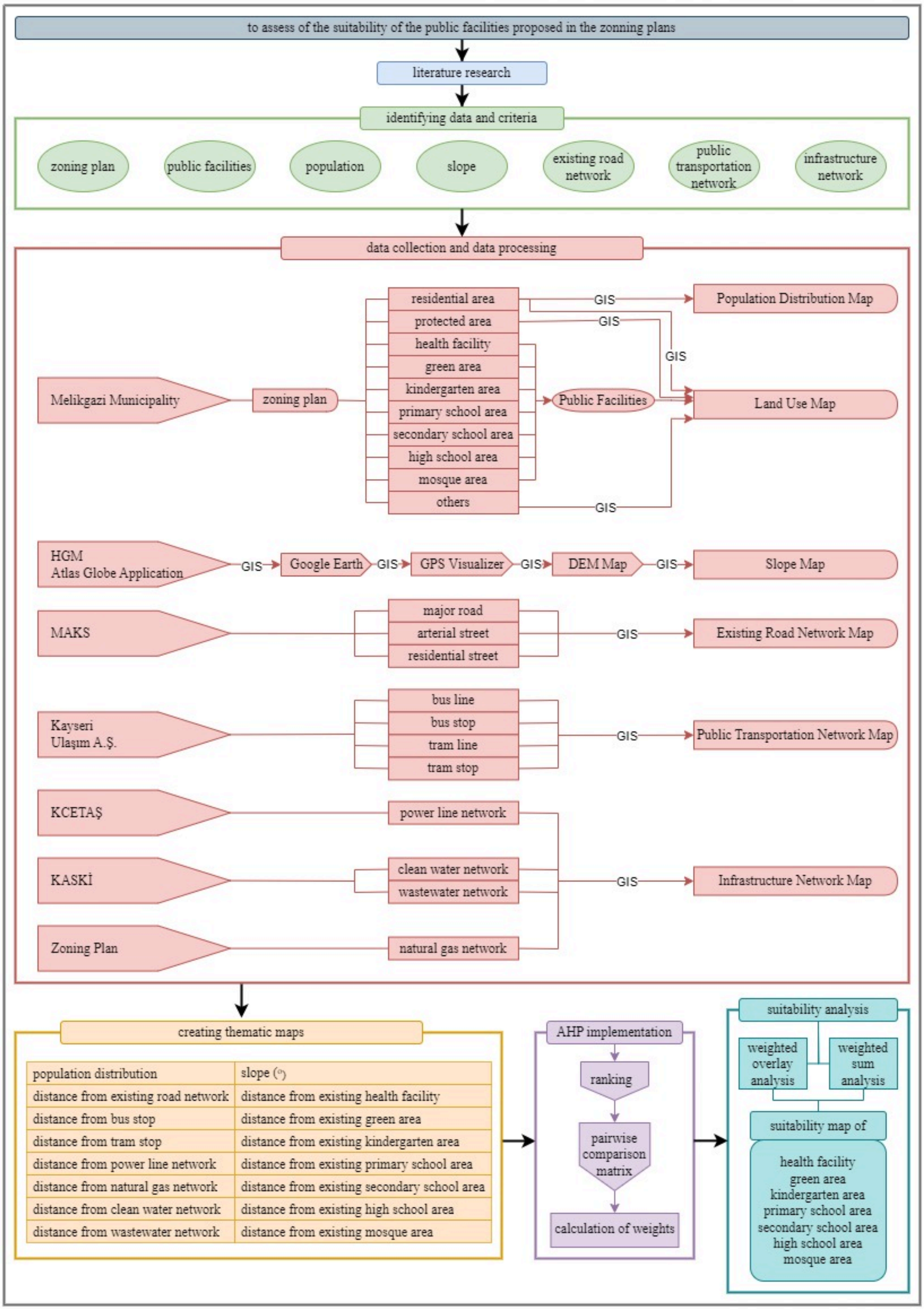



**Figure 1.6 The flow chart of the methodology**

# Chapter 2

# Literature Review

## 2.1 Public Facilities

Public facilities refer to facilities, services, or infrastructure that the state or public organizations are obligated to provide for the overall benefit of the population residing in settlement areas. These facilities should be easily accessible to citizens of all ages and socio-economic backgrounds, geared towards serving the public interest and directly contributing to the well-being and functionality of communities.

If individual analysis is conducted regarding the significance of public facilities, it becomes clear that educational facilities must be provided to the entire population as they are imperative for both individual development and social progress. In addition, public health facilities are necessary to ensure the well-being of society, prevent the spread of diseases, and follow-up on medical treatment programs. Recreational facilities are essential for enabling social interactions within the community, as well as improving the welfare and overall quality of life. These facilities offer a diverse range of activities for individuals to engage in. Conversely, religious facilities should be established based on the prevailing belief preferences of the society, as they serve as hubs for religious education, training, and worship. In addition to the aforementioned, matters pertaining to transportation infrastructure, other infrastructure services, emergency services, government facilities, and waste disposal in residential areas are also encompassed under public facilities. Their requirements are clear. Public facilities, regardless of their nature, are essential components that promote social equity, support economic growth, and improve the overall quality of life within a community. Studies on public facilities have been conducted extensively in the past and present.

Carbone (1974) extended the problem of public facility location by introducing random variables for the number of users. Hodge and Gatrell (1976) investigated the influence of urban spatial form on fair public facility location. Terry Rose and Soland

(1980) argued that public facility location problems should be viewed as multi-criteria problems. Bach (1980) discussed the significance of central location in the distribution of public facilities. Ikporukpo (1987) emphasized the importance of accessibility to public facilities for efficient demand. Min (1988) presented an interactive fuzzy goal programming model for the relocation and expansion of overcapacity public facilities. Yeh and Chow (1996) proposed a location allocation model for effective public facilities planning and discussed the integration of Geographic Information Systems (GIS). Tsou (2005) introduced integrated equity indices using GIS and spatial analysis models, with an emphasis on ensuring fairness in the distribution of urban public facilities. Chang and Liao (2011) presented an integrated modelling framework for assessing spatial equity in the distribution of public facilities, using GIS and spatial analysis models based on the gravity model. Reyes et al (2014) assessed the geographical accessibility of urban parks for children and highlighted the significance of urban parks in terms of environmental and social value. Taleai et al (2014) conducted a spatial multi-criteria analysis to evaluate the balance between the supply and demand of public facilities, while also considering spatial equity in sustainable urban planning. Azmi and Ahmad (2015) identified key indices that contribute to enhancing the accessibility of public facilities in neighborhood areas, with a focus on walkability using GIS. Fan et al (2017) proposed the 'green accessibility index' to measure residents' access to various types of public urban green spaces. Ye et al (2018) used a two-stage floating catchment area model (2SFCA) to examine changes in urban green space accessibility. Tahmasbi et al (2019) assessed horizontal and vertical equity by analyzing the accessibility of public facilities with GIS. Li et al (2021) investigated the accessibility of fundamental public facilities in the city by taking into account various modes of transportation and socio-economic groups. Correa-Parra et al (2020) and Caselli et al (2022) evaluated the potential of an urban area to transform into a 15-minute city by focusing on public facilities. Torinos et al (2022) analyzed the proximity of public facilities to the population using GIS, with a focus on sustainability.

Studies on public facilities have addressed various aspects, including stochastic evaluations, spatial form, multi-criteria problems, accessibility, equity, and the impact of dynamic changes. This emphasizes the importance of public facilities in urban planning.

## 2.2 Geographic Information Systems (GIS)

"A geographic information system (GIS) is a computer system used to capture, store, query, analyze, and display geographic data" [21]. GIS can make inferences about people based on the patterns of their lifestyles, their neighbors', and their friends' [22]. Collecting data has become easier with the advent of the internet and smartphones [23]. The most useful aspect of GIS is its ability to map and visualize data sets in a way that is easily understandable to everyone. If GIS lacked these features, people would need to examine pages and pages of data tables to draw conclusions [24].

GIS comprises hardware [25, 26, 27, 28, 29], software [25, 26, 27, 28, 29], users [25, 26, 27, 28, 29], data [25, 26, 27, 28, 29], graphical data processing [25], organization [25], data usage areas [25], methods [27, 28], and targets [29]. However, considering the basic components, four headings emerge:

***Hardware*** refers to technological devices such as computers, printers, plotters, GPS, and smartphones used to process and manage data.

***Software*** encompasses commercial or open-source computer programs and applications that enable data processing, management, and display.

***The user*** is the individual who adjusts, processes, and presents the system and data according to their needs and goals.

***Data*** refers to the information processed and managed by the hardware and software. In GIS, both graphical and non-graphical data are utilized. Figure 2.1 presents the data types in GIS, rearranged from Alkış's study (1996).

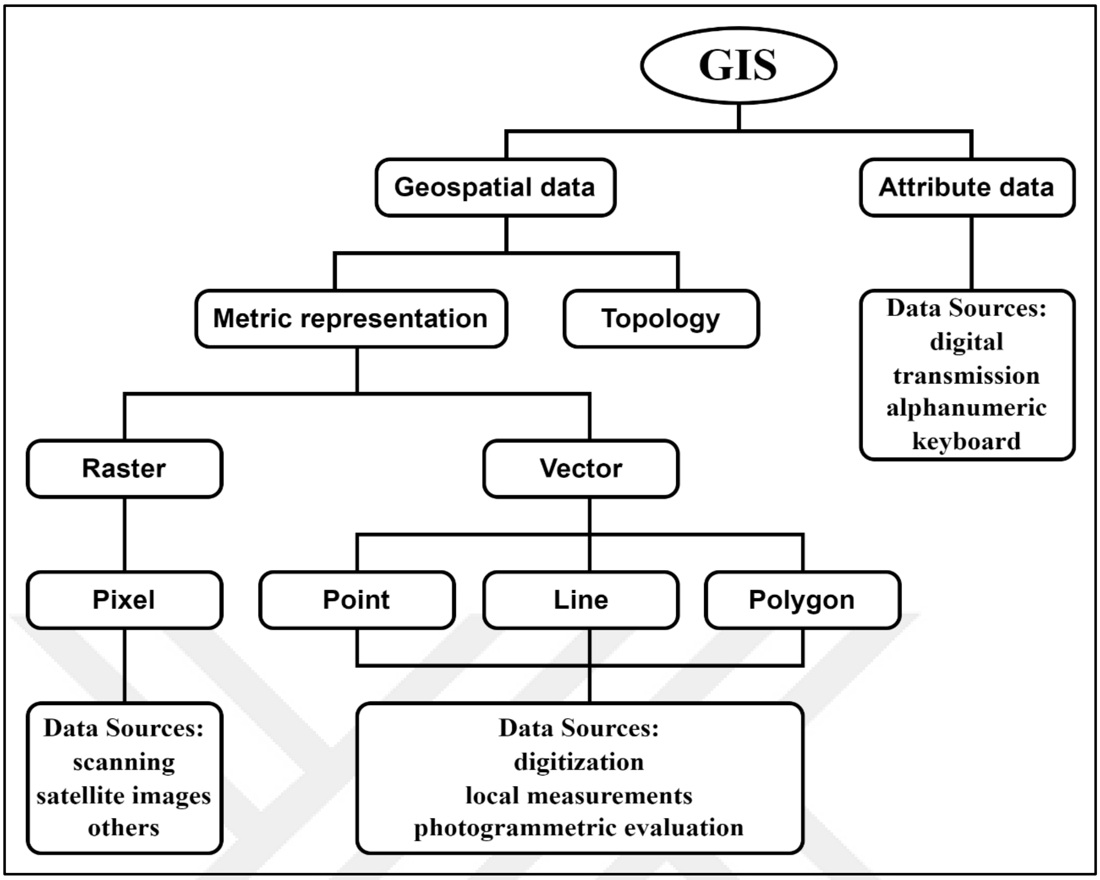



**Figure 2.1 The data type in GIS (rearranged from Alkış's study (1996))**

GIS has a wide range of usage areas. Following list was edited from the studies of Tecim (2008), Rüstemov (2014), Özdemir (2019) and Chang (2019):

- Environmental Management
- Management of Natural Resources
- Administrative Management
- Urban Planning
- Cadastral Management
- Municipal Activities
- Transportation Planning
- Geological Activities
- Disaster Management
- Emergency Planning
- Educational Activities
- Healthcare Management
- Public Order Management

- Forestry Activities
- Agricultural Activities
- Tourism Activities
- Trading Activities
- Industrial Activities
- Military Activities

Besides, according to Scollon (2013), GIS can be used for resource exploitation, economic inequality, the perpetuation of violence, violations of privacy, to democratize, to organize, to advocate, to design and to dream.

Geographic Information Systems (GIS) are versatile and indispensable technologies that empower users to harness the power of spatial data for myriad applications across various domains.

## 2.3 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a decision-making methodology developed by Thomas L. Saaty in the late 1970s, widely recognized and powerful. AHP aids individuals or groups in making complex decisions by organizing them into a structured hierarchy of criteria and alternatives and then systematically evaluating and comparing these elements. The decision-making process can include objective and subjective evaluations in addition to technical data. Therefore, experts widely prefer AHP for its capacity to break down intricate problems, measure preferences, establish priorities, organize decision-making processes, integrate subjective judgments, provide consistency, and be applicable.

AHP is a versatile technique that combines both qualitative and quantitative factors to conduct thorough evaluations of alternative options [30]. It has been widely implemented across numerous disciplines including human resources, production, marketing, finance, mathematics, information and communication technologies, nuclear technology, procurement, planning, urbanization and the environment [31].

Furthermore, Vaidya and Kumar (2006) conducted an analysis of AHP studies, examining its purposes and areas of application. Their study revealed that AHP has been utilized in numerous subjects, including selection, evaluation, benefit-cost analysis, priority-setting, development, resource allocation, decision-making, forecasting, medicine, and quality function deployment (Figure 2.2). In addition, AHP has been employed in various fields of study, such as personal, social, manufacturing, political, engineering, industry, and government (Figure 2.3).

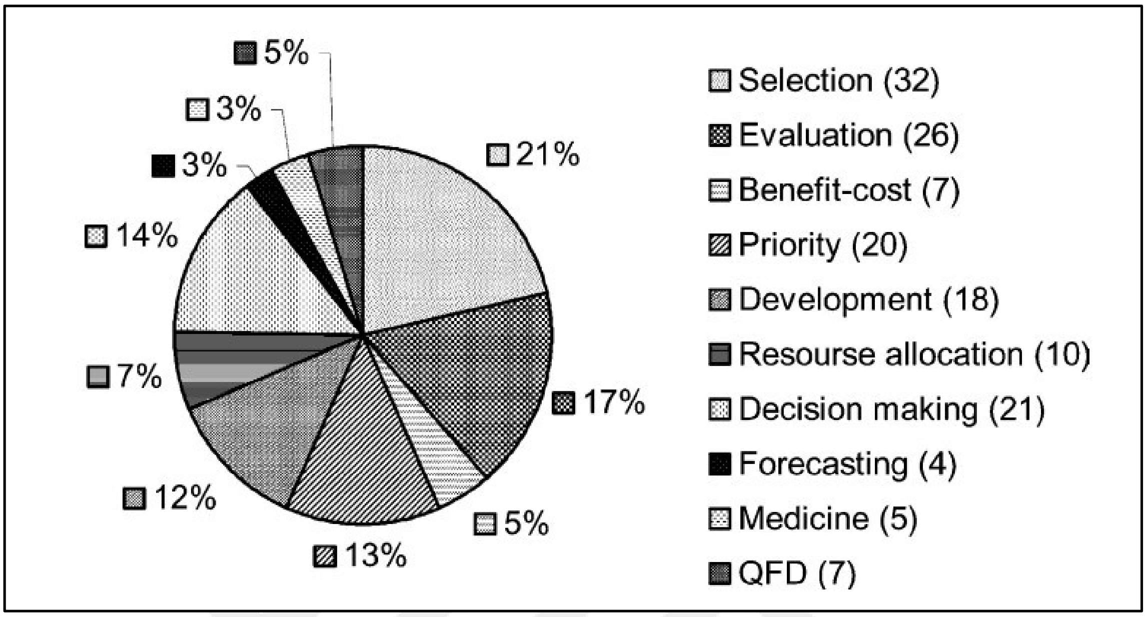



**Figure 2.2 Theme specific distribution of review papers [90]**

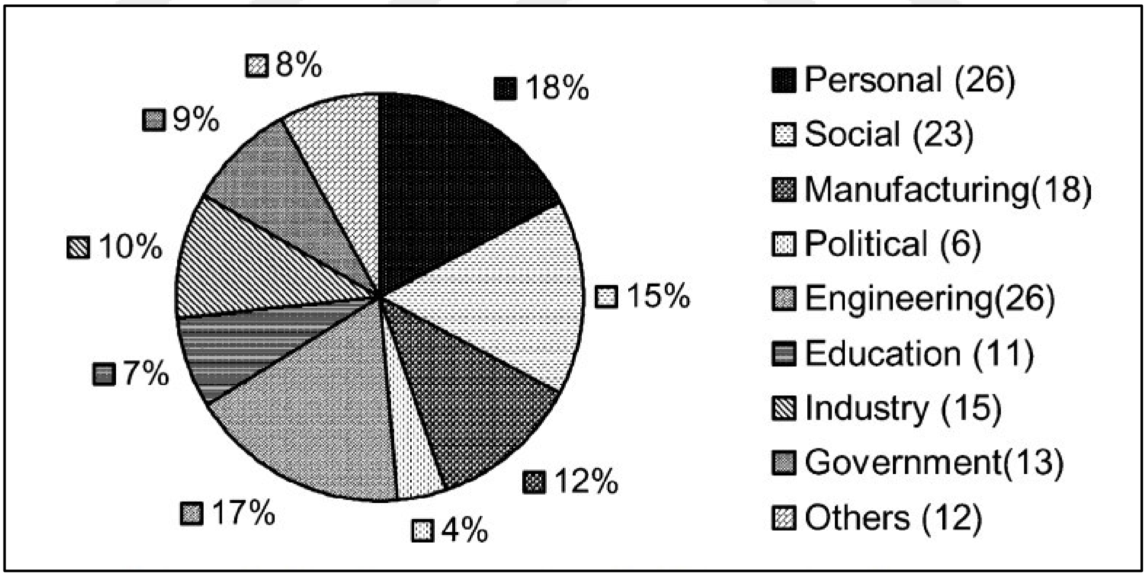



**Figure 2.3 Application area specific distribution of review papers [90]**

## 2.4 Integration of GIS and AHP

The integration of GIS and AHP in spatial decision-making has become increasingly important due to the complementary strengths of these two methodologies. GIS handles the spatial aspects of the data, while AHP provides a structured framework for decision-making based on a set of criteria.

GIS and AHP integration has been the subject of many studies in different disciplines such as land suitability analysis [32, 33, 34, 35, 36, 37, 38, 39, 40, 41], site selection for solar energy fields [42, 43, 44, 45], ecotourism regions [46], organic farms [47], landfills [48, 49, 50, 51], charging station [52], parking areas [53], urban regeneration areas [31], livestock farm [30], shopping centers [54], and house selection [55], disaster management such as floods [56, 57, 58, 59], earthquakes [60] and fires [61], and environmental quality [62].

## 2.5 Analysis of Public Facilities Using GIS&AHP

Geographic Information Systems (GIS) and Analytic Hierarchy Process (AHP) are combined in the analysis of public facilities, making it an important step in contemporary urban planning and decision-making processes. This synthesis of methodologies increases the precision and efficiency of public facility analysis and bridges the gap between spatial information and decision outcomes.

When analyzing public facilities using GIS and AHP, studies on urban green areas [63, 64, 65, 66, 67, 68, 69, 70], health facilities [71, 72, 73, 74, 75, 76, 77, 78], educational facilities [40, 79, 80], and multiple public facilities [81] are prominent. These studies utilize data such as road networks, distance to public transport systems, and population, along with data on the characteristics of the study areas.

# Chapter 3

# Data

## 3.1 Identifying Data

The literature research revealed that public facilities' suitability and site selection studies relied on various data.

Table 3.1 shows that road network, population, existing health area, and public transportation data were the most commonly used data in health facility studies.

Similarly, Table 3.2 indicates that road network, slope, land use, green/vegetation, and water body data were the most commonly used factors in green area studies.

Table 3.3 shows that studies on educational facilities, population, slope, and road network data were the most commonly used.

The study that investigated the suitability of 12 different public facilities only conducted accessibility analysis on a minute level (Table 3.4).

After examining 20 different studies, it was found that although the data varied due to geographical and geological characteristics of the study areas, differences in social structures, and specific study subjects chosen, the common point among all of them was the importance of accessibility in urban areas and suitable location of sites. Therefore, it has been determined that the road network, population, existing areas, public transportation, slope, and land use data are the most preferred, even if their impact values differ.

Based on the findings obtained from the literature study and the scope of this study, the following data will be used: zoning plan, seven different public facilities, population, slope, existing road network, public transportation network, and infrastructure network.

**Table 3.1 Data used in studies on health facilities**

| Data | Ohta et al, 2006 | Khaki et al, 2014 | Salehi & Ahmadian, 2016 | Ajaj et al, 2018 | Halder et al, 2019 | Kaveh et al, 2019 | Gönüllü & Yalçınkaya, 2020 | Dutta et al, 2021 |
|---|---|---|---|---|---|---|---|---|
| road network | * | * | * | * | * | * | * | * |
| population | * | * | – | * | * | * | * | * |
| existing healthcare | – | * | * | * | * | * | – | * |
| public transportation | – | – | * | * | * | – | * | – |
| water body | – | * | – | * | * | – | * | – |
| green area | – | – | * | – | * | * | – | – |
| land use | – | * | – | * | * | – | – | – |
| emergency need areas | – | * | * | – | – | * | – | – |
| slope | – | * | – | – | – | – | * | – |
| gas station | – | * | * | – | – | – | – | – |
| industrial area | – | – | * | – | – | – | * | – |
| educational area | – | – | * | – | * | – | – | – |
| others | availability of beds | potential | place of maternal mortality<br>number of midwives<br>access to maternal facility<br>number of physicians<br>access to cultural centers<br>access to sport centers | distance from public toilet | distance from agricultural land | distance from strong power lines<br>distance from fault (earthquakes, aftershocks area) | surface area (ha) | – |

**Table 3.2 Data used in studies on green areas**

| Data | Yannan et al, 2009 | Abebe & Megento, 2017 | Dağıstanlı et al, 2018 | Li et al, 2018 | Çağlayan et al, 2020 | Ustaoğlu & Aydınoğlu, 2020 | Gelan, 2021 | Li et al, 2022 |
|---|---|---|---|---|---|---|---|---|
| road network | * | * | * | * | * | * | * | * |
| slope | – | * | * | * | * | * | * | * |
| land use | * | * | * | * | * | * | * | – |
| green and vegetation | * | * | * | * | * | * | * | – |
| water body | * | * | * | * | * | * | * | – |
| population | – | * | * | – | – | * | * | * |
| elevation | – | – | – | * | * | * | * | * |
| pollution | * | * | – | * | – | – | – | * |
| heritage site | * | * | * | * | – | – | – | – |
| soil type | * | * | – | – | – | * | – | – |
| aspect | – | – | – | – | * | * | – | * |
| scenic beauty | – | – | – | – | * | – | * | – |
| public transportation | – | – | – | – | – | * | – | * |
| NDVI | – | – | – | * | – | – | – | * |
| Heat-island effect | – | – | – | * | – | – | – | * |
| others | geological type<br>basic farmland | – | erosion | significant infrastructure<br>geological disasters | canopy closure | distance from industry commerce | land ownership | precipitation<br>temperature |

**Table 3.3 Data used in studies on educational areas**

| Data | Javadian et al, 2011 | Samad et al, 2012 | Başer, 2020 |
|---|---|---|---|
| population | * | * | * |
| slope | * | * | * |
| road network | * | * | * |
| water body | – | * | * |
| others | capacity of educational centers of different areas | – | distance from existing schools |
| | | | land use |
| | | | soil |
| | | | proximity to electrical transmission lines |
| | | | geology |

**Table 3.4 Data used in studies on other areas**

| Abd El Karim & Awawdeh, 2020 | |
|---|---|
| **Public Facilities** | **Data** |
| universities | 5-minute<br>10-minute<br>15-minute |
| high schools | |
| middle schools | |
| elementary schools | |
| hospitals | |
| health centers | |
| ambulance facilities | |
| government services | |
| religious services | |
| security services | |
| sports services | |
| recreational services | |

## 3.2 Data Collection and Data Processing

### 3.2.1 Zoning Plan

Zoning plans take into account the region's conditions and the planning area's characteristics, as well as the building's purpose, accessibility, sustainability, and environmental impact. They provide information on building blocks, number of floors, floor area coefficient, yard distances, lines determined for parcel formation, vehicle, pedestrian and bicycle paths, parks, squares, and urban, social and technical infrastructure. Thus, the decision was made to utilize the zoning plan for this study. and the zoning plan for the study area was obtained from Melikgazi Municipality as a CAD-based NCZ file. Various types of data, including polygon, line, polyline, and point, were transferred to ArcGIS. The data was converted into polygon vector data and saved as a SHP file in the TUREF 36M coordinate system, which is used in zoning plans. After transforming and preparing the data for the study area, the data was classified and used to produce information maps.

The types of public facilities to be analyzed were determined based on literature research and zoning plans. Health facility areas and green areas were found to be the most studied subjects. Additionally, there are a few studies on education facility areas. However, urban areas require more than just health facilities and green spaces. While these facilities appeal to all segments of society, there is also a need for educational facilities for different age groups and mosque areas that appeal to a specific segment of society. As such, this study has identified and selected seven different types of public facilities proposed in the zoning plans. The selected facilities for this study include health facilities, green areas, kindergartens, primary schools, secondary schools, high schools, and mosques. These facilities were chosen because they are easily accessible to people of all ages and economic backgrounds in urban areas and are considered necessary for the public benefit. The study excluded areas designated for private sector construction and operation.

Additionally, the data from zoning plans was used to create land use and population maps.

#### 3.2.1.1 Land Use

It has been found that the land use data used in the studies varied within the scope of the study subject. In the studies that analyzed health facilities, land use maps were produced using various criteria, such as vegetation [72, 75], current urban land use [74], ownership status [74], separation of agricultural areas [75]. When analyzing green areas, land use maps were produced based on different categories such as vegetation [68, 69], natural environment [64, 65, 67, 70], and built environment [64, 65, 67, 69, 70]. In contrast, Baser (2020) created land use maps for his study on educational facilities by distinguishing between vegetation, agricultural areas, natural environment, and built environment.

In this study, a land use map was created by reclassifying the zoning plan and data on various areas, including residential, protected, health, mosque, kindergarten, primary school, secondary school, high school, green, and others, in an area with high population density in the city center where construction is mostly completed. The map is presented in Figure 3.1.

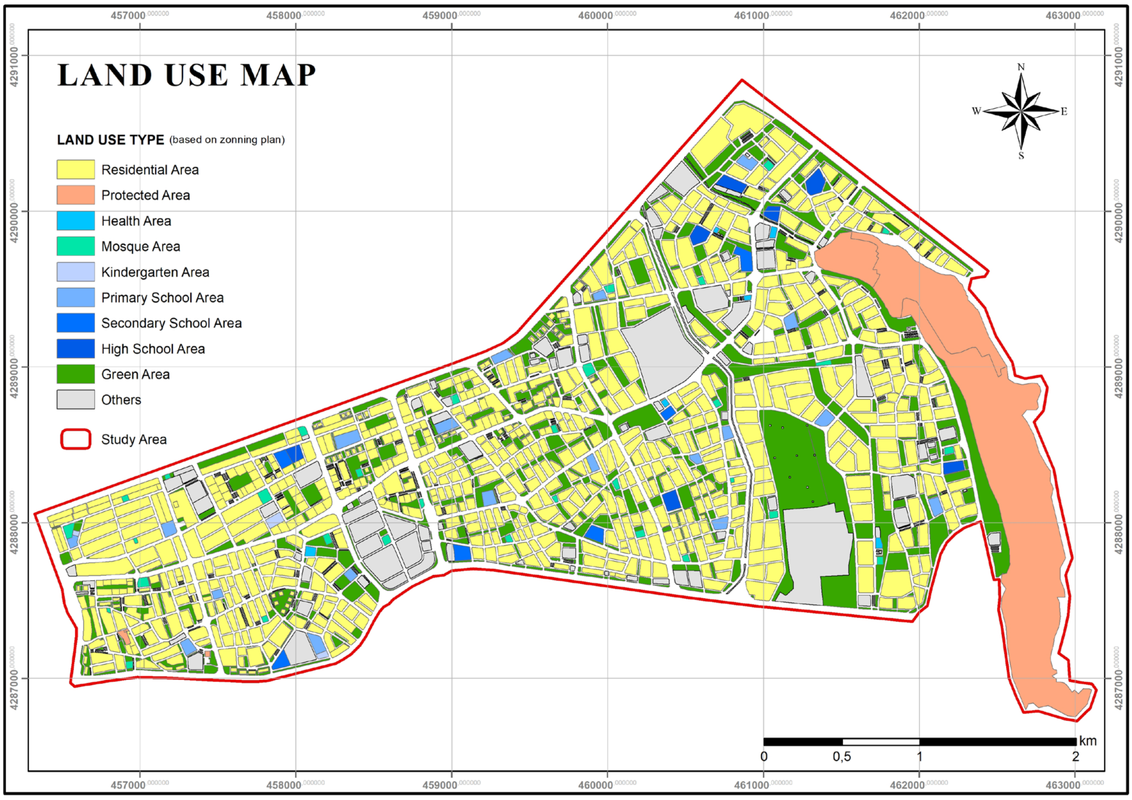



**Figure 3.1 The land use map of study area**

### 3.2.1.2 Population

Areas with high urban population density are crucial in assessing the spatial distribution and suitability of public facilities. As a result, such data is frequently used in studies analyzing public facilities.

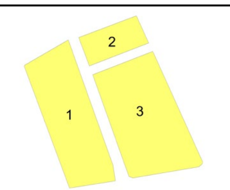
The population of the study area was calculated using the following formula (3.1), based on the residential blocks in the zoning plan and the building rights assigned to them:

$$\frac{total\ area\ of\ residential\ block \times E(the\ floor\ area\ ratio)}{average\ flat\ area} \times average\ family\ size \qquad \textbf{(3.1)}$$

- ***Total area of residential block*** is the area of each residential block in square meters.
- ***E (the floor area ratio)*** is the ratio of the total floor area of a building to the area of the residential block in which it is situated, as determined by zoning plans.
- The accepted ***average flat area*** is 150 square meters.
- The accepted ***average family size*** is 4 people.

Table 3.5 presents an example of the population calculation for three residential blocks using the provided formula.

**Table 3.5 Sample table of population calculation**




| Residential Block | Total area of residential block (square meters) | E | Average flat area (square meters) | Average family size (person) | Population (person) |
|---|---|---|---|---|---|
| 1 | 7783,97 | 1,00 | 150 | 4 | 208 |
| 2 | 2123,25 | 1,60 | 150 | 4 | 91 |
| 3 | 9186,92 | 1,00 | 150 | 4 | 245 |

To calculate the population of each residential block, the area (in square meters) and E ratio data were inputted into the ArcGIS program to create a population calculation table. The population data was then calculated using the field calculator. Next, population ranges were determined in ArcGIS and a distribution map was produced (Figure 3.2).

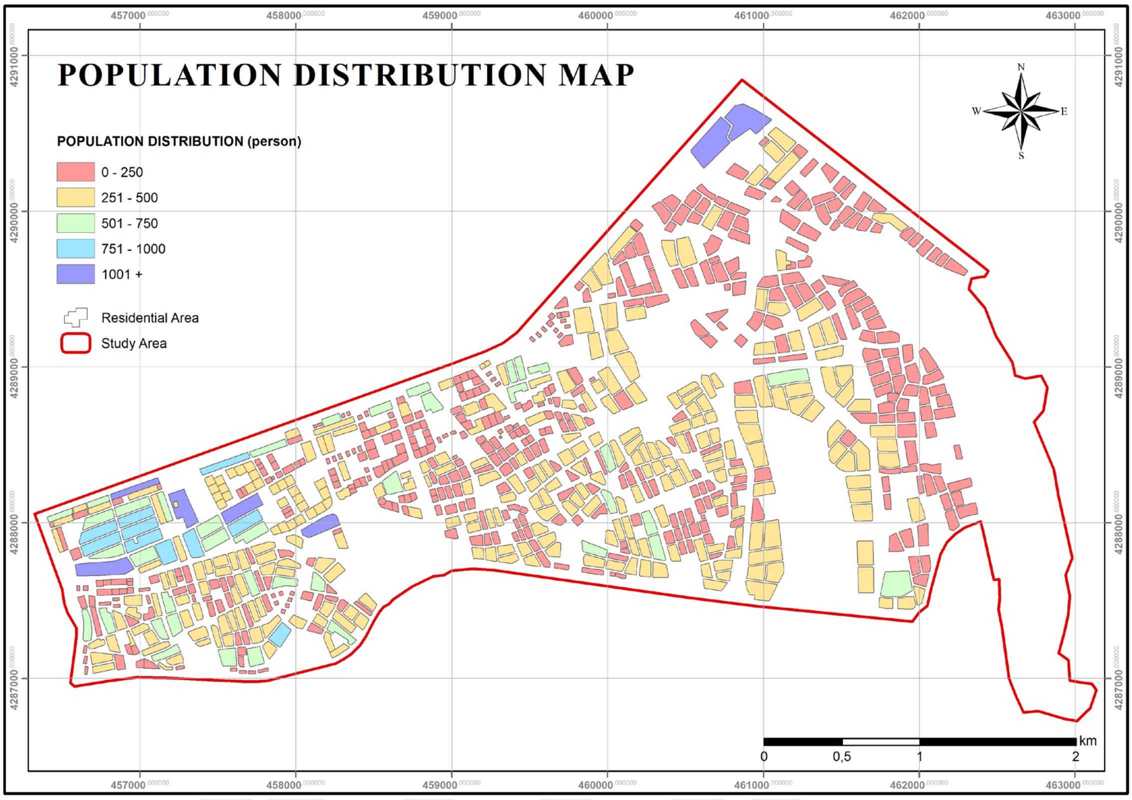



**Figure 3.2 The population distribution map of study area**

The study area has an average population of 263 people. However, the population density is higher in the northwestern region close to the city center and decreases towards the east. Therefore, population distribution is a crucial factor in making development and investment decisions in urban areas.

## 3.2.2 Slope

Slope is a crucial topographical feature that directly impacts construction, transport facilities, and associated costs and durability. As such, it is commonly used as a criterion in urban studies.

To obtain a slope map of the study area, the first step is to save the study area marked in the HGM GLOBE program as a KML file. In the second step, the KML file was transferred to ArcGIS and converted into a SHP file, and then a point file was created within the study area using the 'create random points' command. In the third step, the point file was uploaded to Google Earth and saved as a new KML file. Finally, each point was assigned an elevation value using the GPS Visualizer program to create a GPX file. The given GPX file underwent processing using the 'GPX to Feature' command in the ArcGIS program, resulting in the creation of a new dataset. The coordinate system was defined as TUREF 36M. Subsequently, an interpolation (IDW) analysis was performed on this dataset in ArcGIS, leading to the creation of a DEM map. Raster surface analysis was then applied to obtain slope data, which was subsequently reclassified at appropriate intervals to produce a slope map [85] (Figure 3.3).

As slope data for the study area was not available, various software was used to produce the required data for creating a slope map. TIN (triangular irregular networks) is commonly used for creating surface models, but it could not be used in this case due to the inability to achieve the required contour lines' clear and regular form. A slope map was produced using the IDW (Inverse Distance Weighting) method. This method calculates cell values with unknown points by using the values of sample points in a certain area [91].

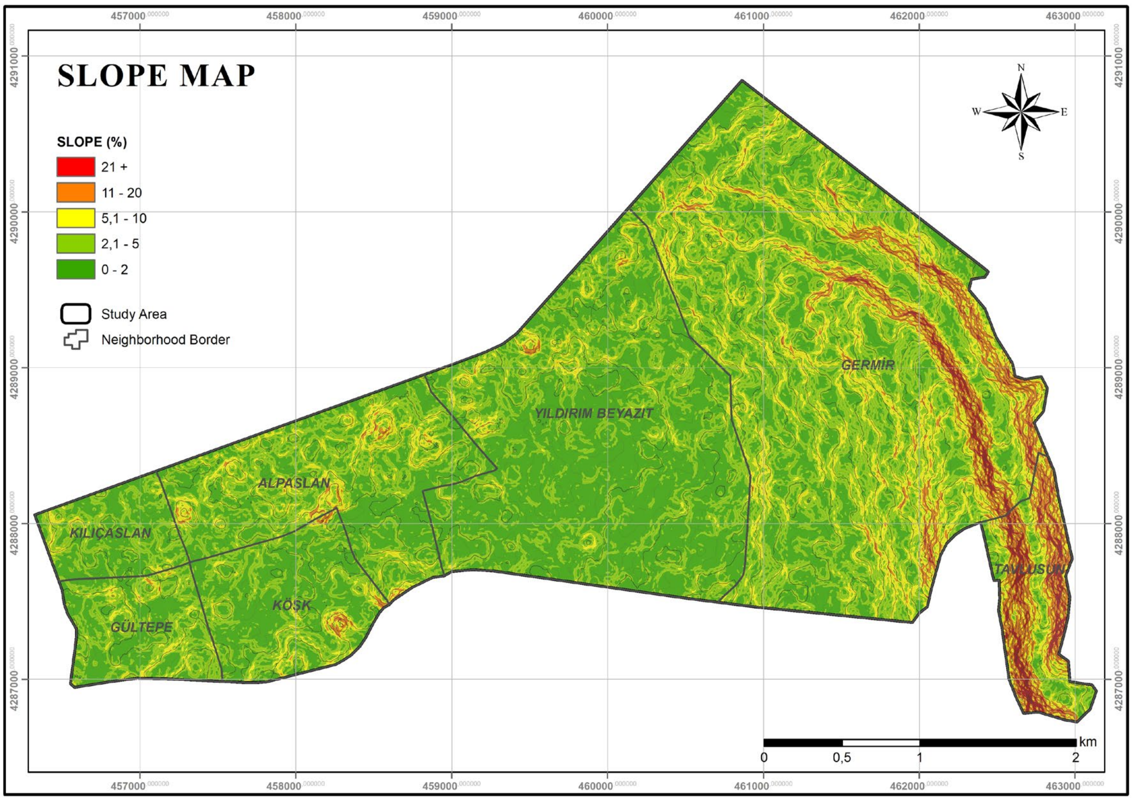



**Figure 3.3 The slope map of study area**

### 3.2.3 Existing Road Network

Transportation facilities are crucial components of settlements. Road networks, which are essential for accessibility, not only facilitate transportation by vehicles but also serve as the foundation for public transportation alternatives and infrastructure services. Therefore, road networks are a key consideration in every study conducted in urban areas, as they enable not only the transportation of people from one place to another but also the transportation of urban services.

MAKS was used to obtain the road network data for the study area as an SHP file. The data was then reorganized and classified in the ArcGIS program, and mapped as major roads, arterial streets, and residential streets (Figure 3.4).

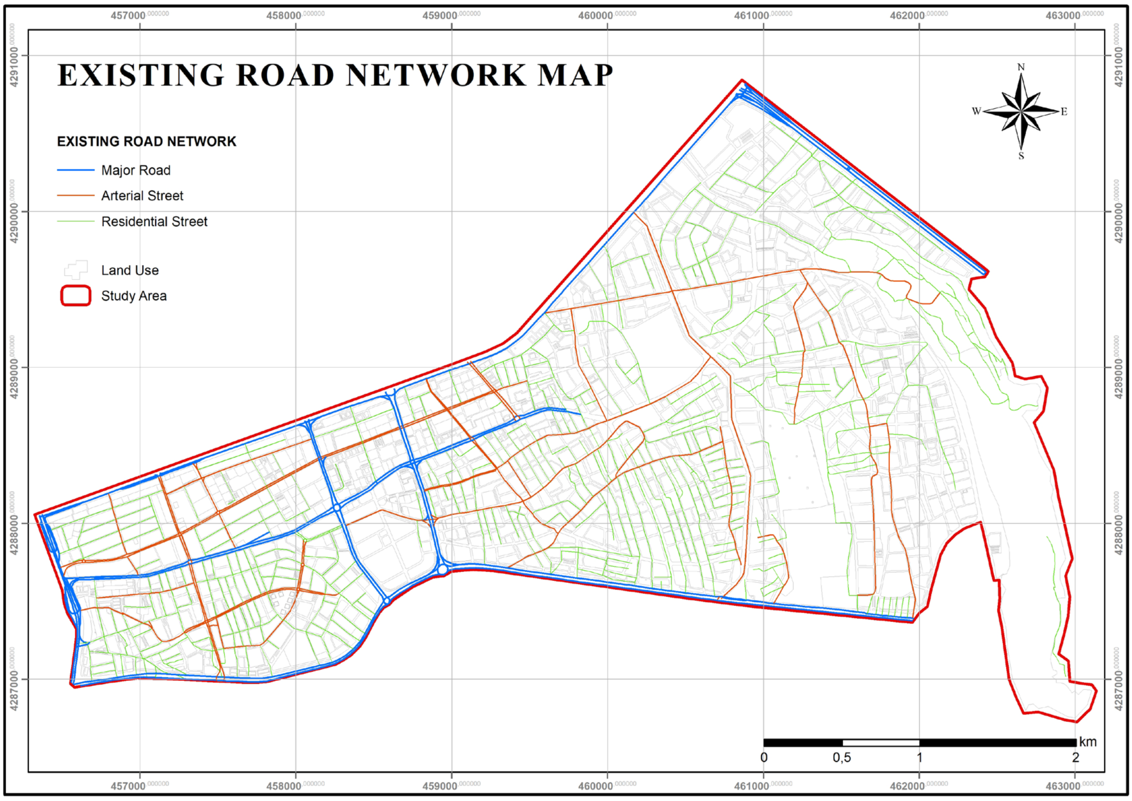



**Figure 3.4 The existing road network map of study area**

The study area is defined by the main roads that form the primary transportation network of the city. These roads are 70 meters wide in the west and 50 meters wide in the north, south, and east. Additionally, roads that connect central points within the study area and have a width of more than 30 meters are also classified as main roads due to their high traffic density. Arterial streets are those with a road width between 15-30 meters, while residential streets have a width of less than 15 meters.

The road networks in the study area are mostly regular and uninterrupted in areas closer to the center and where construction is complete. However, road networks have not yet formed in regions where construction is incomplete towards the east.

### 3.2.4 Public Transportation Network

The use of private vehicles in cities is on the rise. However, not all age groups can rely on vehicles to meet their needs in urban areas, particularly when it comes to accessing public facilities. Therefore, the study considers the importance of public transportation in the urban area, including its routes and stop locations, as criteria for accessibility.

The study area has two types of public transportation: bus lines and tram lines.

#### 3.2.4.1 Bus Line Network

The bus lines and stops within the study area were obtained from Kayseri Ulaşım A.Ş. in KML file format. The KML data was then transferred to the ArcGIS program and converted to the TUREF 36M coordinate system before being reorganized as an SHP file.

#### 3.2.4.2 Tram Line Network

The tram lines and stops within the study area were also obtained from Kayseri Ulaşım A.Ş. in KML file format, transferred to ArcGIS, converted to TUREF 36M coordinate system, and reorganized as an SHP file.

#### 3.2.4.3 Public Transportation System

The bus lines, bus stops, tram lines, and tram stops were reorganized and merged in the TUREF 36M coordinate system using ArcGIS. The resulting was reflected on the public transportation system map. (Figure 3.5).

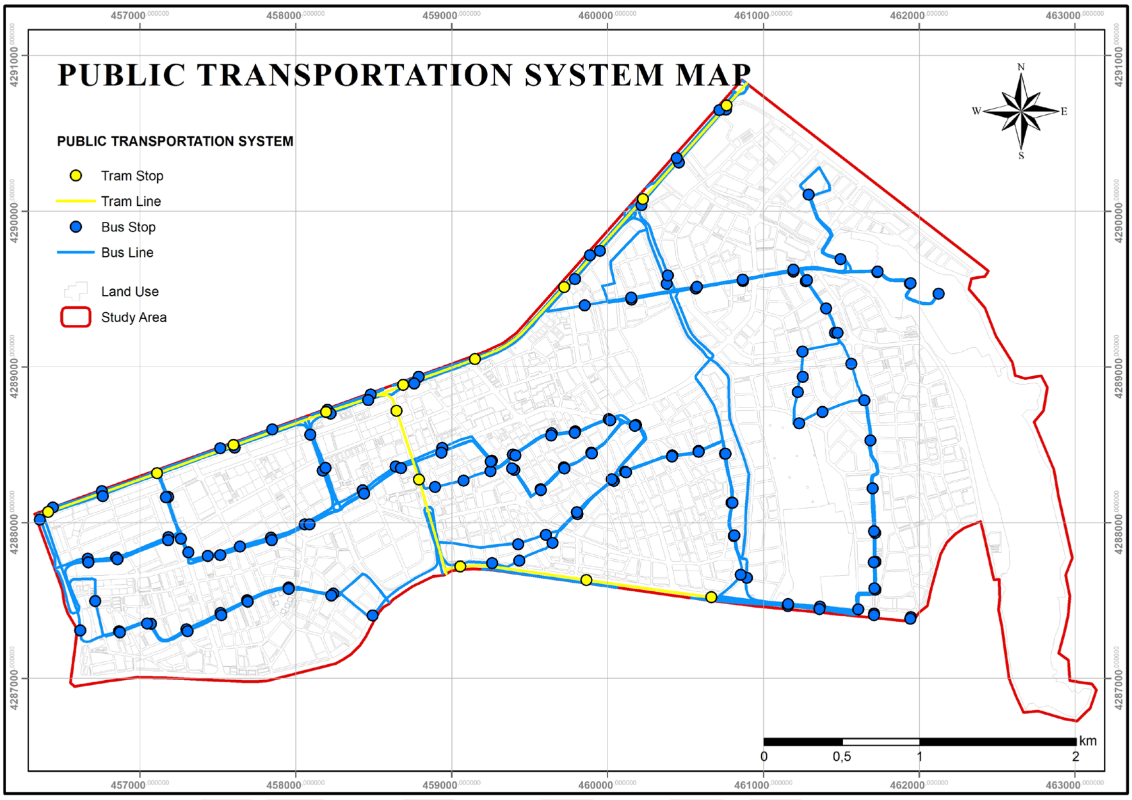



**Figure 3.5 The public transportation system map of study area**

In the public transportation system in the study area, bus lines and bus stops come from various parts of the city and generally use arterial street routes to access various parts of the residential area.

Tram lines and stops come from the western part of the city center and continue to the eastern part of the city and are divided into two lines within the study area. The first line provides access to the eastern and western end of the city, while the second line provides access to the southern areas. There are also transfer facilities at the intersection points.

### 3.2.5 Infrastructure Network

The presence of technical infrastructure in residential areas is important for maintaining a clean environment and promoting healthy living. Additionally, when selecting a location for new investments, proximity to technical infrastructure services can result in significant cost and time savings. Especially public facility areas should benefit from technical infrastructure services. Therefore, power line network, natural gas network, clean water network, and wastewater network data were used as criteria in this study.

#### 3.2.5.1 Power Line Network

The power line network data in the study area was obtained from KCETAŞ in the form of an SHP file. The required data was extracted and rearranged in ArcGIS program.

#### 3.2.5.2 Natural Gas Network

The natural gas data in the study area were reorganized in ArcGIS program as a SHP file, taking into account the lines in the zoning plan.

#### 3.2.5.3 Clean Water Network

The clean water network data in the study area was obtained as a SHP file from KASKI and rearranged in ArcGIS program to be suitable for the study area.

#### 3.2.5.4 Wastewater Network

The wastewater network data in the study area was obtained as a SHP file from KASKI and rearranged in ArcGIS program to be suitable for the study area.

#### 3.2.5.5 Infrastructure Network System

The data for the power line network, natural gas network, clean water network, and wastewater network in the study area were obtained from various institutions. After editing in ArcGIS, the data were combined and presented in the infrastructure network map (Figure 3.6).

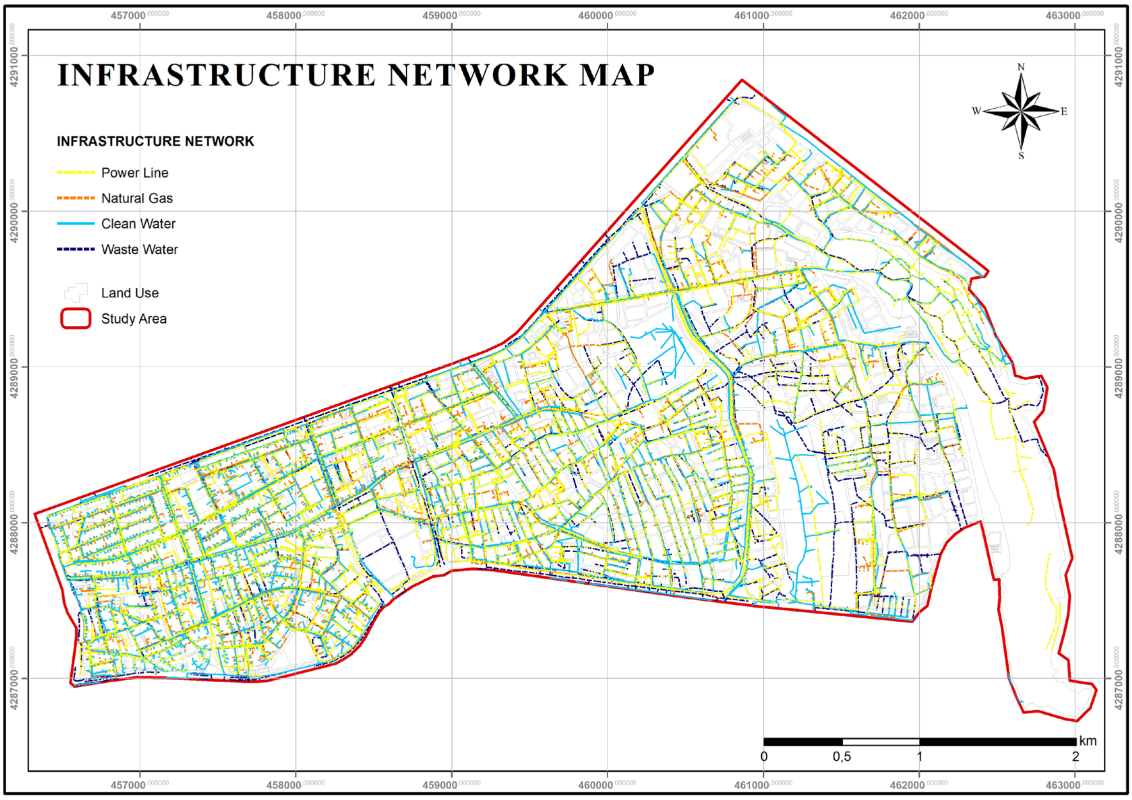



**Figure 3.6 The infrastructure network map of study area**

As the study area was chosen near the city center, it appears that nearly all of the settlements can take advantage of the technical infrastructure facilities. Since the technical infrastructure areas are provided over the routes of the existing road networks, they are more regular and uninterrupted in the western part of the study area, which is closer to the city center. In contrast, they continue more irregularly in the eastern part of the study area where the construction has not yet been completed.

## 3.3 Data Production for Analysis

The data collected from the institutions and organizations were processed using the ArcGIS program, converted to the TUREF 36M coordinate system and reclassified according to the boundaries of the study area.

The study will use the AHP method to evaluate the suitability of public facilities in the area. Applying the AHP method requires criteria related to the study area. These criteria are produced from the data collected and processed in the ArcGIS program on the issues deemed necessary for the suitability assessment.

In this study, 16 different data were produced as criteria from the processed data for suitability evaluation. 9 factors were commonly used in the analysis of public facilities:

- slope,
- population,
- distance from existing road network,
- distance from bus stop,
- distance from tram stop,
- distance from power line network,
- distance from natural gas network,
- distance from clean water network, and
- distance from wastewater network.

The analysis for each public facility included 7 factors:

- distance from existing health facility area,
- distance from existing green area,
- distance from existing kindergarten area,
- distance from existing primary school area,
- distance from existing secondary school area,
- distance from existing high school area, and
- distance from existing mosque area.

Chapter 4 presents detailed information and maps of the generated data.

# Chapter 4

# Implementation of the Analytical Hierarchy Process

## 4.1 Analytical Hierarchy Process

The Analytical Hierarchical Process (AHP) is a method for making decisions based on multiple criteria. It involves structuring decision problems hierarchically and deriving priorities through pairwise comparisons of decision elements [83]. The hierarchy includes the main purpose, criteria, sub-criteria, and options [55]. The AHP framework decomposes complex decision problems into simpler sub-problems organized hierarchically. Qualitative and quantitative data are used to establish ratio scales between decision elements at each level of the hierarchy [83].

The Analytic Hierarchy Process (AHP) is implemented in a number of key stages [55, 83, 84, 85]:

a. Identifying the criteria required to make a decision is crucial.
b. To develop a pairwise comparison matrix (A), first identify the decision criteria. Then, create a matrix (4.1) in the form of $A_{n,n}$ (n=number of criteria) and compare the criteria using ratios from 1 to 9, as given in the pairwise comparison scale (Table 4.1). Consider the importance relationship between the criteria in these pairwise comparisons.

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} = 1/a_{12} & 1 & \cdots & a_{2n} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ a_{n1} = 1/a_{1n} & a_{n2} = 1/a_{2n} & \cdots & 1 \end{bmatrix} \qquad \textbf{(4.1)}$$

**Table 4.1 Scale for pairwise comparison developed by Saaty [83]**

| Intensity of importance | Definition | Explanation |
|---|---|---|
| **1** | equal importance | contribute equally to the objective |
| **3** | moderate importance | slightly favor one objection over another |
| **5** | strong importance | strongly favor one objection over another |
| **7** | very strong importance | favored very strongly one objective over another; dominance demonstrated in practice |
| **9** | extreme importance | evidence favoring one objective over another is of the highest possible order of affirmation |
| **2,4,6,8** | for compromise between above values | sometimes one need to interpolate compromise judgment numerically |

c. Calculation of Weights (W: Eigenvector): The calculation process involves two steps. Firstly, the normalized pairwise comparison matrix must be calculated. Secondly, the eigenvector (W) must be calculated for each criterion.

   i. To calculate the normalized pairwise comparison matrix, first, sum the column to which each value belongs in the generated pairwise comparison matrix. Then divide each value in the matrix by its column sum to create the normalized matrix (4.2).

$$a'_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}\,, \qquad i,j = 1,2,\ldots,n \tag{4.2}$$

   ii. To calculate the weights for each criterion, we calculate the average of the values in each row of the normalized matrix (4.3). These averages represent the eigenvector/weight values ($W_i$) of the criteria.

$$W_i = \left(\frac{1}{n}\right)\sum_{i=1}^{n} a'_{ij}\,, \qquad i,j = 1,2,\ldots,n \tag{4.3}$$

d. Consistency check is crucial to ensure that decisions follow the rule of transitivity. In AHP, the consistency ratio (CR) is used to check consistency. The CR is calculated in several steps.

i. The calculation of eigenvalues (X) is performed by (4.4) multiplying the pairwise comparison matrix (A) by the eigenvectors (W) of the criteria to obtain the eigenvalue of each criterion ($X_i$).

$$A \times W = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} = 1/a_{12} & 1 & \cdots & a_{2n} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ a_{n1} = 1/a_{1n} & a_{n2} = 1/a_{2n} & \cdots & 1 \end{bmatrix} \times \begin{bmatrix} W_1 \\ W_2 \\ . \\ . \\ . \\ W_n \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \\ . \\ . \\ . \\ X_n \end{bmatrix} \quad \textbf{(4.4)}$$

ii. The largest eigenvalue ($\lambda_{max}$) is obtained by (4.5) calculating the ratio of each criterion's eigenvalue ($X_i$) to its eigenvector ($W_i$), (4.6) summing the results, and dividing by the number of criteria.

$$d_i = \frac{X_i}{W_i}, \qquad i = 1, 2, \dots, n \quad \textbf{(4.5)}$$

$$\lambda_{max} = \frac{\sum_{i=1}^{n} d_i}{n} \quad \textbf{(4.6)}$$

iii. To calculate the Consistency Index (CI), subtract the largest eigenvalue ($\lambda_{max}$) from the number of criteria (n) and divide the result by the number of criteria (n) minus 1 (4.7).

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad \textbf{(4.7)}$$

iv. To evaluate consistency, it is necessary to know the Random Index (RI) value. Table 4.2 provides RI values for n-dimensional comparison matrices.

**Table 4.2 RI values with respect to the number of layers (n) developed by Saaty [83]**

| n | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RI | 0.00 | 0.00 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 | 1.51 | 1.48 | 1.56 | 1.57 | 1.59 |

v. Finally, to obtain the Consistency Ratio (CR), divide the Consistency Index (CI) by the Random Index (RI) (4.8).

$$CR = \frac{CI}{RI} \tag{4.8}$$

vi. The threshold for consistency ratio (CR) is set at 0.10. If the CR exceeds 0.10, the proportions in the pairwise comparison matrix should be revised and adjusted accordingly. Conversely, if the CR is less than 0.10, the comparisons are considered consistent.

## 4.2 Main Criteria, Sub-criteria and Ranking

To conduct an AHP analysis, it is necessary to identify the main criteria, sub-criteria, and ranking of the subject under study.

To evaluate the suitability of public facilities in this study, 7 public facilities were identified: health facility areas, green areas, kindergarten areas, primary school areas, secondary school areas, high school areas, and mosque areas. 10 main criteria and 42 sub-criteria were used to evaluate these areas. The main criteria included slope, population, distance from existing facility areas, distance from existing road network, distance from bus stop, distance from tram stop, distance from power line network, distance from natural gas network, distance from clean water network, and distance from wastewater network (Table 4.3).

Previous studies have utilized varying values and ranges for ranking. In this study, the 5-point ranking values previously used by Akin (2009) were reordered and used (Table 4.4). The ranking indicates the degree of suitability, ranging from 1 to 5. A score of 1 indicates non-suitable areas, while a score of 5 indicates areas with the highest degree of suitability. The needs were also taken into consideration when determining the degree of suitability. For instance, the areas with the lowest slope were assigned a value of 5, as they are physically suitable for construction. Conversely, areas with the highest population density were also assigned a value of 5, due to the greater need for public facility areas.

**Table 4.3 The criteria table of the AHP**

| | Main Criteria | Sub-criteria |
|---|---|---|
| 1 | Slope (°) | 0-2% |
| | | 3-5% |
| | | 6-10% |
| | | 11-20% |
| | | 21% + |
| 2 | Population (person) | 0-250 |
| | | 251-500 |
| | | 501-750 |
| | | 751-1000 |
| | | 1000+ |
| 3 | Distance from Existing Public Facility (m) | 250 |
| | | 500 |
| | | 750 |
| | | 1000 |
| | | 1000+ |
| 4 | Distance from Existing Road Network (m) | 25 |
| | | 50 |
| | | 75 |
| | | 100 |
| | | 100+ |
| 5 | Distance from Bus Stop (m) | 50 |
| | | 100 |
| | | 150 |
| | | 200 |
| | | 200+ |
| 6 | Distance from Tram Stop (m) | 50 |
| | | 100 |
| | | 150 |
| | | 200 |
| | | 200+ |
| 7 | Distance from Power Line Network (m) | <10 |
| | | 10-20 |
| | | 20< |
| 8 | Distance from Natural Gas Network (m) | <10 |
| | | 10-20 |
| | | 20< |
| 9 | Distance from Clean Water Network (m) | <10 |
| | | 10-20 |
| | | 20< |
| 10 | Distance from Wastewater Network (m) | <10 |
| | | 10-20 |
| | | 20< |

**Table 4.4 The table of the ranking value [83]**

| *Ranking* | *Definition* |
|---|---|
| ***1*** | non-suitable area |
| ***2*** | low suitable area |
| ***3*** | moderate suitable area |
| ***4*** | high suitable area |
| ***5*** | very high suitable area |

The suitability assignment and AHP implementation for each criterion identified in the study area are presented separately.

### 4.2.1 Slope

The slope condition of land is a crucial factor as it directly impacts construction and transportation possibilities. In the study area, slope values are categorized into five main classes (Figure 4.1). The suitability ranking was determined by assigning a value of 1 to areas with the highest slope, as construction opportunities would be difficult, and a value of 5 to areas with the least slope, as they are suitable for construction (Table 4.5).

**Table 4.5 Classification of slope**

| Slope class (°) | Ranking |
|---|---|
| 0-2 | 5 |
| 3-5 | 4 |
| 6-10 | 3 |
| 11-20 | 2 |
| 21 + | 1 |

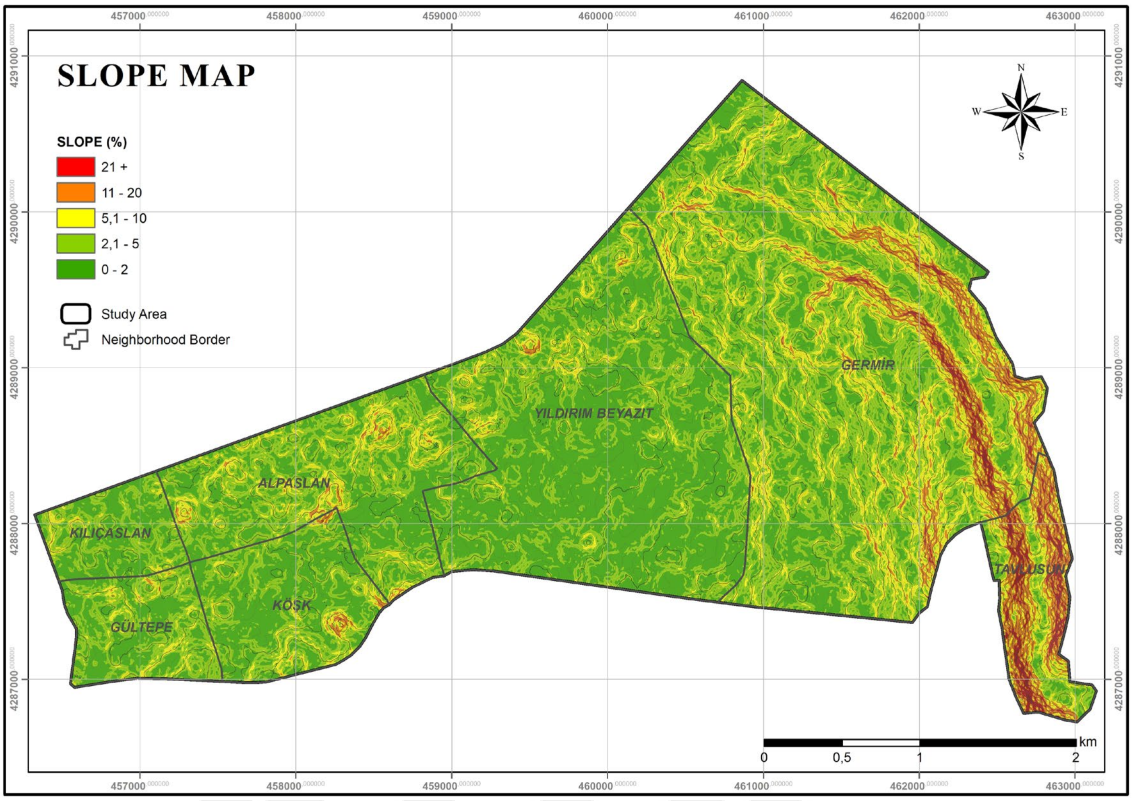



**Figure 4.1 The slope map of study area**

## 4.2.2 Population

The population sizes for each residential block in the study area were determined using the calculations outlined in Section 3.2.1.2. The population sizes were classified into five main categories for suitability assessment, as shown in Figure 4.2. Areas with more than 1000 inhabitants were assigned a value of 5, while areas with less than 250 inhabitants were assigned a value of 1, as indicated in Table 4.6. This was done because more public facilities will be needed as the population density increases.

**Table 4.6 Classification of population**

| Population class (person) | Ranking |
|---|---|
| 0-250 | 1 |
| 251-500 | 2 |
| 501-750 | 3 |
| 751-1000 | 4 |
| 1000+ | 5 |

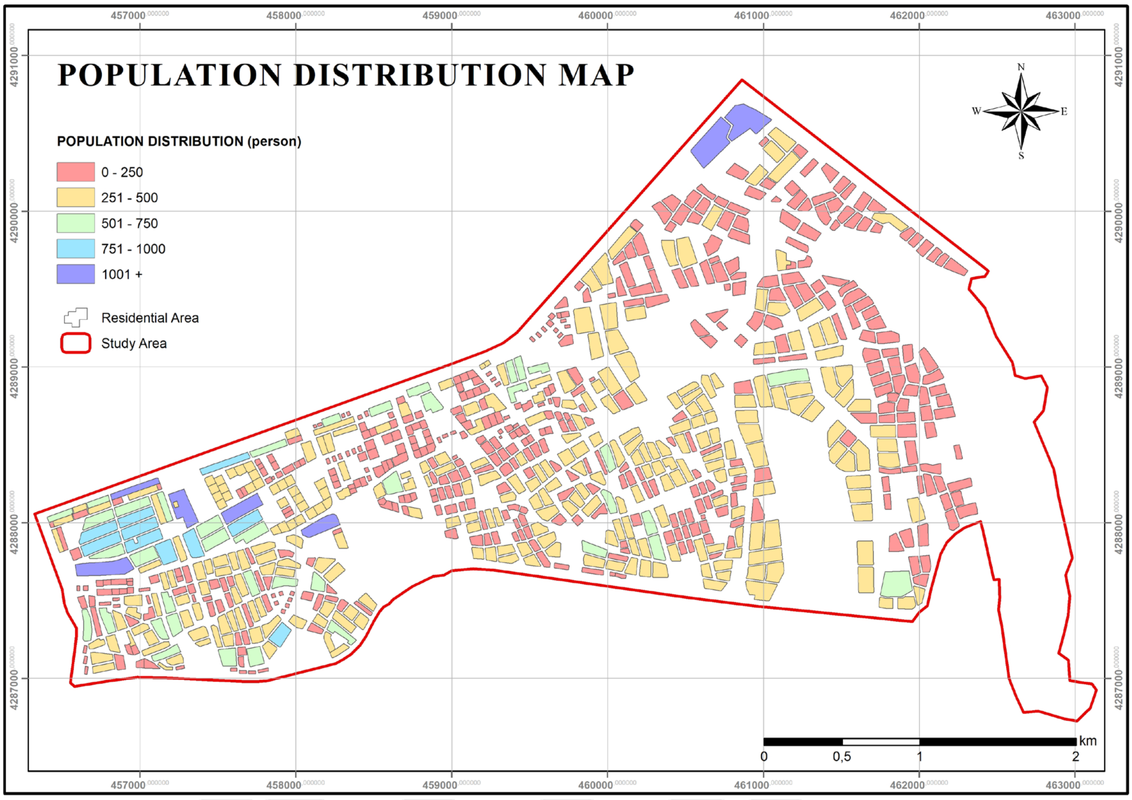



**Figure 4.2 The population distribution map of study area**

## 4.2.3 Distance from Existing Facility

Distance from public facilities was also considered an important criterion for evaluating suitability. The distance from public facilities, excluding green areas, was classified based on the minimum walking distance given in Table 1.1, which is 250 meters and its multiples.

The suitability assessment of each public facility was conducted separately in this study, and the classification and suitability rankings were also done separately.

### 4.2.3.1 Distance from Existing Health Facility Area

There are six areas of existing health facilities in the study area. To evaluate suitability, areas within 250 meters of the existing health facility are assigned a value of 1, as they can benefit from the facility. Conversely, areas more than 1000 meters away are assigned a value of 5, as they are less likely to benefit from the facility (Table 4.7). In other words, the need for a new health facility area increases as the distance from the existing health facility increases (Figure 4.3).

**Table 4.7 Classification of distance from existing health facility area**

| Distance class (m) | Ranking |
|---|---|
| 250 | 1 |
| 500 | 2 |
| 750 | 3 |
| 1000 | 4 |
| 1000+ | 5 |

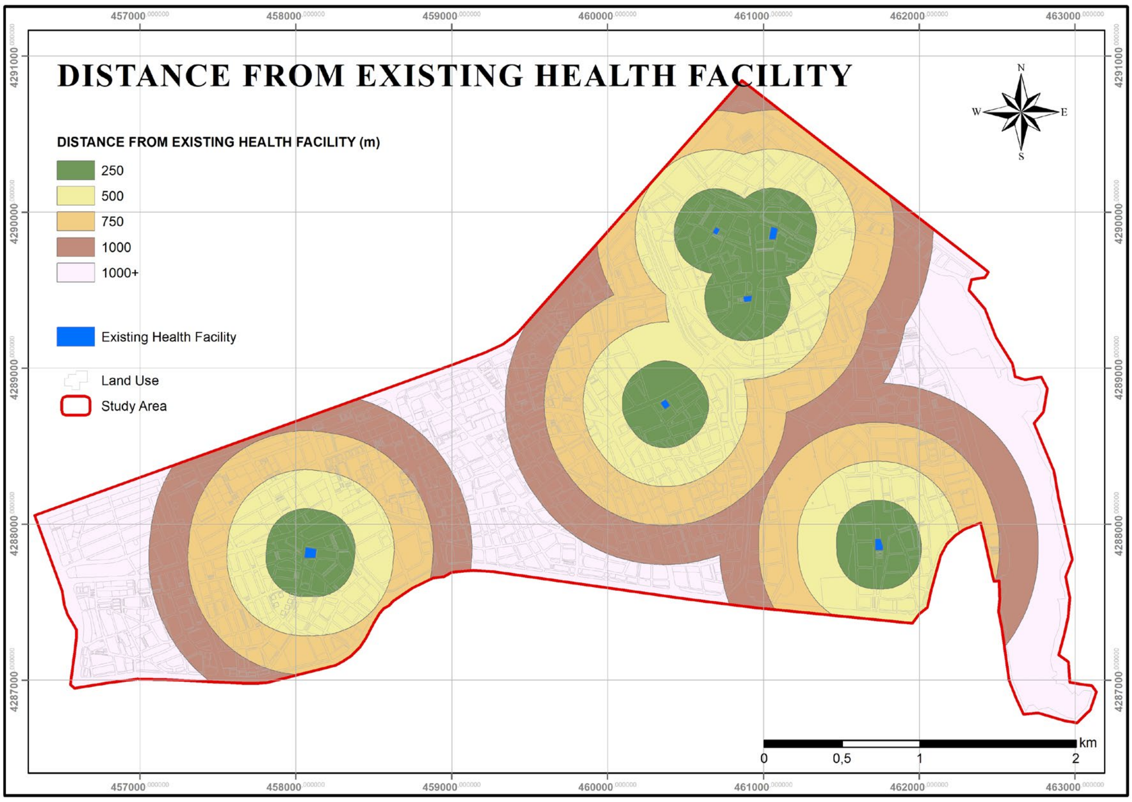



**Figure 4.3 The distance from existing health facility map of study area**

### 4.2.3.2 Distance from Existing Green Area

Figure 3.1 shows the land use map of the study area, which reveals numerous small and large green areas. It is important to note that green areas in urban settings should not be limited to parks, but should also include spaces for various sports and recreational activities. Therefore, during the analysis of green areas, this aspect was taken into consideration.

In the study area, a green area with both landscaping and seating area, children's playground, walking track, sports field and sports equipment was identified. Since this area of 10500 $m^2$ contains all the facilities, a green area size of 10000 $m^2$ is considered standard. Therefore, 29 green areas with an area of more than 10000 m$^2$ in the study area were considered as existing and evaluated for suitability.

Considering the fact that people of all ages and physical conditions (children, elderly, parents with strollers, people with wheelchairs, etc.) go every day without the need to travel by vehicle, the distance to the green areas for the suitability evaluation was determined as at least 50 m and multiples, contrary to other public facilities (Figure 4.4). For the suitability evaluation, areas with a distance of less than 50 m were assigned a value of 1, and areas with a distance of more than 200 m were assigned a value of 5, as the need would increase and would be suitable for new green areas (Table 4.8).

**Table 4.8 Classification of distance from existing green area**

| Distance class (m) | Ranking |
|---|---|
| 50 | 1 |
| 100 | 2 |
| 150 | 3 |
| 200 | 4 |
| 200+ | 5 |


**Figure 4.4 The distance from existing green area map of study area**

#### 4.2.3.3 Distance from Existing Kindergarten Area

There are three existing kindergarten areas in the study area. To evaluate their suitability, the distances from these existing kindergartens were classified into five main classes (Figure 4.5). Areas within 250 meters of an existing kindergarten were assigned a value of 1, indicating that they would benefit from this facility. Conversely, areas more than 1000 meters away were assigned a value of 5, indicating that they are more suitable for new kindergarten areas (Table 4.9).

**Table 4.9 Classification of distance from existing kindergarten area**

| Distance class (m) | Ranking |
|---|---|
| 250 | 1 |
| 500 | 2 |
| 750 | 3 |
| 1000 | 4 |
| 1000+ | 5 |

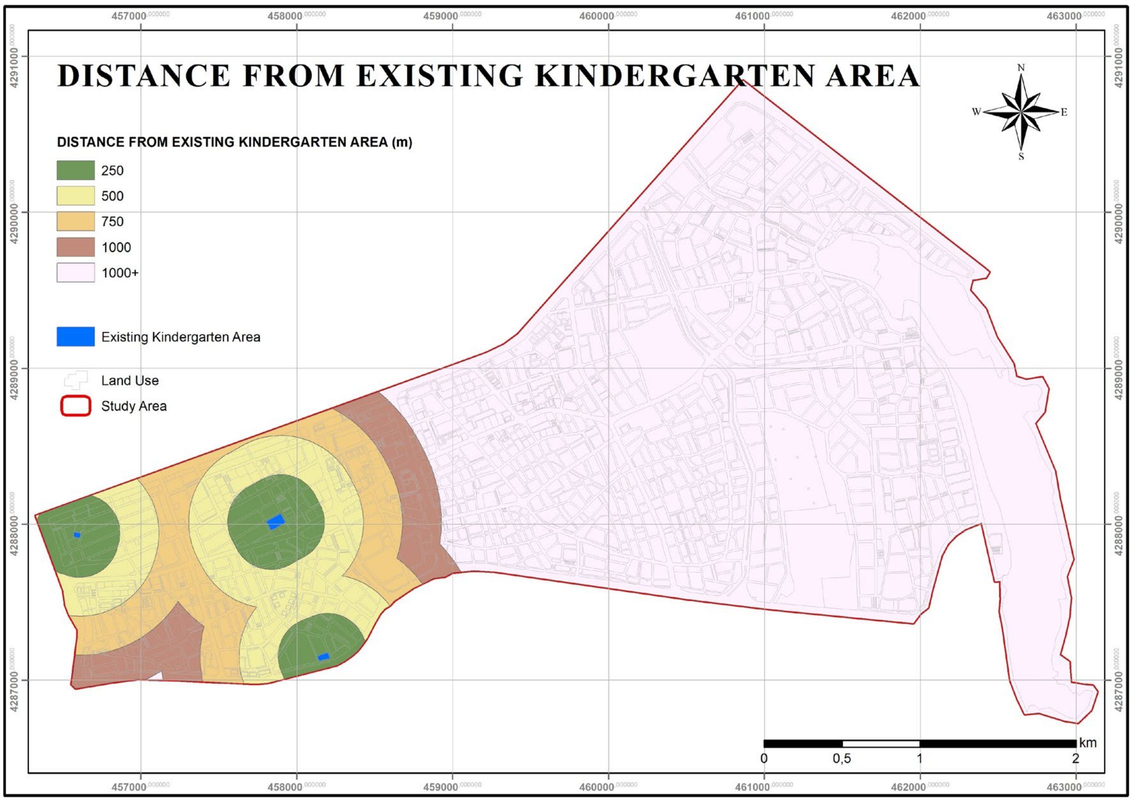



**Figure 4.5 The distance from existing kindergarten area map of study area**

#### 4.2.3.4 Distance from Existing Primary School Area

There are 19 primary school areas in the study area. To evaluate suitability, distances from existing primary school areas were classified into five main classes (Figure 4.6). Areas within 250 meters of an existing primary school were assigned a value of 1, while areas more than 1000 meters away were assigned a suitability value of 5, as the possibility of utilization decreases while the need for new areas increases (Table 4.10).

**Table 4.10 Classification of distance from existing primary school area**

| Distance class (m) | Ranking |
|---|---|
| 250 | 1 |
| 500 | 2 |
| 750 | 3 |
| 1000 | 4 |
| 1000+ | 5 |

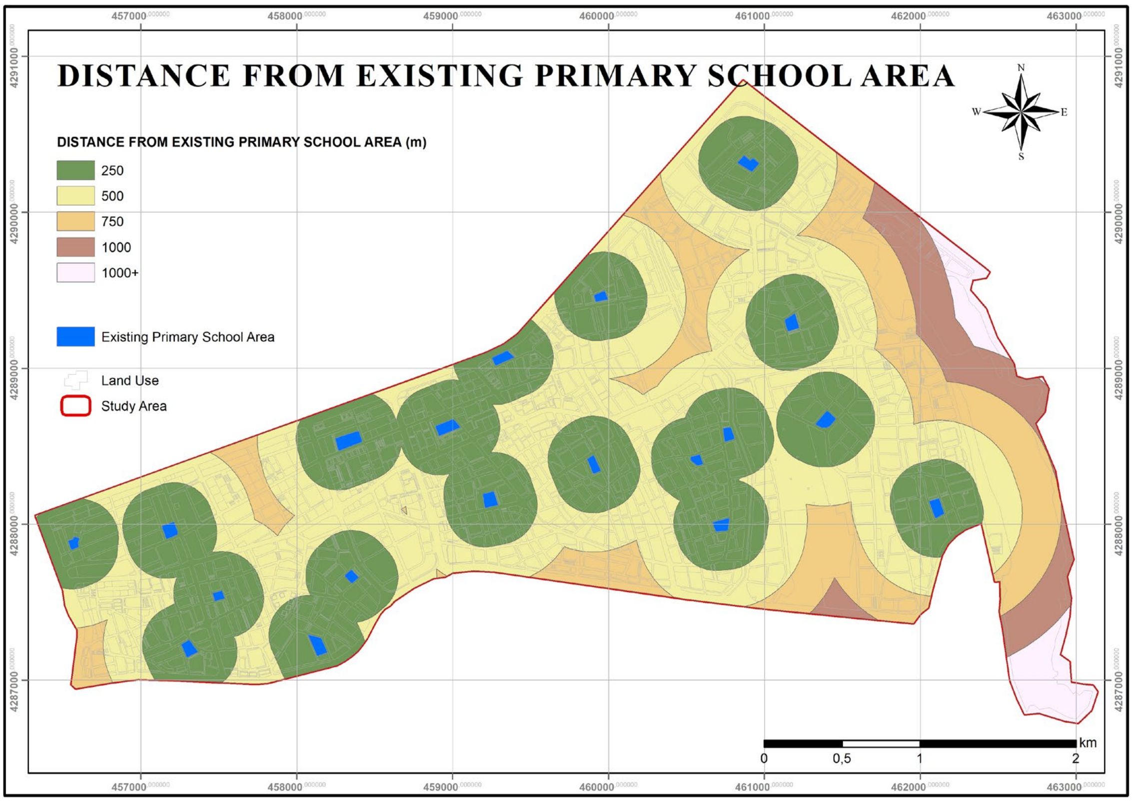



**Figure 4.6 The distance from existing primary school area map of study area**

### 4.2.3.5 Distance from Existing Secondary School Area

There are 6 existing secondary school areas in the study area. To evaluate suitability, distances from these existing areas were also classified into five main classes (Figure 4.7). Similar to the categorization of kindergarten and primary school areas, areas within 250 meters of an existing secondary school were assigned a value of 1, while areas more than 1000 meters away were assigned a value of 5 (Table 4.11).

**Table 4.11 Classification of distance from existing secondary school area**

| Distance class (m) | Ranking |
|---|---|
| 250 | 1 |
| 500 | 2 |
| 750 | 3 |
| 1000 | 4 |
| 1000+ | 5 |

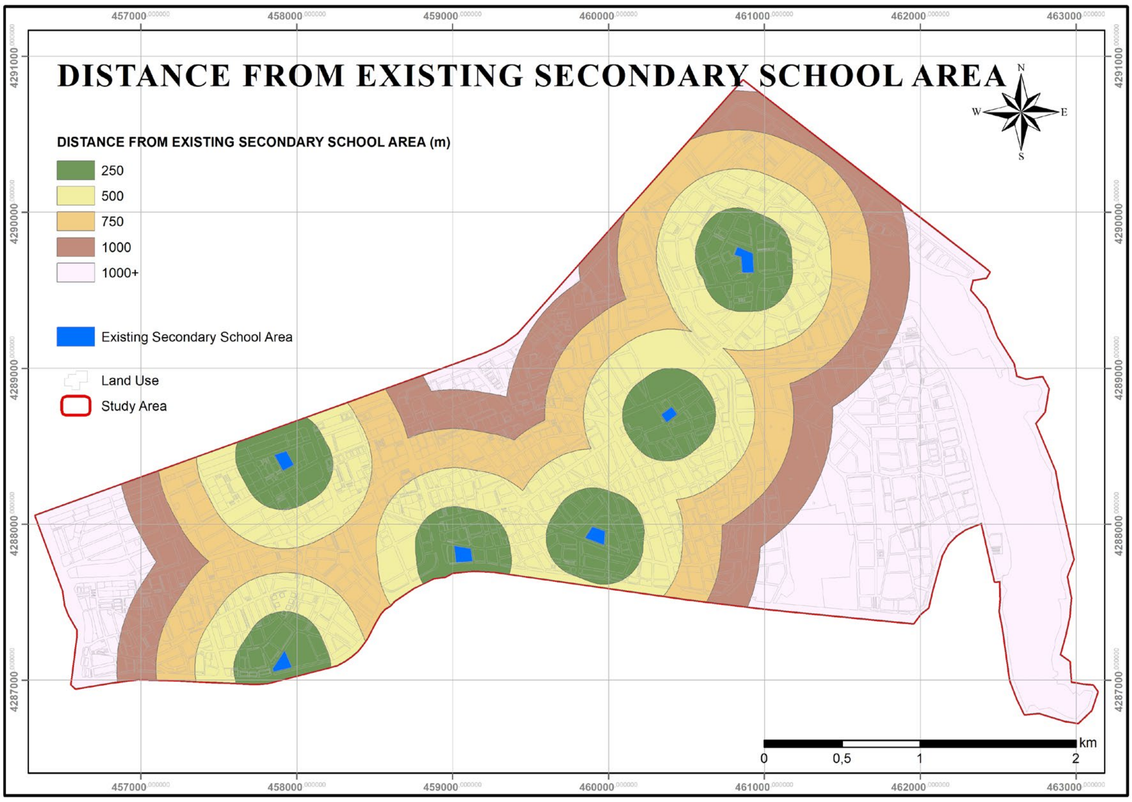



**Figure 4.7 The distance from existing secondary school area map of study area**

#### 4.2.3.6 Distance from Existing High School Area

There are 7 existing high school areas in the study area. To evaluate suitability, distances from existing high school areas were also classified into five main classes (Figure 4.8). Like other school areas, areas within 250 meters of an existing high school were assigned a value of 1, while areas more than 1000 meters away were assigned a value of 5 (Table 4.12).

**Table 4.12 Classification of distance from existing high school area**

| Distance class (m) | Ranking |
|---|---|
| 250 | 1 |
| 500 | 2 |
| 750 | 3 |
| 1000 | 4 |
| 1000+ | 5 |

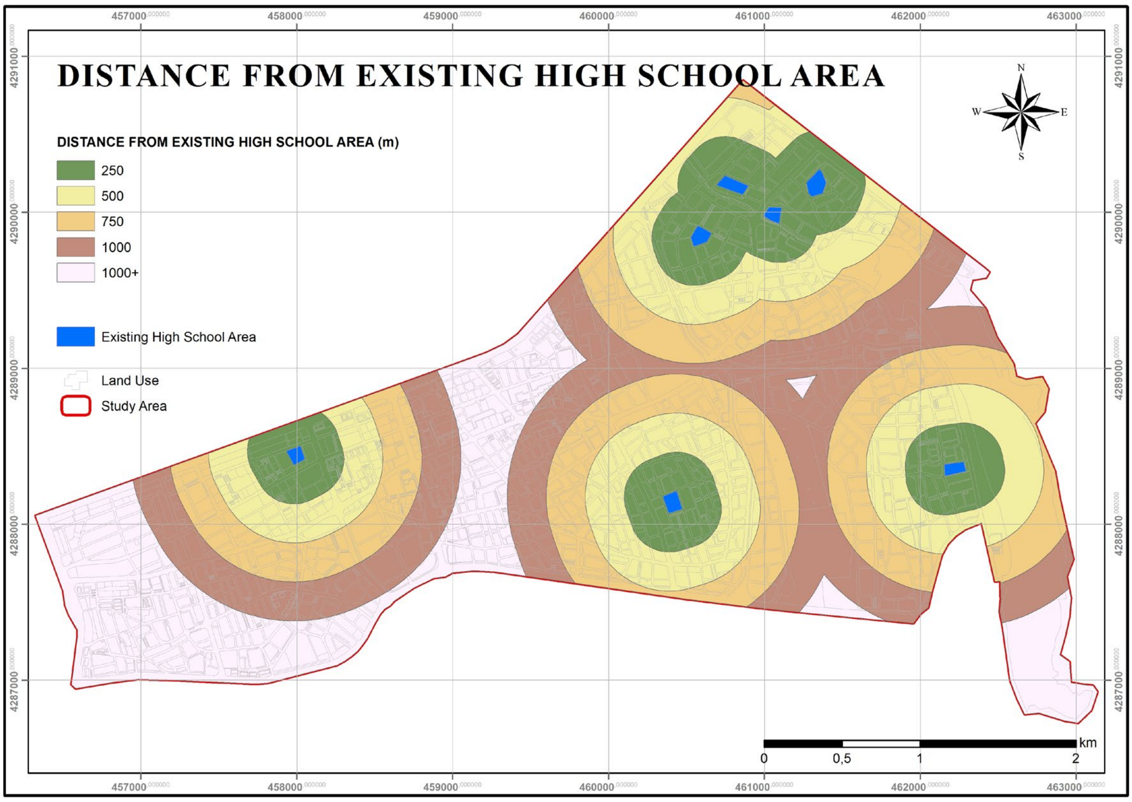



**Figure 4.8 The distance from existing high school area map of study area**

#### 4.2.3.7 Distance from Existing Mosque Area

There are 31 mosque areas in the study area. To evaluate suitability, distances from these areas were classified into five main classes (Figure 4.9). As with other evaluations of distance to public facilities, a value of 1 was assigned to areas closer than 250 meters to the existing mosque area, and a value of 5 was assigned to areas more than 1000 meters away (Table 4.13).

**Table 4.13 Classification of distance from existing mosque area**

| Distance class (m) | Ranking |
|---|---|
| 250 | 1 |
| 500 | 2 |
| 750 | 3 |
| 1000 | 4 |
| 1000+ | 5 |

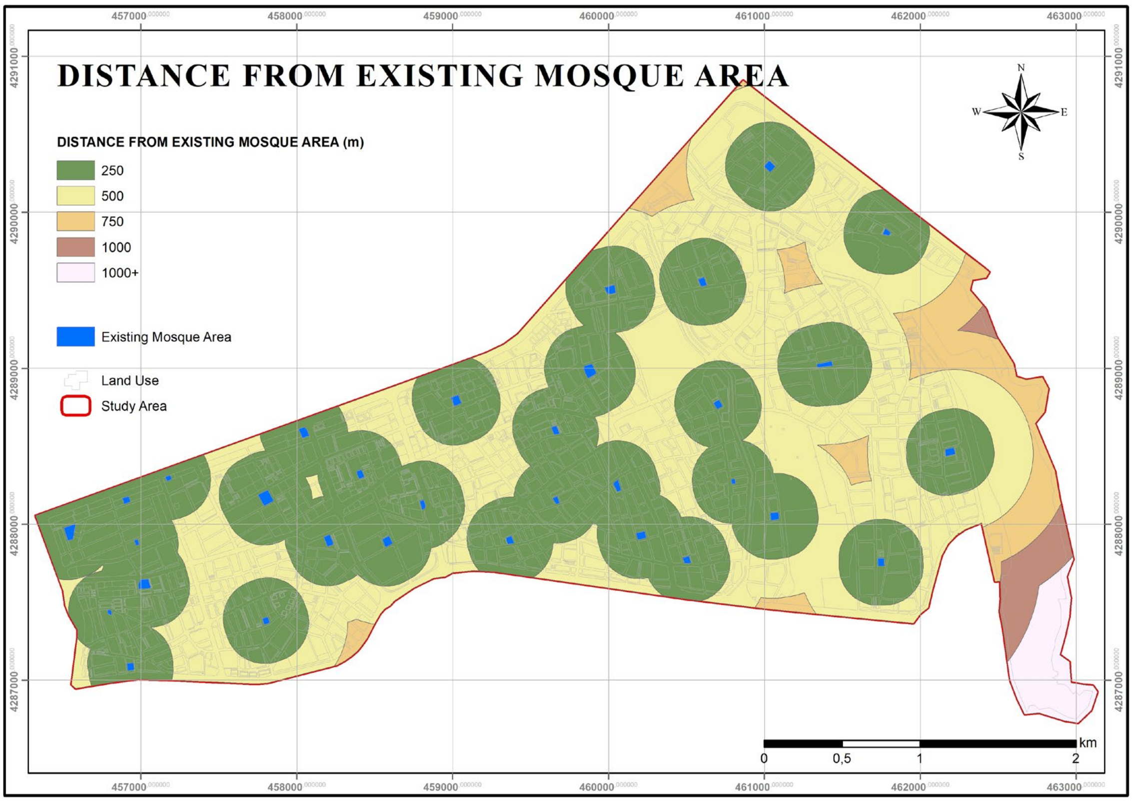



**Figure 4.9 The distance from existing mosque area map of study area**

### 4.2.4 Distance from Existing Road Network

Accessibility in urban areas is primarily determined by the existing road networks, which also have a direct impact on public transportation facilities and infrastructure services. It is critical to have access to existing road networks, whether it is for private vehicles or public transportation stops. Therefore, distance from the existing road network in the study area was set at a minimum of 25 meters and classified into five main classes in multiples of 25 (Figure 4.10). When evaluating suitability, a value of 5 was assigned to locations less than 25 meters away because they have easy access to transportation. Conversely, a value of 1 was assigned to locations more than 100 meters away because they have reduced accessibility (Table 4.14).

**Table 4.14 Classification of distance from existing road network**

| Distance class (m) | Ranking |
|---|---|
| 25 | 5 |
| 50 | 4 |
| 75 | 3 |
| 100 | 2 |
| 100+ | 1 |

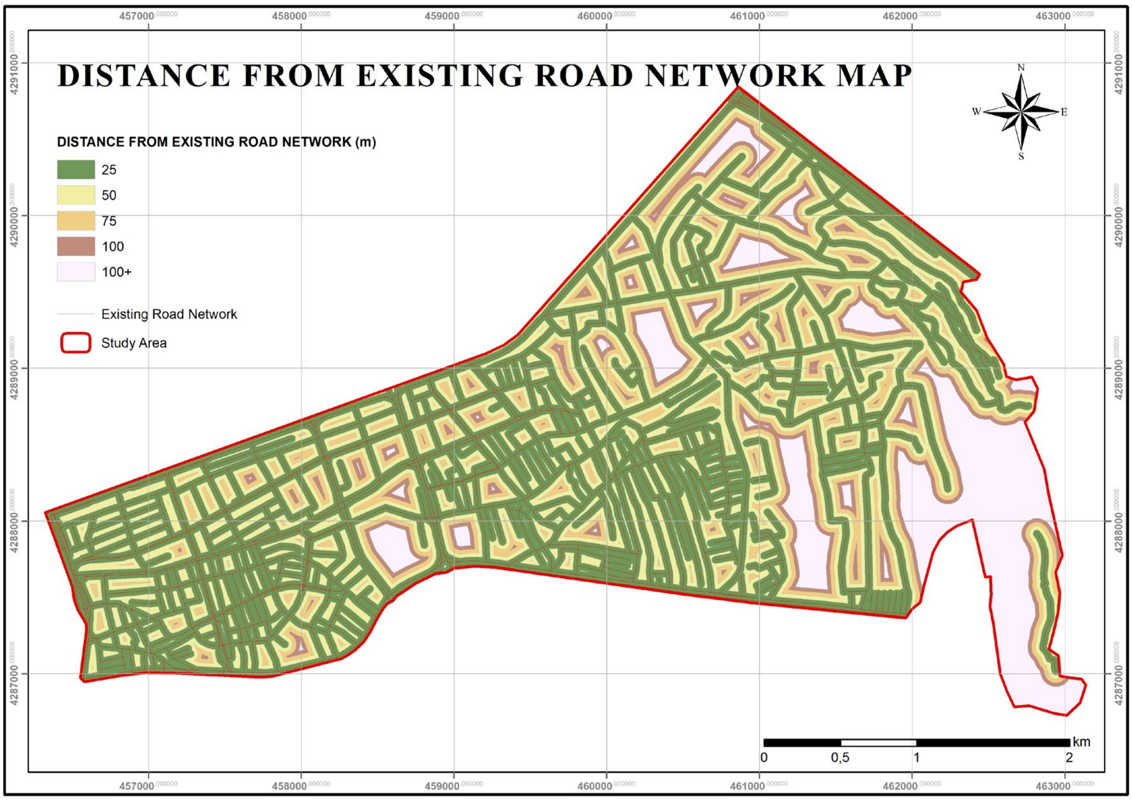



**Figure 4.10 The distance from existing road network map of study area**

### 4.2.5 Distance from Bus Stop

The primary mode of public transportation in the study area is the bus, with 154 bus stops. To utilize this mode of transportation, the journey should be considered in three stages: walking from the starting point to the bus stop, traveling by bus, and walking from the bus stop to the destination. To ensure ease of travel, it is important to keep the walking distance to the bus stops short. The distance from bus stops is classified into five main categories, starting with a minimum of 50 meters (Figure 4.11). In evaluating suitability, a value of 5 was assigned to distances under 50 meters because the walking distance is short, and a value of 1 was assigned to distances over 200 meters because the walking distance is long (Table 4.15).

**Table 4.15 Classification of distance from bus stop**

| Distance class (m) | Ranking |
|---|---|
| 50 | 5 |
| 100 | 4 |
| 150 | 3 |
| 200 | 2 |
| 200+ | 1 |

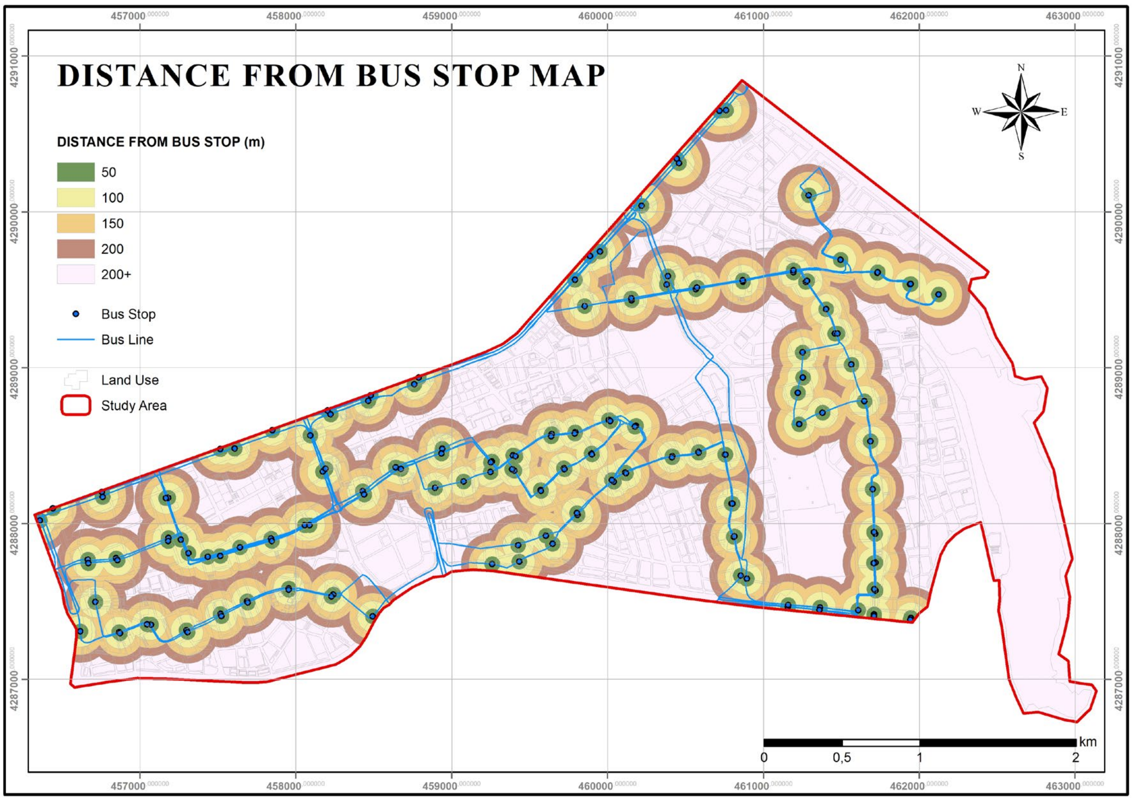



**Figure 4.11 The distance from bus stop map of study area**

## 4.2.6 Distance from Tram Stop

The study area has two tram lines with 14 stops, providing an additional mode of public transportation. Similar to the bus journey, the tram journey consists of three stages: walking from the starting point to the tram stop, traveling by tram, and walking from the tram stop to the destination. It is important to ensure that the walking distance to the tram stops is also short. Thus, the distance from the tram stops is classified into five main categories, starting from a minimum of 50 meters (Figure 4.12). In evaluating suitability, a value of 5 was assigned to distances below 50 meters due to their short walking distance, while a value of 1 was assigned to distances above 200 meters due to their long walking distance (Table 4.16).

**Table 4.16 Classification of distance from tram stop**

| Distance class (m) | Ranking |
|---|---|
| 50 | 5 |
| 100 | 4 |
| 150 | 3 |
| 200 | 2 |
| 200+ | 1 |

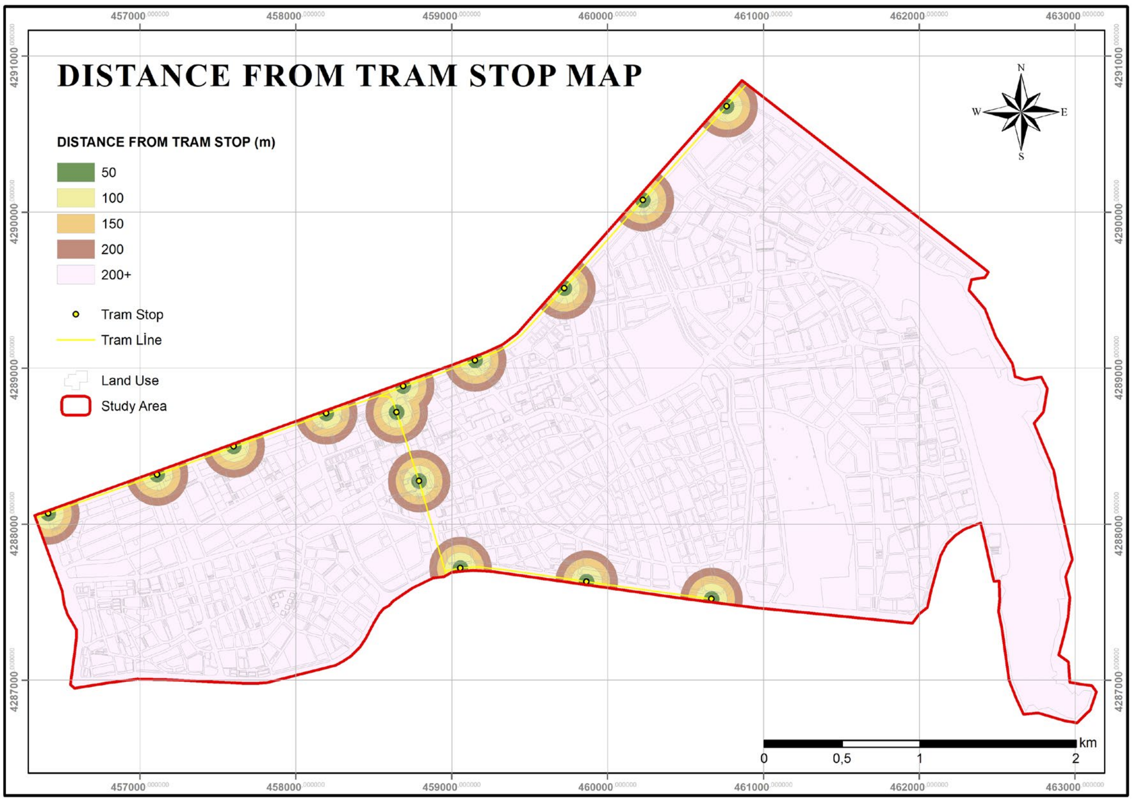



**Figure 4.12 The distance from tram stop map of study area**

### 4.2.7 Distance from Power Line Network

The power line networks in the study area are regular in areas where construction has been completed, but irregular in areas where construction has not yet been completed. It is important to consider the distance from these lines as public facilities can impact investment decisions in terms of both accessibility and cost. Distance from the power line networks in the study area is classified into three main classes, with a minimum distance of 10 meters (Figure 4.13). Areas less than 10 meters are assigned a value of 5 for suitability evaluation, while areas more than 20 meters are assigned a value of 1 (Table 4.17).

**Table 4.17 Classification of distance from power line network**

| Distance class (m) | Ranking |
| --- | --- |
| <10 | 5 |
| 10-20 | 3 |
| 20< | 1 |

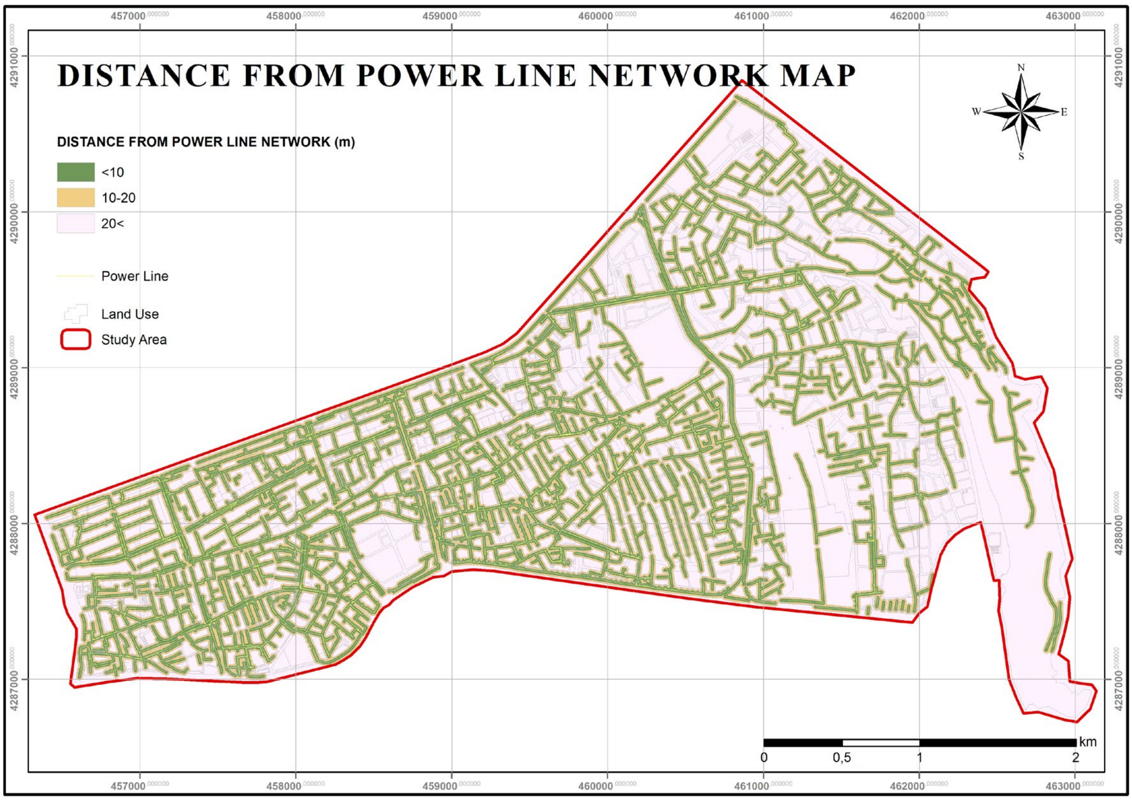



**Figure 4.13 The distance from power line network map of study area**

### 4.2.8 Distance from Natural Gas Network

The study area is situated in the center, resulting in regular natural gas lines in completed construction areas and irregular lines in areas where construction is ongoing. The distance from the natural gas lines is important even if the natural gas lines are irregular, because it affects the investment decisions of public facilities in terms of both accessibility and cost, just as it does for the power lines. The distance to natural gas lines is classified into three main classes, with a minimum distance of 10 meters (Figure 4.14). For suitability assessment, areas less than 10 meters were assigned a value of 5, while areas more than 20 meters were assigned a value of 1 (Table 4.18).

**Table 4.18 Classification of distance from natural gas network**

| Distance class (m) | Ranking |
|---|---|
| <10 | 5 |
| 10-20 | 3 |
| 20< | 1 |

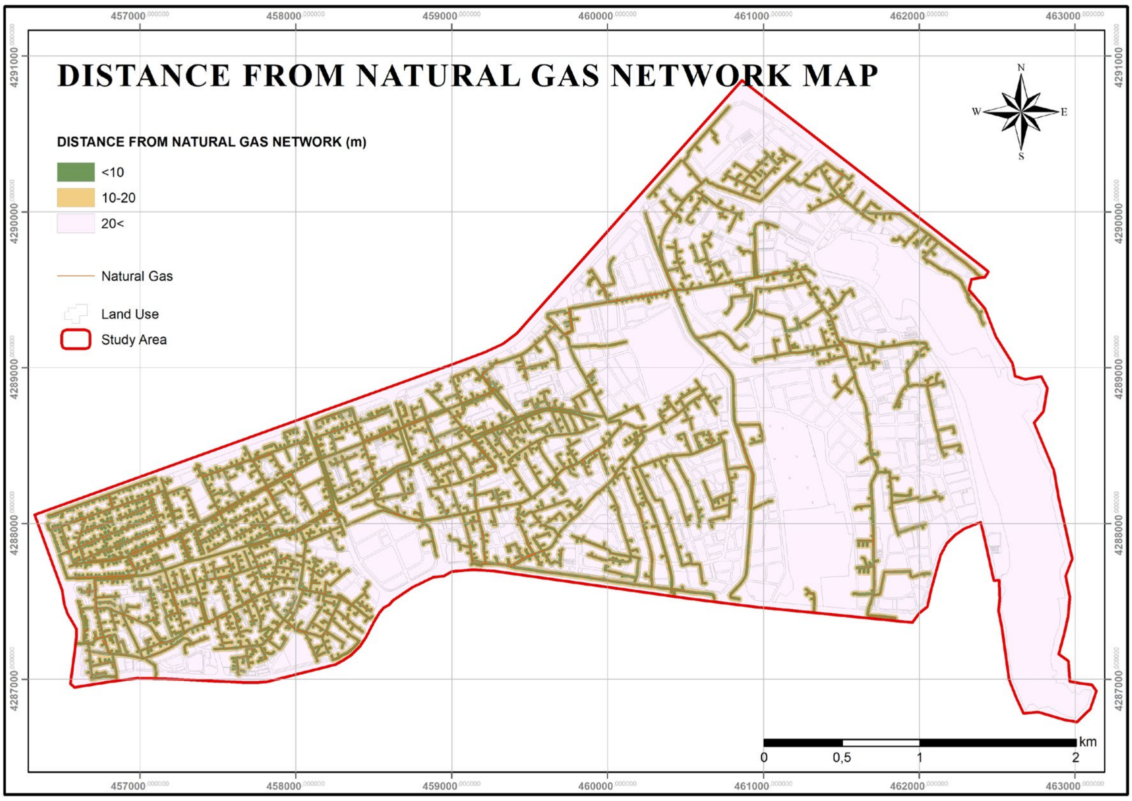



**Figure 4.14 The distance from natural gas network map of study area**

## 4.2.9 Distance from Clean Water Network

Access to clean water networks is a crucial factor in any settlement area, even if they are not fully developed. Because the network has a direct impact on investment decisions of the public facilities, both in terms of accessibility and cost. In the study area, the distance from clean water networks was therefore classified into three main classes, with a minimum distance of 10 meters (Figure 4.15). For the evaluation of suitability, areas less than 10 meters were assigned a value of 5 and areas more than 20 meters were assigned a value of 1 (Table 4.19).

**Table 4.19 Classification of distance from clean water network**

| Distance class (m) | Ranking |
|---|---|
| <10 | 5 |
| 10-20 | 3 |
| 20< | 1 |

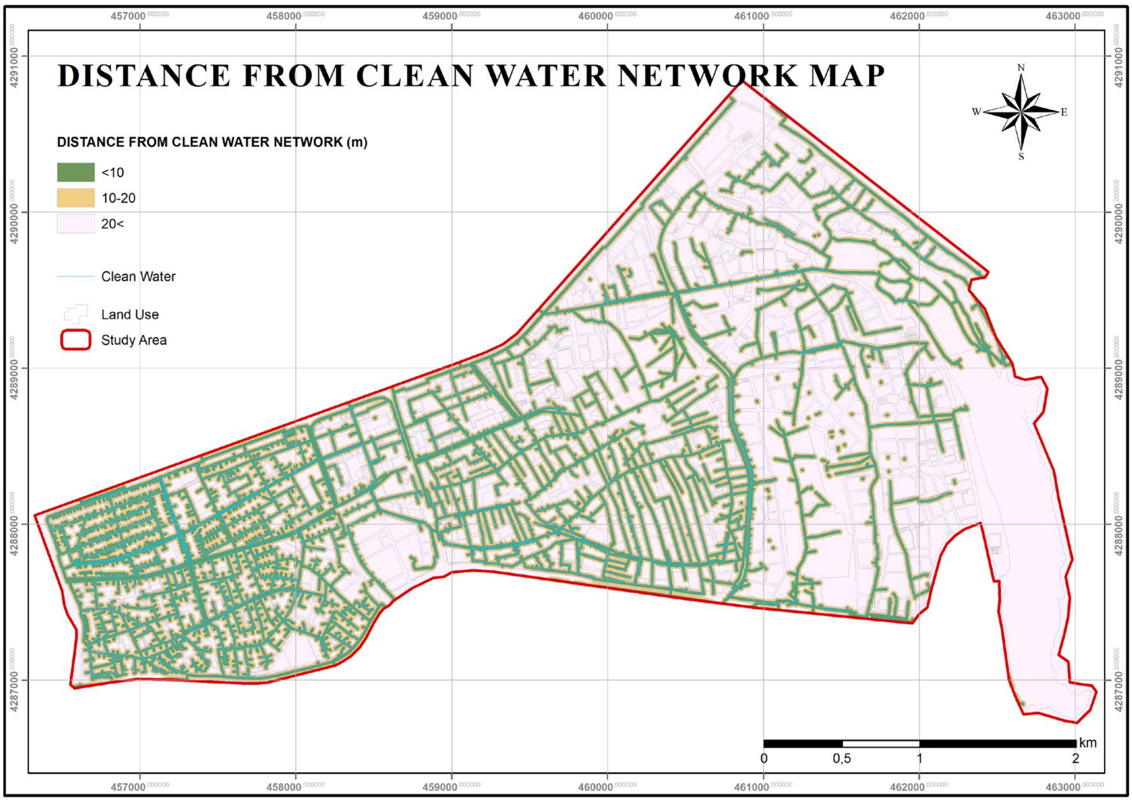



**Figure 4.15 The distance from clean water network map of study area**

### 4.2.10 Distance from Wastewater Network

As with clean water networks, wastewater networks have a direct impact on the investment decisions of public facilities for providing a clean environment. Therefore, the distance from the wastewater network in urban areas is important. In the study area, the distance from clean water networks was therefore classified into three main classes, with a minimum distance of 10 meters (Figure 4.16). For the evaluation of suitability, areas less than 10 meters were assigned a value of 5 and areas more than 20 meters were assigned a value of 1 (Table 4.20).

**Table 4.20 Classification of distance from wastewater network**

| Distance class (m) | Ranking |
|---|---|
| <10 | 5 |
| 10-20 | 3 |
| 20< | 1 |

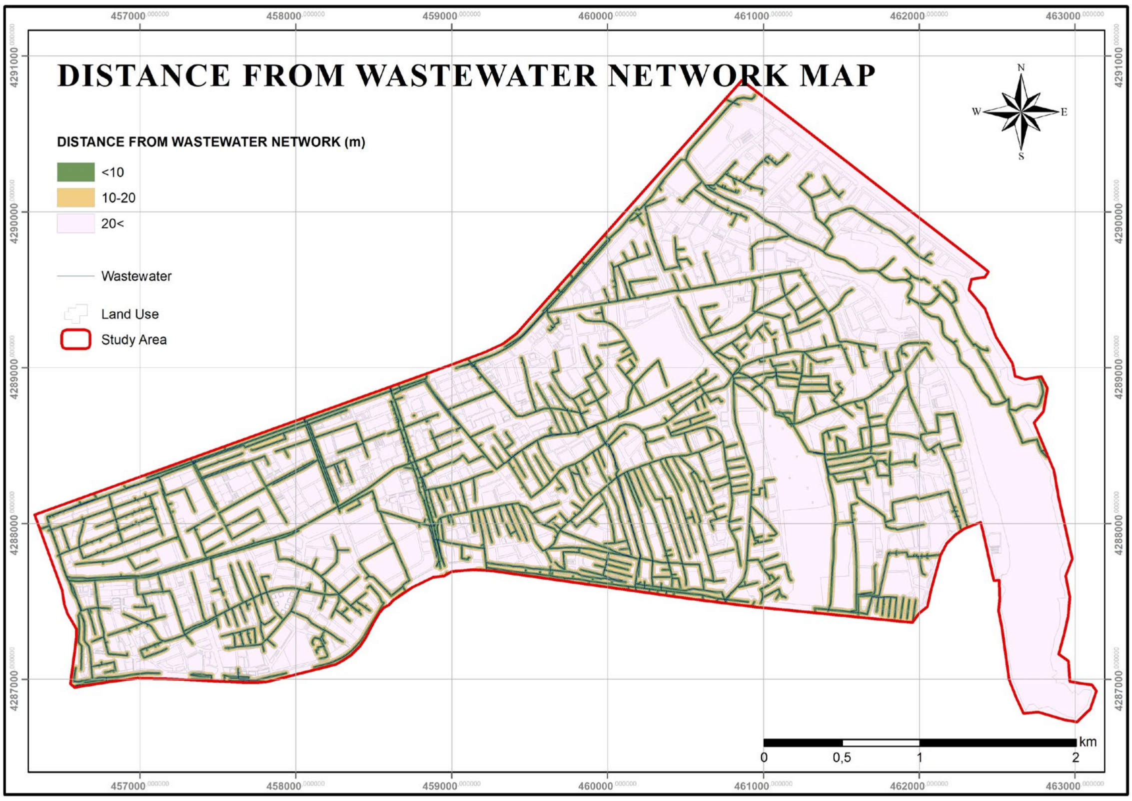



**Figure 4.16 The distance from wastewater network map of study area**

# 4.3 Calculation of Weights

After establishing the main criteria, sub-criteria, and rankings for AHP, a pairwise comparison matrix is created for the main criteria. The weights of the criteria are then calculated based on this pairwise matrix using by Microsoft Excel, and necessary consistency (CR) checks are performed. However, before this step, as shown in Table 4.21, the pairwise matrix is created by assigning ranking values to the sub-criteria.

**Table 4.21 Pairwise comparison matrix for sub-criteria**

| **S** (°) | 0-2% | 3-5% | 6-10% | 11-20% | 21% + |
|---|---|---|---|---|---|
| 0-2% | 1 | 3 | 5 | 7 | 9 |
| 3-5% | 1/3 | 1 | 3 | 5 | 7 |
| 6-10% | 1/5 | 1/3 | 1 | 3 | 5 |
| 11-20% | 1/7 | 1/5 | 1/3 | 1 | 3 |
| 21% + | 1/9 | 1/7 | 1/5 | 1/3 | 1 |

| **P** (person) | 1000+ | 751-1000 | 501-750 | 251-500 | 0-250 |
|---|---|---|---|---|---|
| 1000+ | 1 | 3 | 5 | 7 | 9 |
| 751-1000 | 1/3 | 1 | 3 | 5 | 7 |
| 501-750 | 1/5 | 1/3 | 1 | 3 | 5 |
| 251-500 | 1/7 | 1/5 | 1/3 | 1 | 3 |
| 0-250 | 1/9 | 1/7 | 1/5 | 1/3 | 1 |

| **ERN** (m) | 25 | 50 | 75 | 100 | 100+ |
|---|---|---|---|---|---|
| 25 | 1 | 3 | 5 | 7 | 9 |
| 50 | 1/3 | 1 | 3 | 5 | 7 |
| 75 | 1/5 | 1/3 | 1 | 3 | 5 |
| 100 | 1/7 | 1/5 | 1/3 | 1 | 3 |
| 100+ | 1/9 | 1/7 | 1/5 | 1/3 | 1 |

| **PT** (m) | 50 | 100 | 150 | 200 | 200+ |
|---|---|---|---|---|---|
| 50 | 1 | 3 | 5 | 7 | 9 |
| 100 | 1/3 | 1 | 3 | 5 | 7 |
| 150 | 1/5 | 1/3 | 1 | 3 | 5 |
| 200 | 1/7 | 1/5 | 1/3 | 1 | 3 |
| 200+ | 1/9 | 1/7 | 1/5 | 1/3 | 1 |

| **I** (m) | <10 | 10-20 | 20< |
|---|---|---|---|
| <10 | 1 | 3 | 5 |
| 10-20 | 1/3 | 1 | 3 |
| 20< | 1/5 | 1/3 | 1 |

**S**: Slope
**P**: Population
**ERN**: Distance from existing road network
**PT***: Distance from bus/tram stop
**I***: Distance from power line/natural gas/clean water/wastewater
(*The given values are presented in a single table)

| **PF** (m) | 1000+ | 1000 | 750 | 500 | 250 |
|---|---|---|---|---|---|
| 1000+ | 1 | 3 | 5 | 7 | 9 |
| 1000 | 1/3 | 1 | 3 | 5 | 7 |
| 750 | 1/5 | 1/3 | 1 | 3 | 5 |
| 500 | 1/7 | 1/5 | 1/3 | 1 | 3 |
| 250 | 1/9 | 1/7 | 1/5 | 1/3 | 1 |

| **GA** (m) | 200+ | 200 | 150 | 100 | 50 |
|---|---|---|---|---|---|
| 200+ | 1 | 3 | 5 | 7 | 9 |
| 200 | 1/3 | 1 | 3 | 5 | 7 |
| 150 | 1/5 | 1/3 | 1 | 3 | 5 |
| 100 | 1/7 | 1/5 | 1/3 | 1 | 3 |
| 50 | 1/9 | 1/7 | 1/5 | 1/3 | 1 |

**PF***: Distance from health/kindergarten/primary/secondary/high/mosque
**GA**: Distance from green area
(*The given values are presented in a single table)

Table 4.22 shows the pairwise comparison matrix for the main criteria. The matrix is based on 10 different criteria, with the distance from existing public facilities criterion representing the 7 different public facilities examined in this study. Separate calculations are made for each criterion, but they are all presented in a single matrix since the same values are assigned in pairwise comparisons.

**Table 4.22 Pairwise comparison matrix for main criteria**

| AHP calculation criterion | Slope | Distance from existing public facility | Population | Distance from existing road network | Distance from bus stop | Distance from tram stop | Distance from power line network | Distance from natural gas network | Distance from clean water network | Distance from wastewater network |
|---|---|---|---|---|---|---|---|---|---|---|
| **Slope** | 1 | 1/9 | 1/9 | 1/3 | 1/3 | 1/3 | 1/5 | 1/5 | 1/5 | 1/5 |
| **Distance from existing public facility*** | 9 | 1 | 3 | 5 | 7 | 7 | 9 | 9 | 9 | 9 |
| **Population** | 9 | 1/3 | 1 | 3 | 5 | 5 | 7 | 7 | 7 | 7 |
| **Distance from existing road network** | 3 | 1/5 | 1/3 | 1 | 3 | 3 | 5 | 5 | 5 | 5 |
| **Distance from bus stop** | 3 | 1/7 | 1/5 | 1/3 | 1 | 1 | 3 | 3 | 3 | 3 |
| **Distance from tram stop** | 3 | 1/7 | 1/5 | 1/3 | 1 | 1 | 3 | 3 | 3 | 3 |
| **Distance from power line network** | 5 | 1/9 | 1/7 | 1/5 | 1/3 | 1/3 | 1 | 1 | 1 | 1 |
| **Distance from natural gas network** | 5 | 1/9 | 1/7 | 1/5 | 1/3 | 1/3 | 1 | 1 | 1 | 1 |
| **Distance from clean water network** | 5 | 1/9 | 1/7 | 1/5 | 1/3 | 1/3 | 1 | 1 | 1 | 1 |
| **Distance from wastewater network** | 5 | 1/9 | 1/7 | 1/5 | 1/3 | 1/3 | 1 | 1 | 1 | 1 |

* It represents seven types of public facilities

The AHP-based suitability evaluation of public facilities is based on the distance to existing public facilities as the most important criterion in the comparison matrix. This is because the proposed distribution of public facilities in zoning plans and the distance to them directly affect the areas they serve and do not serve.

It is important to note that public facilities serve the population directly. Therefore, the need for public facilities increases in areas with high population, while it decreases in areas with lower population. When evaluating suitability, this was also taken into account and it was determined that population is less important than existing public facilities and more important than other criteria.

It is also important to consider transportation when evaluating the presence of public facilities in urban areas. Existing public facilities and population are considered more important than roads that have not yet been built, as the latter can negatively affect transportation and investment decisions. However, roads remain a crucial aspect of transportation infrastructure, as public transportation facilities and technical infrastructure services directly rely on existing road networks.

The study area has two types of public transportation: buses and trams. These modes of transportation are considered equivalent as they provide different routes and stops, increasing transportation opportunities. However, they are less important than roads since they are directly connected to the existing road network.

It is indisputable that technical infrastructure areas are necessary both during the construction and use of public facilities. However, the importance of these areas is technically lower than that of other criteria because they depend on the existing road networks and require technical personnel during the construction phase. As all technical infrastructure types are equally necessary, they are considered equally important.

Given that the study area is predominantly urban and relatively flat, the slope criterion was considered to be the least important criterion. However, in areas with significant and varied slopes, it should be considered the most important criterion.

The weight values of the criteria, based on the pairwise matrix, were calculated using the formulas provided in section 4.1 and are presented in Table 4.23.

After performing calculations using by Microsoft Excel, it was found that the distance from existing public facilities received the highest weight value, while slope received the lowest weight value. A consistency check was then performed using the formulas given in section 4.1, resulting in a consistency ratio (CR) of 0.096. The pairwise comparison matrix created using the criteria determined in the study area is considered acceptable, as this value is below the consistency threshold of 0.10.

**Table 4.23 Assigned rank and weight values to the criteria in AHP**

| Main criteria | Sub-criteria | Ranking | Weighting |
|---|---|---|---|
| **Slope (°)** | 0-2% | 5 | 0,018 |
| | 3-5% | 4 | |
| | 6-10% | 3 | |
| | 11-20% | 2 | |
| | 21% + | 1 | |
| **Distance from Existing Public Facility (m)** | 250 | 1 | 0,353 |
| | 500 | 2 | |
| | 750 | 3 | |
| | 1000 | 4 | |
| | 1000+ | 5 | |
| **Population (person)** | 0-250 | 1 | 0,222 |
| | 251-500 | 2 | |
| | 501-750 | 3 | |
| | 751-1000 | 4 | |
| | 1000+ | 5 | |
| **Distance from Existing Road Network (m)** | 25 | 5 | 0,126 |
| | 50 | 4 | |
| | 75 | 3 | |
| | 100 | 2 | |
| | 100+ | 1 | |
| **Distance from Bus Stop (m)** | 50 | 5 | 0,068 |
| | 100 | 4 | |
| | 150 | 3 | |
| | 200 | 2 | |
| | 200+ | 1 | |
| **Distance from Tram Stop (m)** | 50 | 5 | 0,068 |
| | 100 | 4 | |
| | 150 | 3 | |
| | 200 | 2 | |
| | 200+ | 1 | |
| **Distance from Electricity Network (m)** | <10 | 5 | 0,036 |
| | 10-20 | 3 | |
| | 20< | 1 | |
| **Distance from Natural Gas Network (m)** | <10 | 5 | 0,036 |
| | 10-20 | 3 | |
| | 20< | 1 | |
| **Distance from Clean Water Network (m)** | <10 | 5 | 0,036 |
| | 10-20 | 3 | |
| | 20< | 1 | |
| **Distance from Wastewater Network (m)** | <10 | 5 | 0,036 |
| | 10-20 | 3 | |
| | 20< | 1 | |

# Chapter 5

# Suitability Analyzes, Results and Discussion

To evaluate suitability, the weight values of the criteria were calculated using the AHP method. These values were then used in weighted overlay and weighted sum analyses to evaluate the suitability of each public facility.

## 5.1 Weighted Overlay Analyze

The Weighted Overlay Analyze applies one of the most commonly used approaches for analyzing and solving multicriteria problems, such as site selection and suitability models. Weighted overlay analysis requires defining the problem, breaking the model into sub-models, and identifying the input criteria [86].

The Weighted Overlay Analyze functions as illustrated in Figure 5.1.

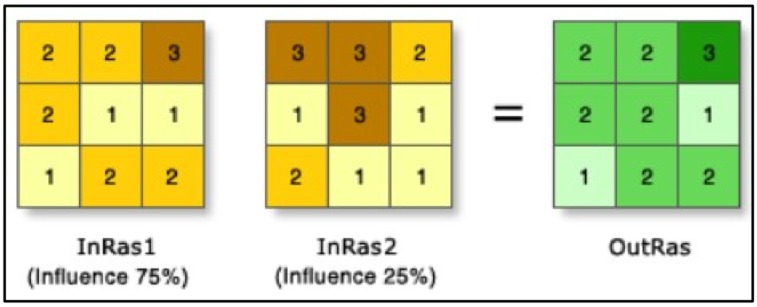



**Figure 5.1 The working principle of the Weighted Overlay Analysis [90]**

The two-input raster were reclassified to a standardized measurement scale ranging from 1 to 3. Each raster was assigned a specific percentage influence. The cell values were then multiplied by their respective percentage influences, and the resulting values were aggregated to generate the output raster. For example, in the upper-right cell, the values for the two inputs were transformed to (3 * 0.75) = 2.25 and (2 * 0.25) = 0. 5. The sum of these values, 2.25 and 0.5, equals 2.75. As the output raster from Weighted Overlay is integer-based, the final value is rounded to 3 [87].

## 5.2 Weighted Sum Analyze

The Weighted Sum Analysis allows for the weighting and combination of multiple inputs to create an integrated analysis. With multiple raster inputs, representing various factors, it is easy to combine them, taking into account their weights or relative importance. Maintaining the model resolution in Weighted Sum can be helpful when identifying only the top few favorable locations or a specific number of sites [88].

The Weighted Sum Analyze functions as illustrated in Figure 5.2.

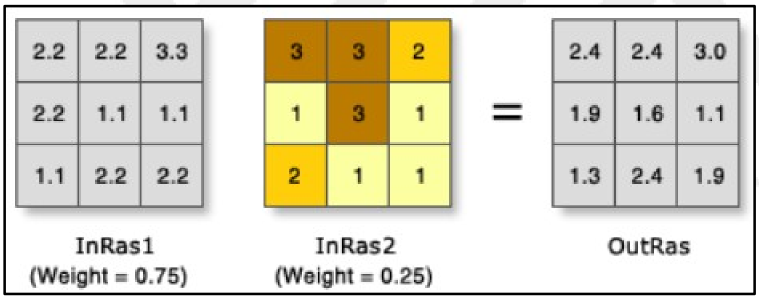



**Figure 5.2 The working principle of the Weighted Sum Analysis [89]**

The output raster is created by adding together the cell values multiplied by their weight factor. For example, in the bottom-right cell, the values for the two inputs were transformed to (2.2 * 0.75) = 1.65 and (1 * 0.25) = 0.25. The sum of these values, 1.65 and 0.25, equals 1.90 [89].

## 5.3 Comparison of The Analyzes for Public Facilities

Although the Weighted Sum and Weighted Overlay are similar, there are two significant differences between them. The Weighted Sum tool does not rescale the reclassified values back to an evaluation scale like the Weighted Overlay tool does. Additionally, the Weighted Sum tool accepts both floating-point and integer values, while the Weighted Overlay tool only accepts integer raster as inputs [89].

The Weighted Overlay tool is mainly used for suitability modeling, and it is important to follow accurate methodologies when applying it. In contrast, the Weighted Sum tool is useful in situations where maintaining the model resolution is crucial or when dealing with floating-point output or decimal weights is necessary [89].

Both analyses were used to evaluate compliance for each public facility. This provides a clearer picture of the suitability of public facilities proposed in zoning plans in urban areas.

According to the established criteria, calculations, and both analyses results, the study area was divided into three categories based on the suitability evaluation: non-suitable area, suitable area, and very high suitable area.

**Non-suitable areas** are those that can benefit from public facilities and are not needed if new public facility areas are proposed in the zoning plans.

**Suitable areas** can partially benefit from public facilities. In zoning plans, new public facility areas can be proposed in certain areas.

**Very high suitable area** indicates areas that cannot benefit from public facilities. It is understood that new public facility areas should definitely be proposed in zoning plans.

Areas that are non-suitable, suitable, and very high suitable have been analyzed for each public facility. The weight values obtained from the AHP calculation were used in this analysis. The weight values were converted into integers for the Weighted Overlay analysis, as it only accepts integers and the sum should be 100. Conversely, for the Weighted Sum analysis, which accepts floating-point and the sum should be 1, the weight values were used as is.

### 5.3.1 Health Facility

The study area has 6 health facility areas. Figure 5.3 shows the results of the suitability evaluation of these areas using Weighted Overlay analysis. The majority of the areas are found to be suitable according to the map. However, the western region, which is closer to the center and has a high population density, and the central region, which is far from existing health facilities, have particularly very high suitable areas. This indicates a need for new health facilities in these locations.

Figure 5.4 presents the suitability evaluation using Weighted Sum analysis. The analysis shows a decrease in non-suitable and very high suitable areas, and an increase in suitable areas compared to the Weighted Overlay analysis. However, there is no change in the areas where new health facilities are needed.

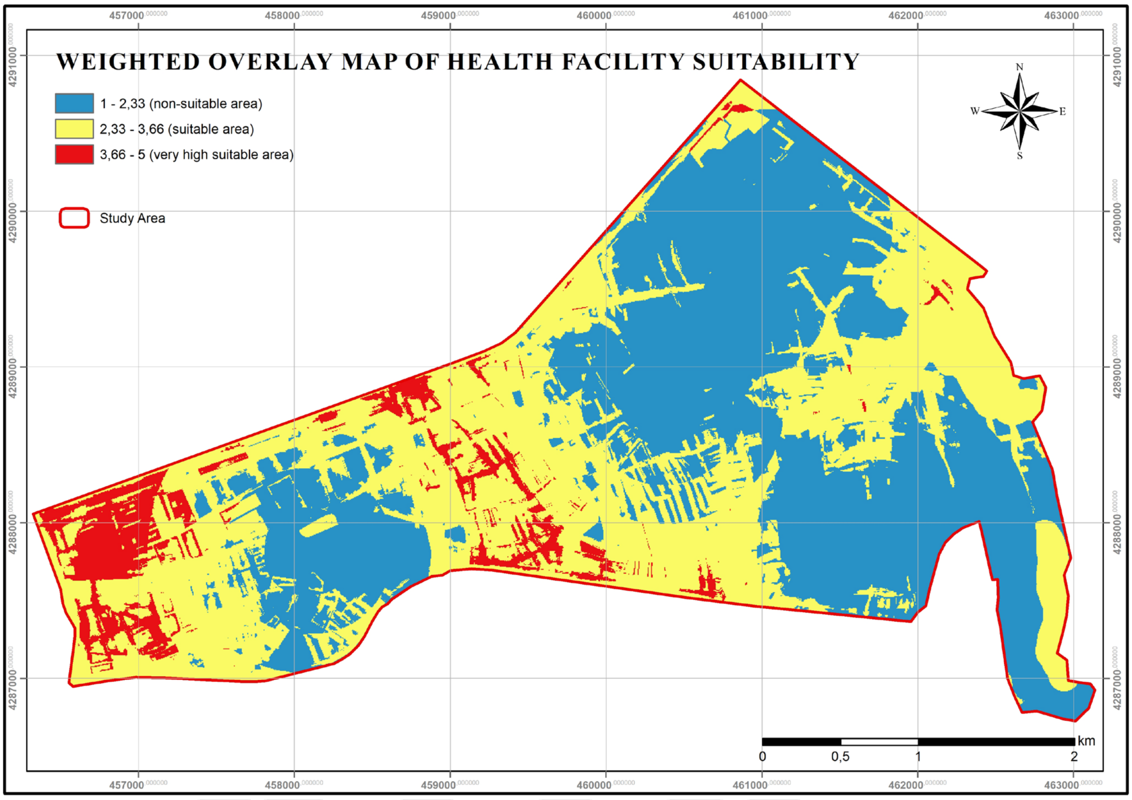



Figure 5.3 Weighted overlay map of health facility suitability

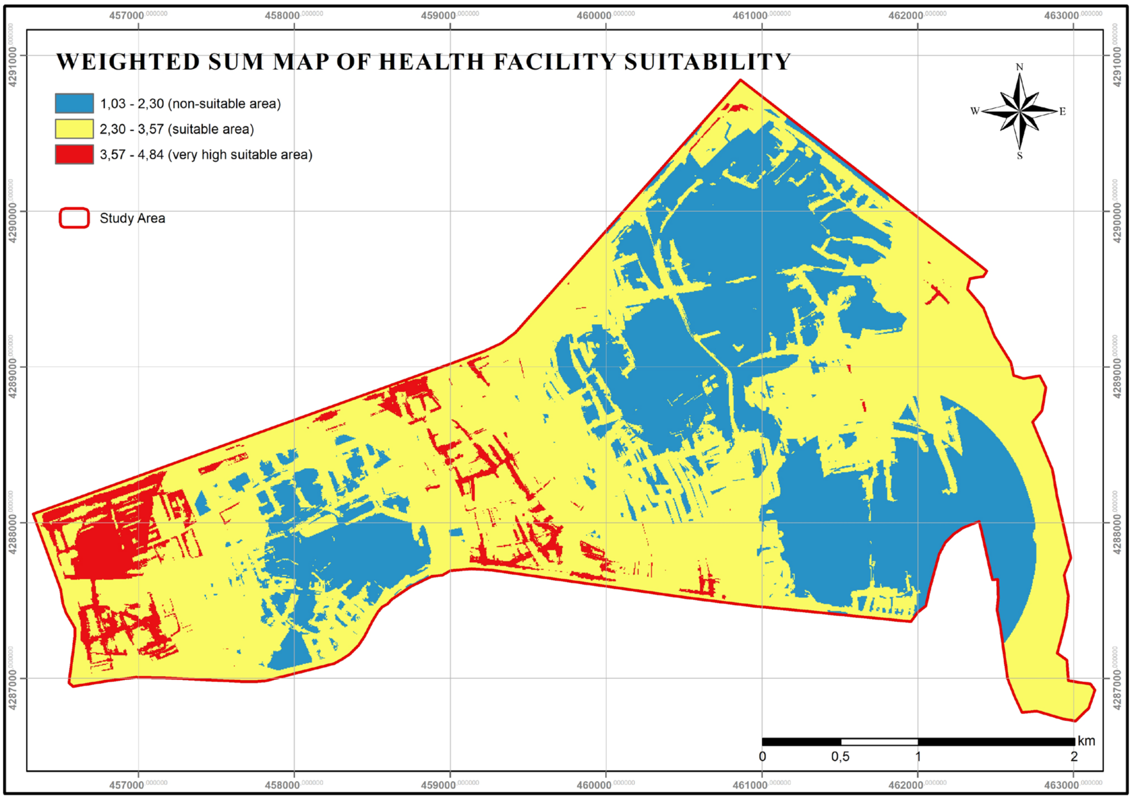



Figure 5.4 Weighted sum map of health facility suitability

## 5.3.2 Green Area

The study area has 29 green areas. Figure 5.5 shows the results of the suitability evaluation of these areas using Weighted Overlay analysis. The majority of the areas are found to be suitable according to the map. However, the density of suitable and very high suitable areas in most of the area, especially in the western and central regions, indicate that the study area has significant green area needs.

Figure 5.6 presents the suitability evaluation using Weighted Sum analysis. The analysis shows a decrease in non-suitable and very high suitable areas, and an increase in suitable areas compared to the Weighted Overlay analysis. However, there is no change in the areas where new green areas are needed.

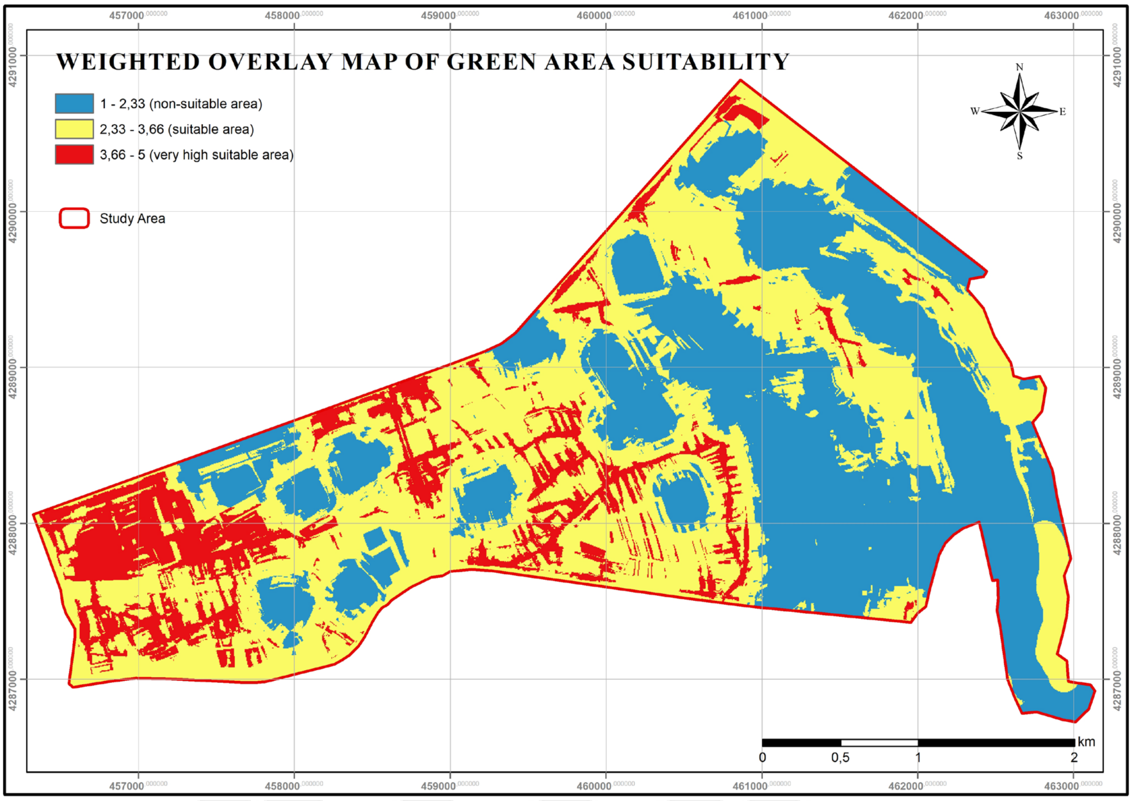



**Figure 5.5 Weighted overlay map of green area suitability**

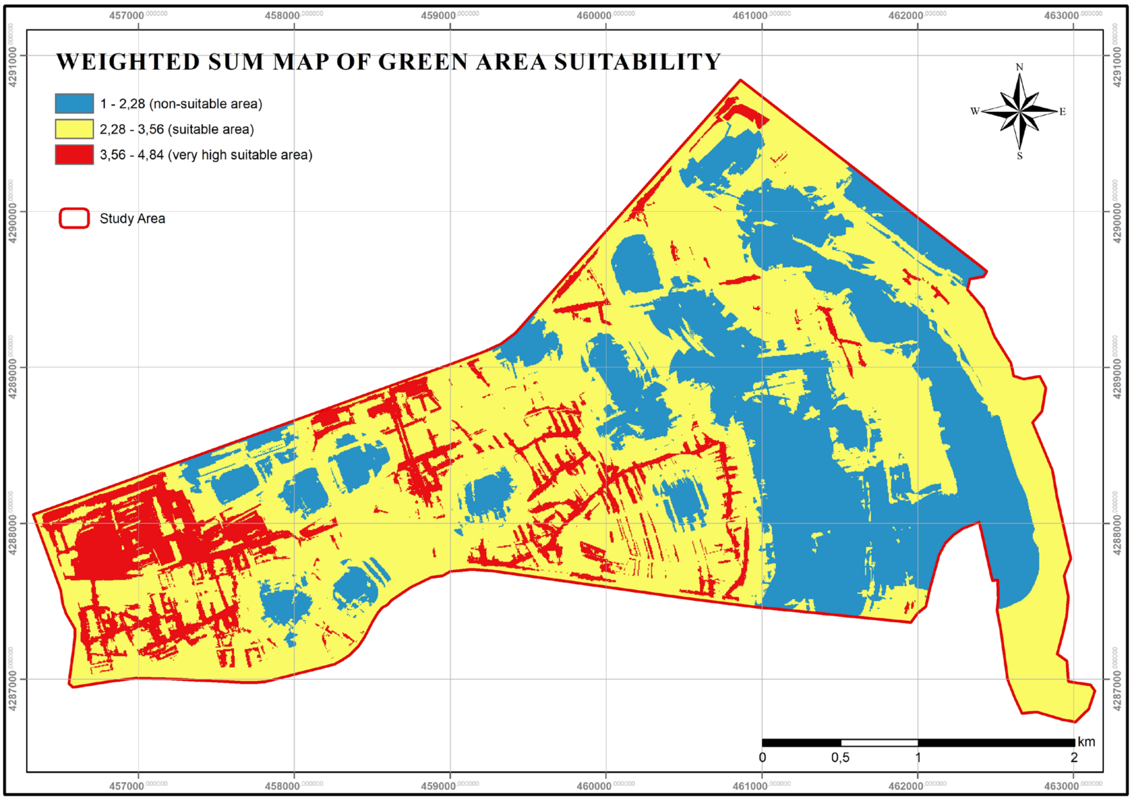



**Figure 5.6 Weighted sum map of green area suitability**

### 5.3.3 Kindergarten Area

The study area has 3 kindergarten areas. Figure 5.7 displays the results of the suitability evaluation of these areas using Weighted Overlay analysis. The map indicates that the majority of the study area, particularly the central and eastern regions, comprises of suitable and very high suitable areas. This suggests that there is a shortage of kindergarten areas in the study area and the distribution of the existing ones is problematic.

Figure 5.8 illustrates the suitability evaluation using Weighted Sum analysis. The analysis indicates a decrease in non-suitable and an increase in suitable areas compared to the Weighted Overlay analysis. However, it suggests that new kindergarten areas are needed throughout the study area, except for the western part.

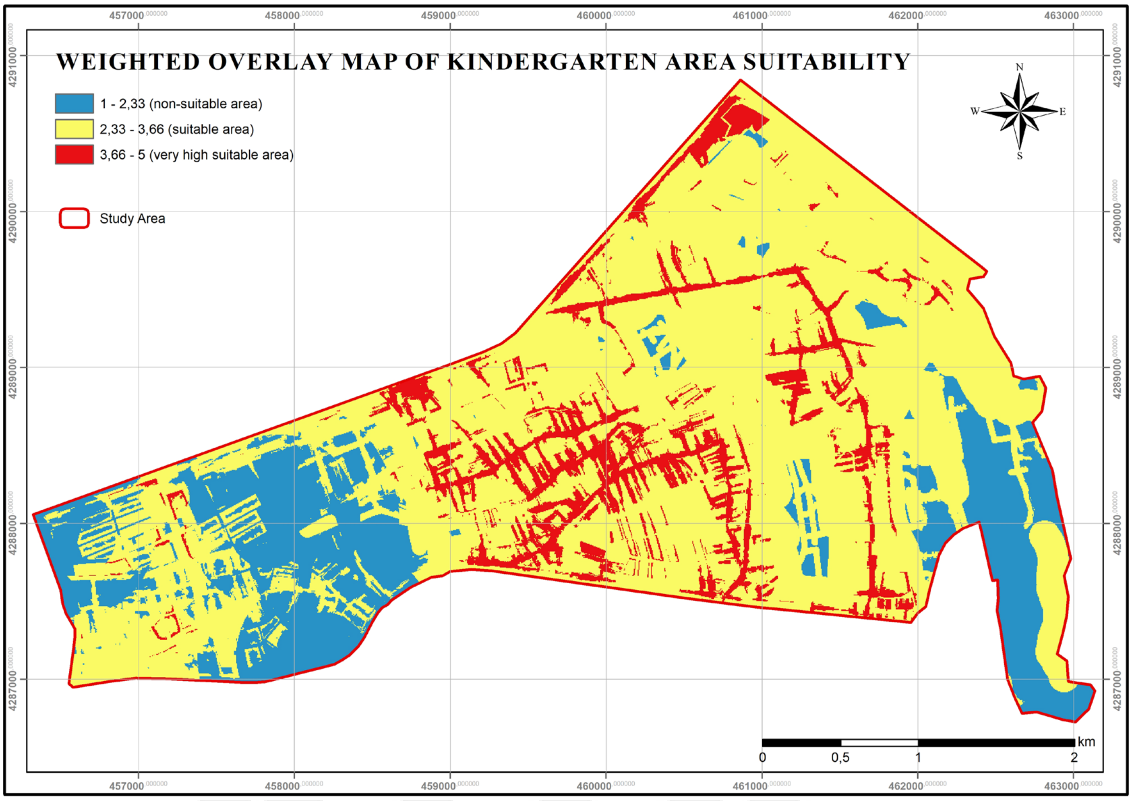



**Figure 5.7 Weighted overlay map of kindergarten area suitability**

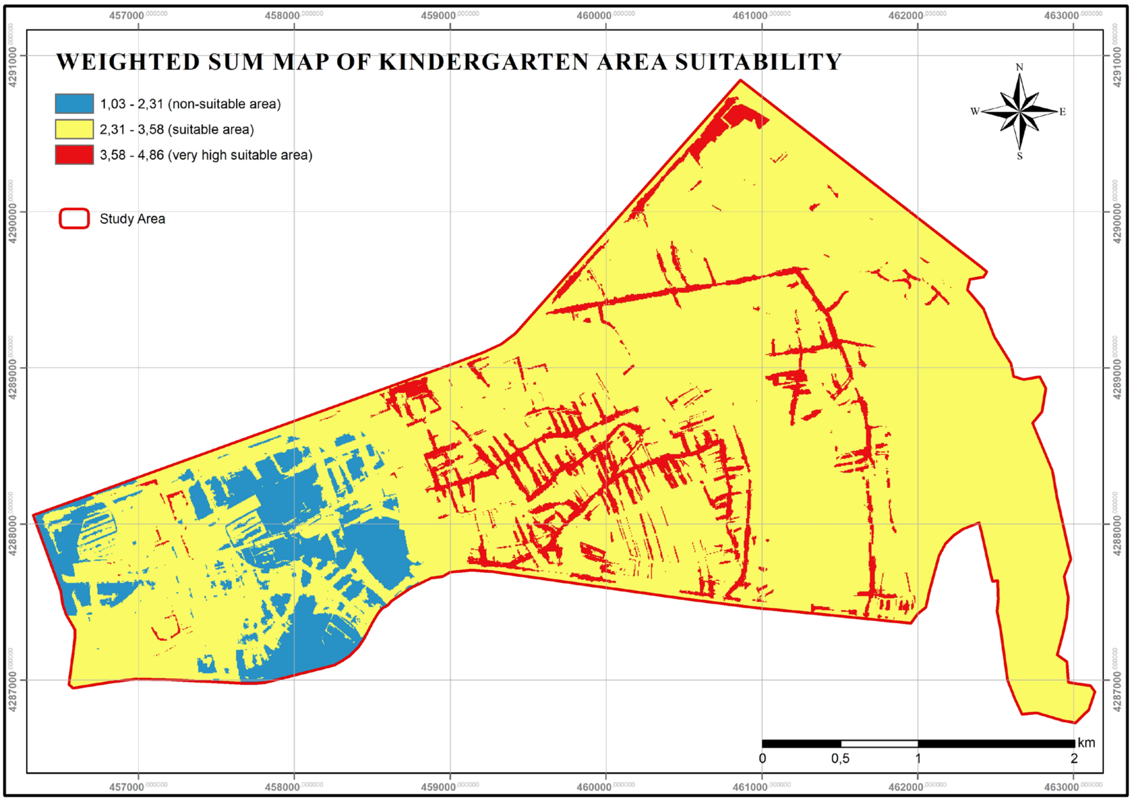



**Figure 5.8 Weighted sum map of kindergarten area suitability**

### 5.3.4 Primary School Area

The study area has 19 primary school areas. Figure 5.9 displays the results of the suitability evaluation of these areas using Weighted Overlay analysis. The map indicates that the majority of the study area is non-suitable. This suggests that the existing primary school areas are evenly distributed and there is no need for new areas.

Figure 5.10 presents the suitability evaluation using Weighted Sum analysis. The analysis indicates a decrease in non-suitable areas and an increase in suitable areas compared to the Weighted Overlay analysis. The results suggest a need for new school areas in the study area, particularly in the eastern and western regions where suitable and very high suitable areas are concentrated.

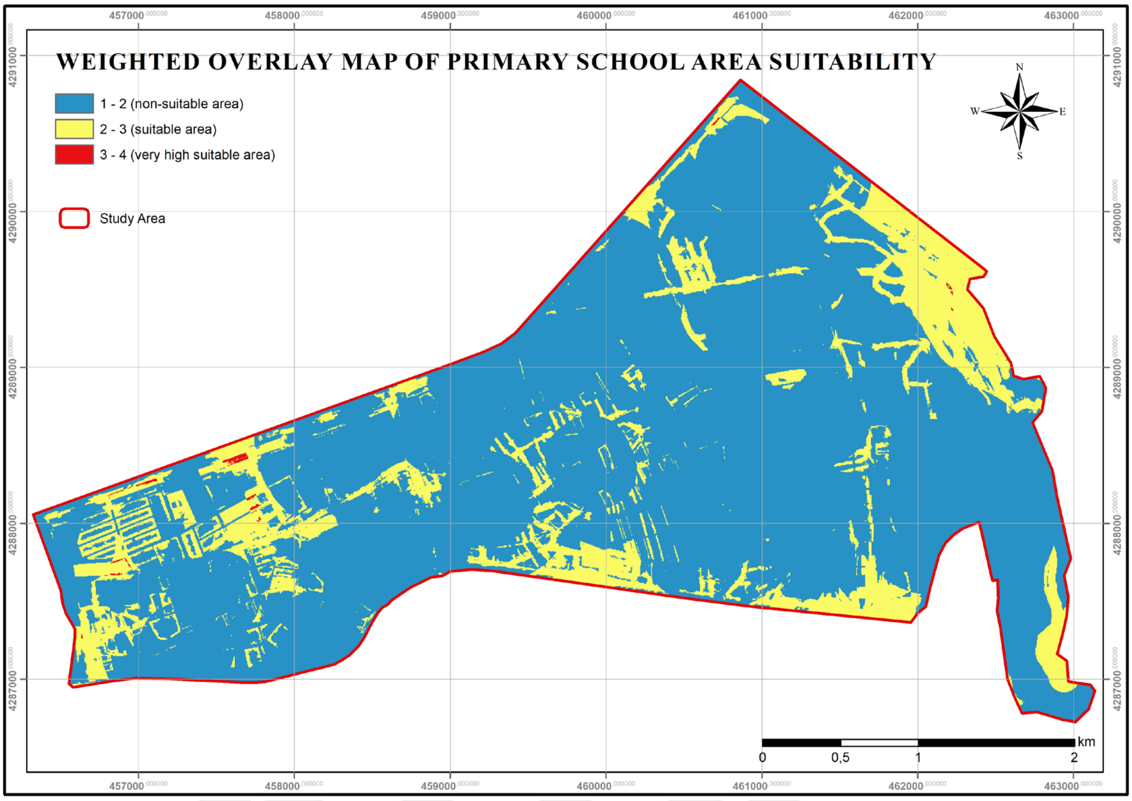



**Figure 5.9 Weighted overlay map of primary school area suitability**

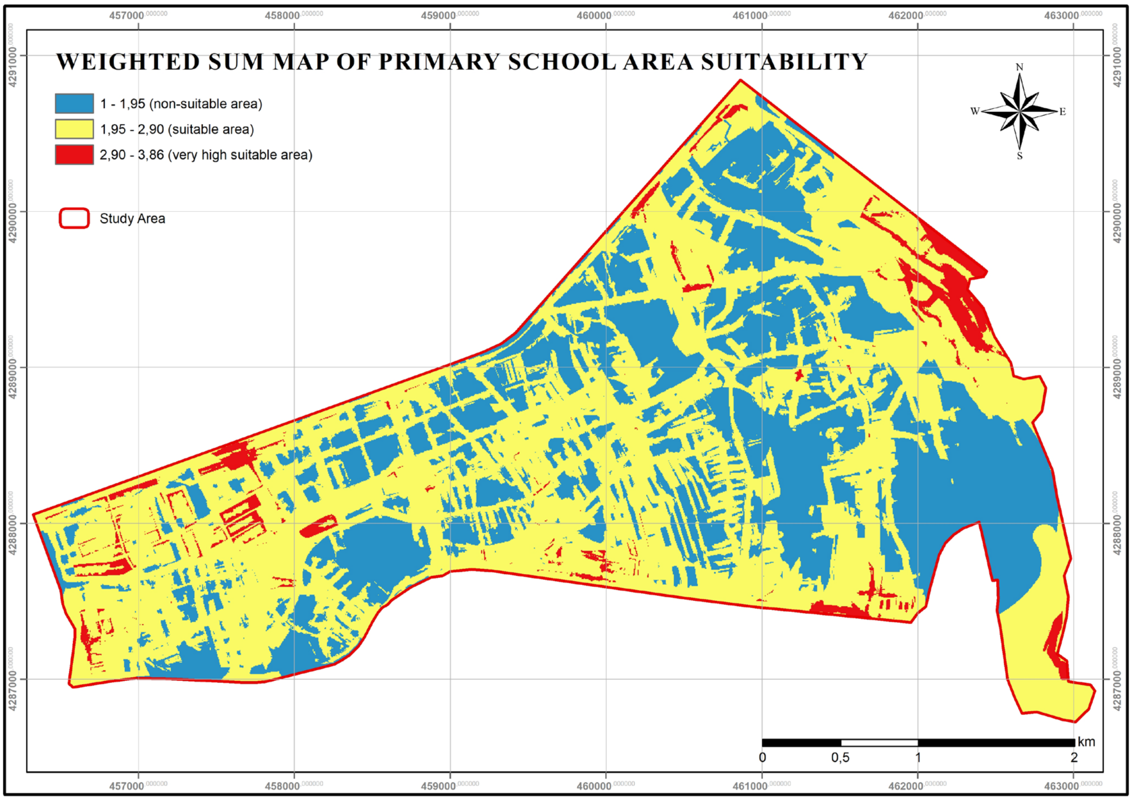



**Figure 5.10 Weighted sum map of primary school area suitability**

### 5.3.5 Secondary School Area

The study area has 6 secondary school areas. Figure 5.11 displays the results of the suitability evaluation of these areas using Weighted Overlay analysis. The map indicates that the western part of the study area has a very high density of very high suitable areas, indicating that this region cannot benefit from secondary school facilities and is in need of new secondary school areas. The distribution of secondary school areas is uneven, with concentration in the common northern and southeastern regions.

Figure 5.12 displays the results of the suitability evaluation using Weighted Sum analysis. The increase in suitable areas, as determined by the Weighted Overlay analysis, indicates an uneven distribution of secondary school areas. Therefore, new secondary school areas are required in all regions of the study area.

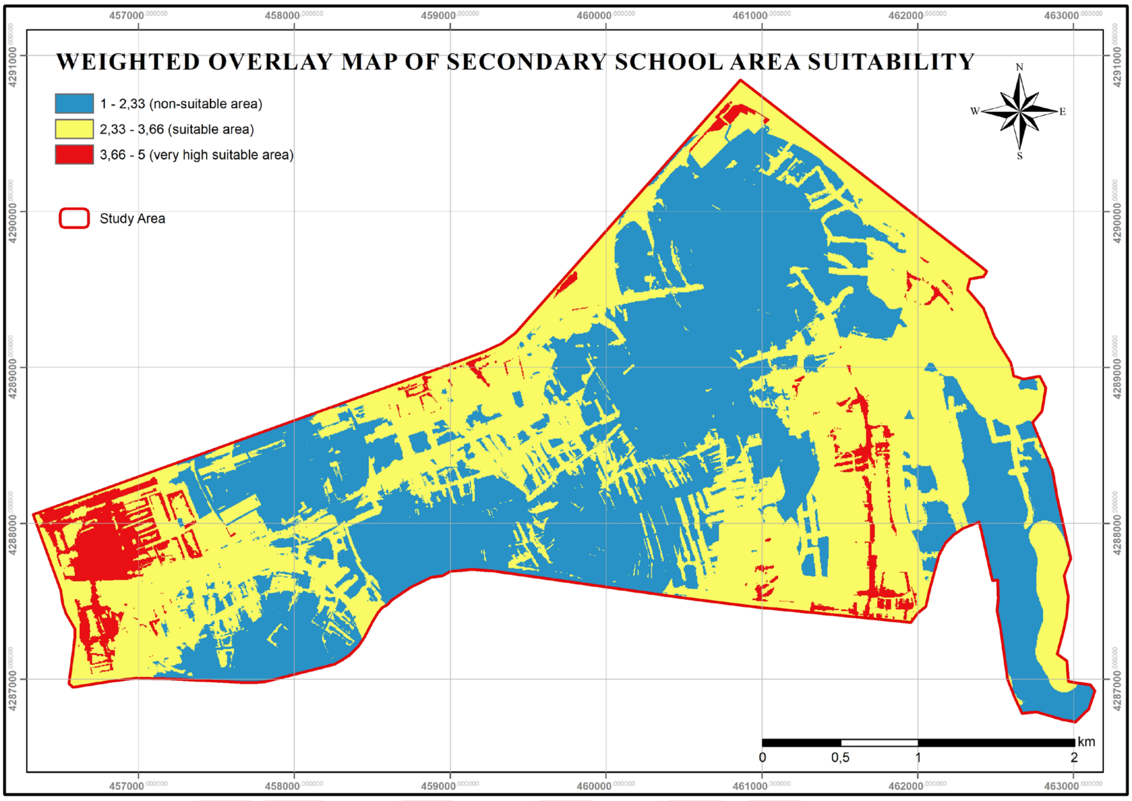



**Figure 5.11 Weighted overlay map of secondary school area suitability**

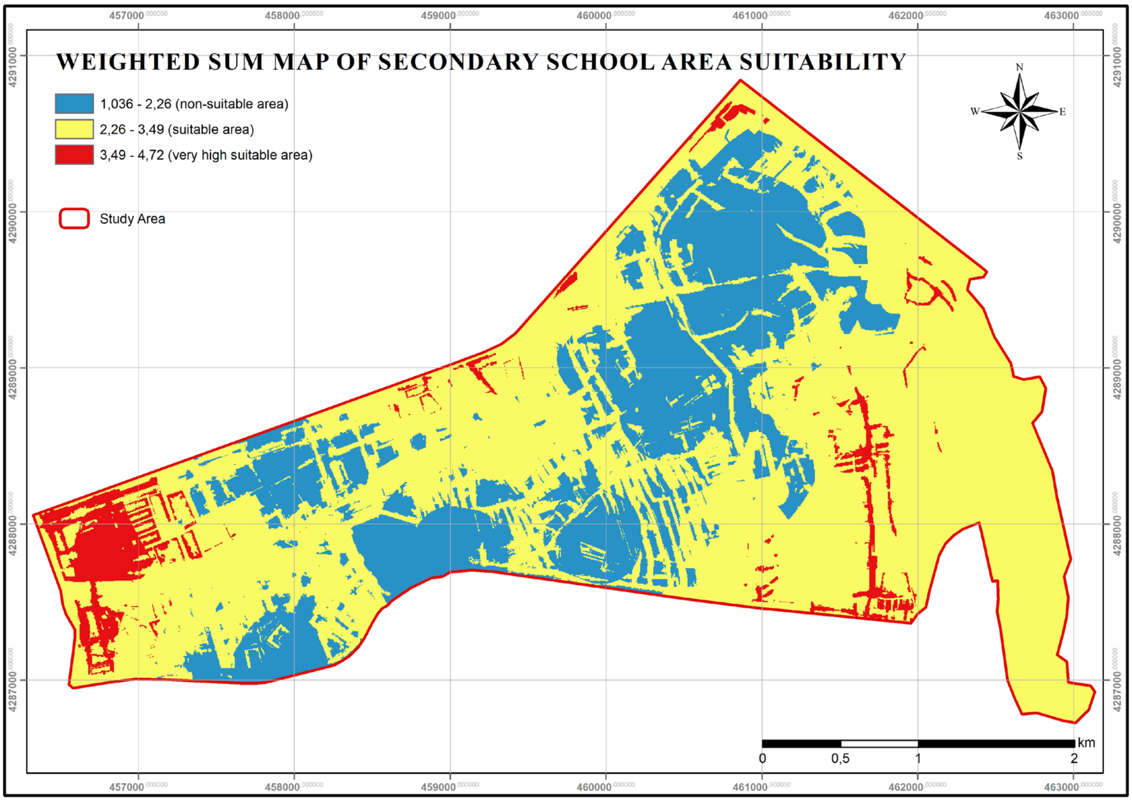



**Figure 5.12 Weighted sum map of secondary school area suitability**

### 5.3.6 High School Area

The study area has 7 high school areas. Figure 5.13 displays the results of the suitability evaluation of these areas using Weighted Overlay analysis. The map indicates a high density of very high suitable areas in the western part of the study area, suggesting that this region requires new high school areas. Additionally, there is a significant need for new high school facilities in the central part of the study area.

Figure 5.14 shows the results of the suitability evaluation using Weighted Sum analysis. The analysis indicates that the distribution of high school areas is not appropriate and that the western part of the study area is in need of new high school areas, followed by the other parts of the study area.

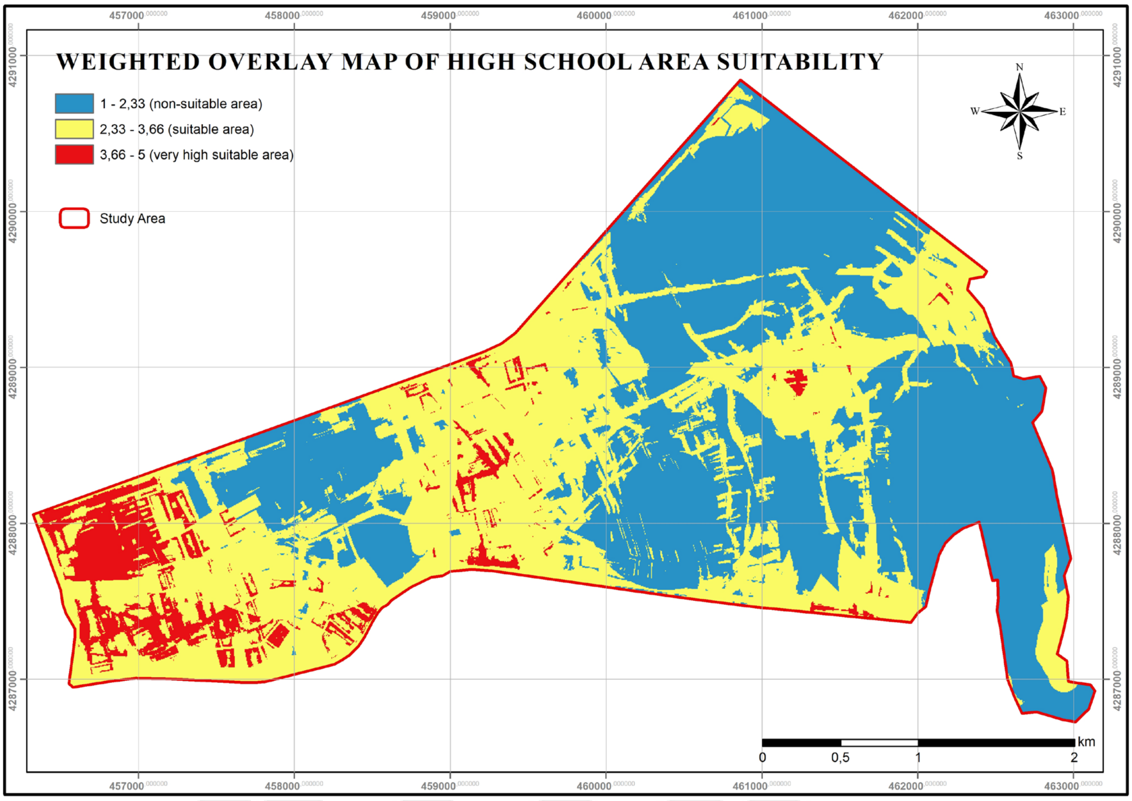



**Figure 5.13 Weighted overlay map of high school area suitability**

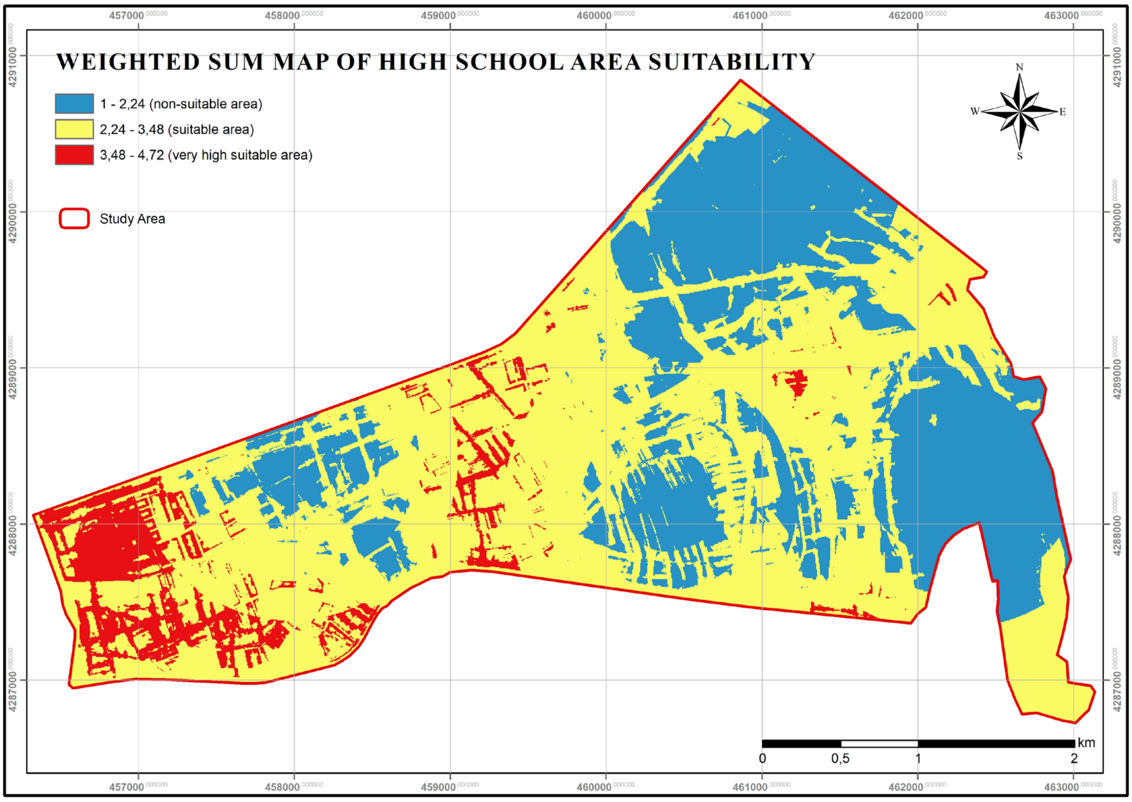



**Figure 5.14 Weighted sum map of high school area suitability**

### 5.3.7 Mosque Area

The study area has 31 mosque areas. Figure 5.15 displays the results of the suitability evaluation of these areas using Weighted Overlay analysis. The map indicates that the majority of the study area is comprised of non-suitable areas. This suggests that the mosque areas in the study area are evenly distributed and that there is no need for new areas.

Figure 5.16 presents the suitability evaluation using Weighted Sum analysis. The analysis differs from the Weighted Overlay analysis in that it indicates a higher density of suitable areas, suggesting a relative need for new mosque sites in various areas.

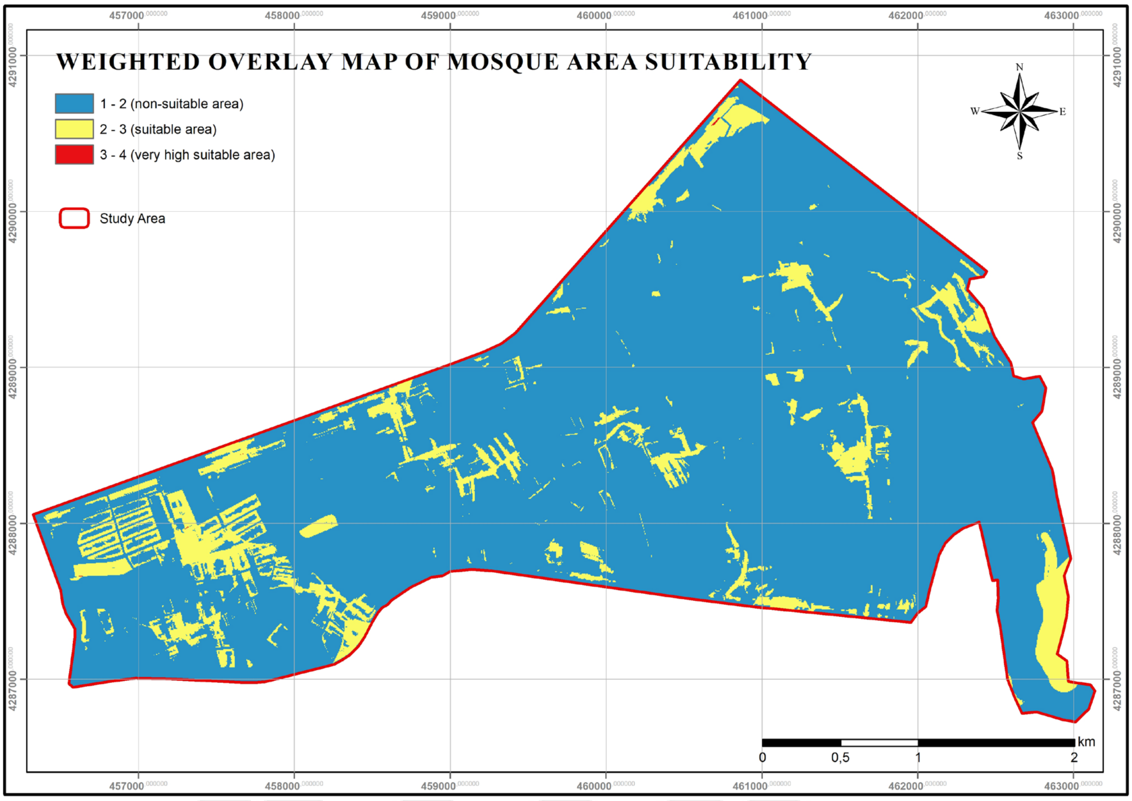



Figure 5.15 Weighted overlay map of mosque area suitability

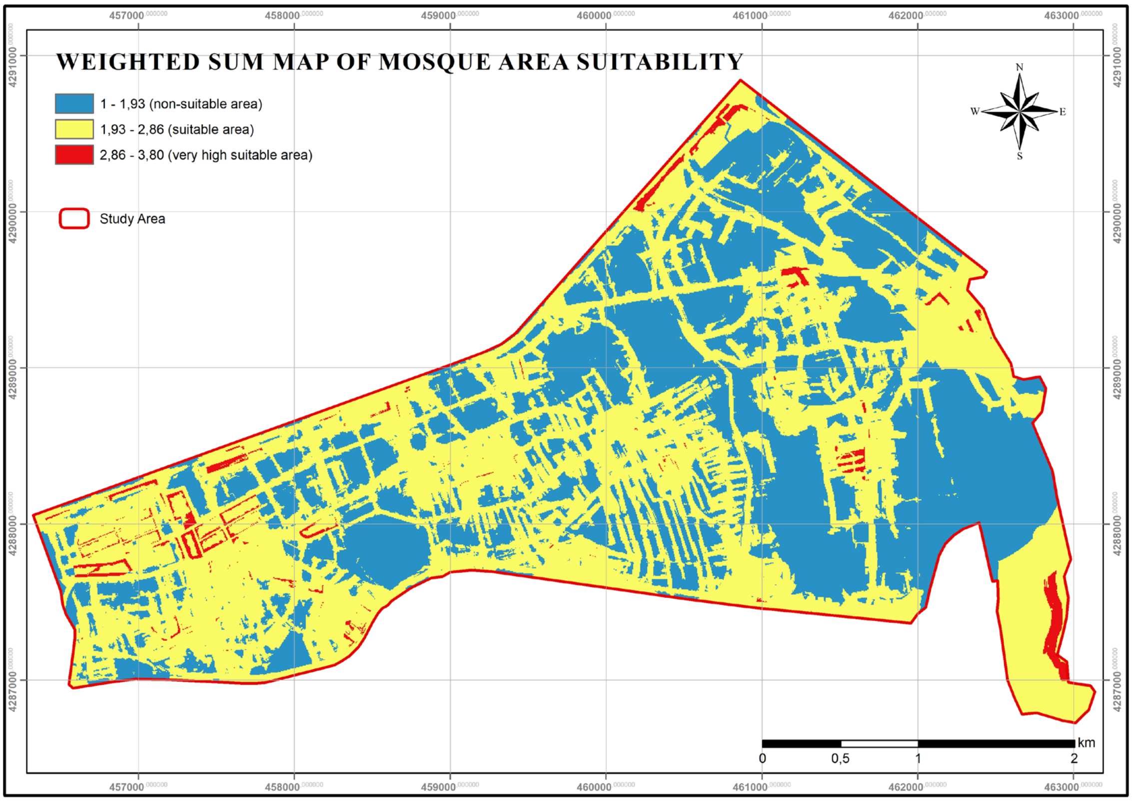



Figure 5.16 Weighted sum map of mosque area suitability

## 5.4 Results

The analysis of each proposed public facility in the zoning plan using Weighted Overlay and Weighted Sum resulted in varying outcomes. Weight values calculated based on AHP formulas were entered into the Weighted Overlay analysis as percentage values and into the Weighted Sum analysis as decimal values, and evaluations were made by producing suitability maps.

Based on the results of the Weighted Overlay analysis, it can be concluded that the proposed primary school and mosque areas in the zoning plans are suitable and sufficient for the study area in terms of distribution, number, and walking distances required by the legislation. There is relatively no need for new areas. However, the zoning plans' proposed health facilities, green areas, kindergarten areas, secondary school areas, and high school areas were found to be inappropriate and insufficient in terms of distribution, number, and walking distances in certain parts of the study area.

In the western part of the study area, where the population density is highest and closest to the center, a concentration of areas has been observed, which is of critical importance. It has been determined that this region definitely needs new areas especially in terms of new health facility, green area, secondary school and high school, relatively fewer new kindergarten area, but does not need a primary school and mosque area.

Based on the Weighted Sum analysis, the zoning plans' proposed public facilities are inadequate in terms of distribution, number, and walking distance.

Similar to the results of the Weighted Overlay analysis, the Weighted Sum analysis indicates that the highest concentration of suitable areas is in the western part of the study area. It has been determined that this region requires new health facilities, green areas, secondary schools, and high schools, and relatively fewer new kindergarten, primary school, and mosque areas.

It was determined that Weighted Overlay analysis is more suitable for large-scale study areas, such as urban areas. Therefore, the results of the Weighted Overlay analysis were overlapped with additional data to better identify areas of need.

One of the overlaid data is the proposed existing facility areas. In this way, it was possible to compare the service radius of the facilities with the suitable areas and very high suitable areas. The population distribution was also overlaid to observe the population densities within the service radius of the facilities. Finally, the areas where residential use is not allowed were overlaid. In the study area, there are four zones totaling over 150,000 $m^2$ where residential use is prohibited. These zones include protected areas, water storage areas, and areas designated for non-residential use. This overlap allowed for the identification of extensive unpopulated areas.

Overlaying the analysis results with the locations of public facilities, areas where residential use is prohibited, and population distribution data allowed for a more detailed evaluation of the suitable and highly suitable areas. This was done for each public facility, revealing the needs of the study area more clearly.

## 5.4.1 Health Facility

Figure 5.17 shows that 5 out of 6 health facilities in the zoning plans are located in the eastern part of the study area. The analysis indicates that there is no need for new health facilities in these areas. However, it is important to note that the service scales of these health facilities cover low population densities when compared to the population density. Furthermore, the presence of three significant zones where residential use is prohibited in this region indicates that health facilities are not distributed based on the needs of the population.

The zoning plan proposes another health facility in a region with a higher population density. However, there is also a zone where residential use is not permitted within the service area of this facility. Although the population density is low in the central part where no health facility is proposed in the zoning plan, it is still necessary to propose new health facilities in this region since it is far from the existing ones.

The western part, which has the highest population density and lacks any proposed health facilities in the zoning plan, is also far from the only health facility in that region. This region has been identified as highly suitable with a high need in the analysis results. It is critically important to propose new facilities in this area.

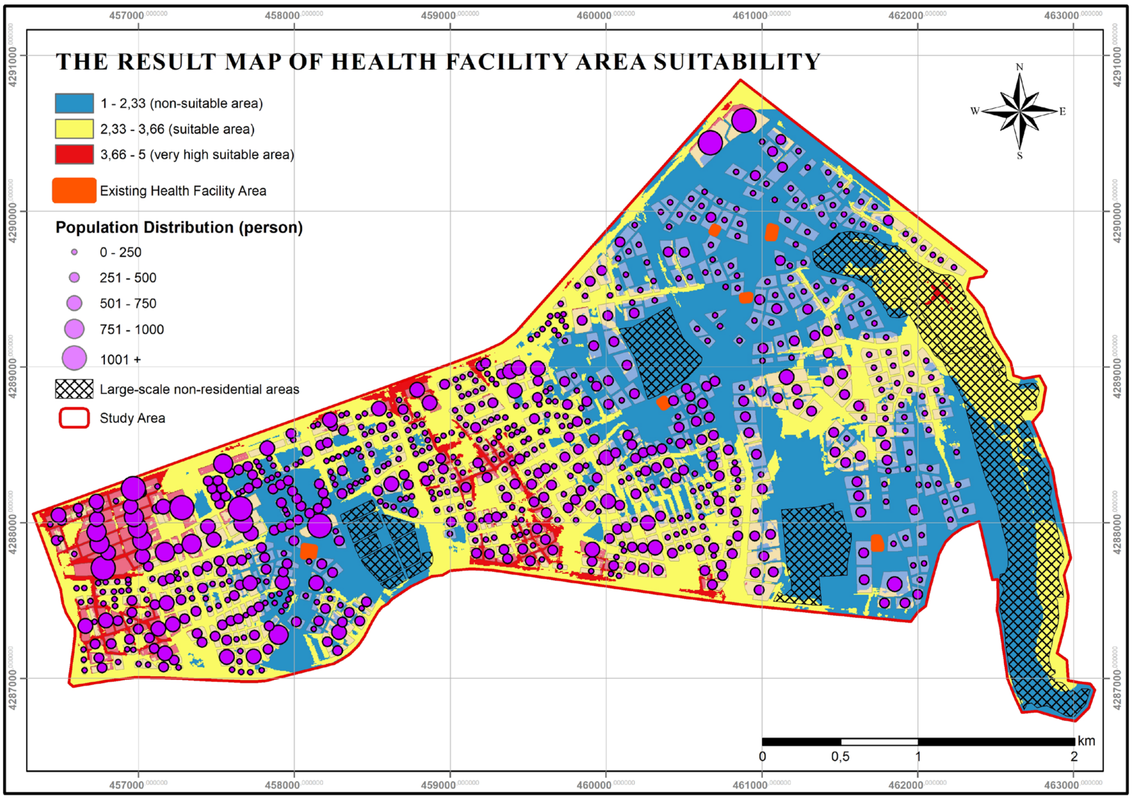



**Figure 5.17 The result map of health facility area suitability**

### 5.4.2 Green Area

Figure 5.18 shows that the proposed green areas larger than 10,000 $m^2$ in the zoning plans are few and concentrated in the eastern regions with low population density. Additionally, there are three large areas where residential use is not allowed in this region, indicating that green areas are not distributed according to the needs of the area.

The central region, which has a moderate population density, is far from the proposed green areas and requires new areas. Although this study is based on green areas larger than 10,000 square meters in the zoning plan, a more detailed analysis that considers population distribution could suggest additional green areas with smaller sizes. These areas could include landscaping, seating areas, children's playgrounds, walking tracks, sports fields, and sports equipment.

The western part of the proposed zoning plan has the highest population density and no area larger than 10,000 square meters. It is also far from the proposed green areas. The analysis results have already identified this area as having a very high need. By studying this area in detail, it is possible to propose smaller green areas. For instance, landscaping, seating areas, and playgrounds can be grouped together, or walking trails, sports fields, and sports equipment can be grouped together.

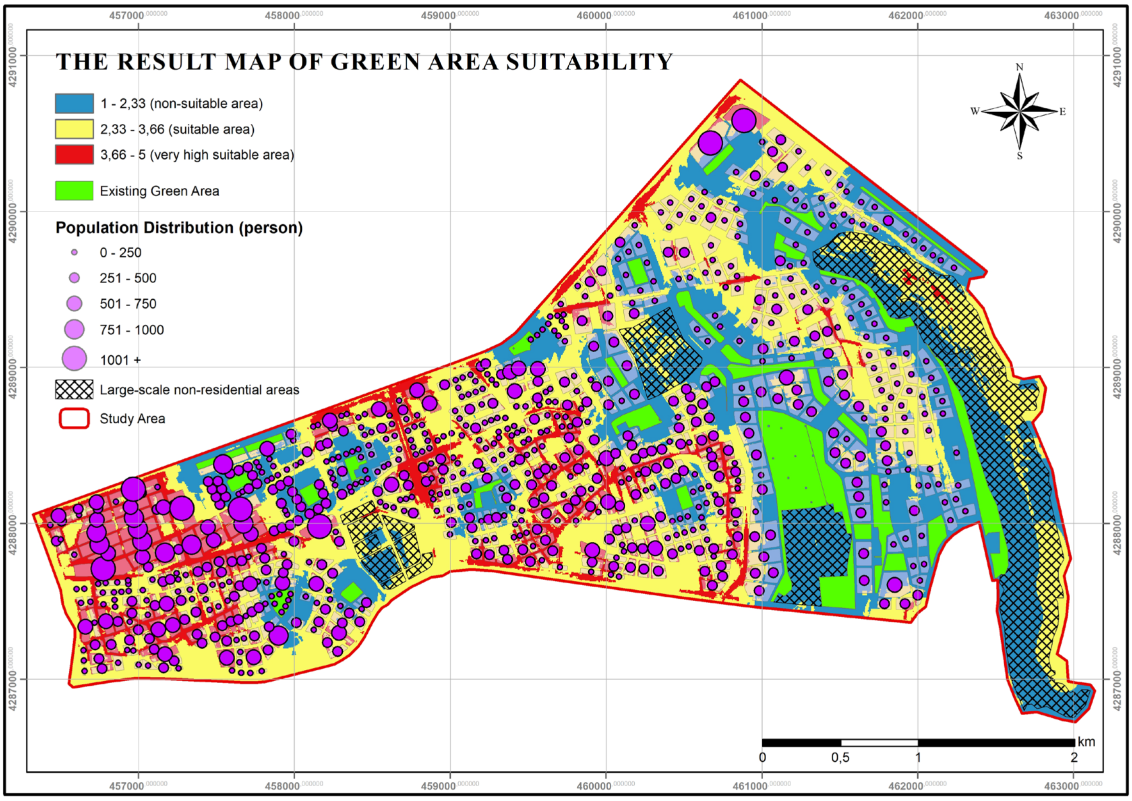



**Figure 5.18 The result map of green area suitability**

### 5.4.3 Kindergarten Area

Figure 5.19 shows that the study area has only three the proposed kindergarten areas in the zoning plan, all of which are located in the western region where population density is high.

The analysis results indicate that the eastern region, which has a low population density, does not have a critical need for kindergarten spaces as none are proposed in the zoning plans. However, accessing the proposed kindergarten areas in the western region is not possible without the use of a vehicle. Therefore, it is necessary to propose kindergarten areas in the region that ensure appropriate distribution according to population and accessibility, taking into account the unpopulated areas in the region where residential use is not allowed.

The central region is another area where kindergarten space is not proposed in the zoning plans despite having a medium population density. Although the analysis results do not indicate a critical need for this region, it is still recommended to propose kindergarten areas with an appropriate distribution considering the population density.

Currently, all proposed kindergarten areas in the zoning plans are located in the western region, but the analysis reveals that new areas are still needed in this region. A new kindergarten area can be proposed outside the service radius of the existing ones.

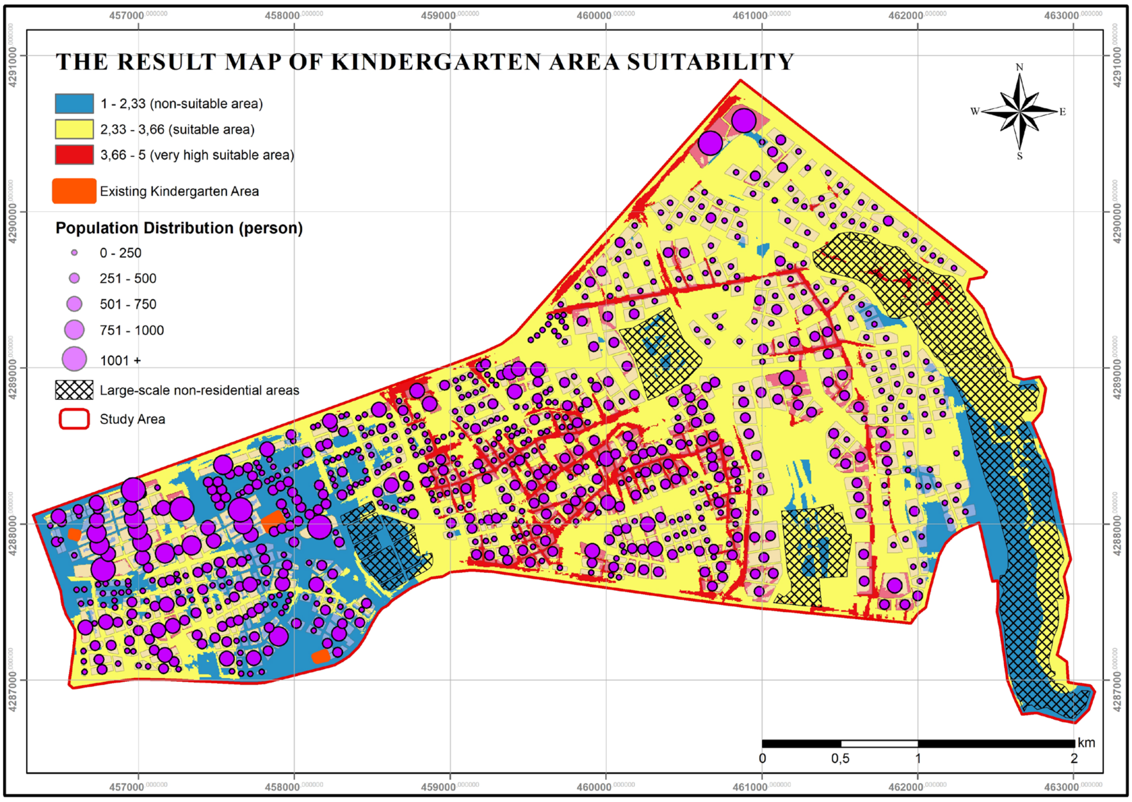



**Figure 5.19 The result map of kindergarten area suitability**

### 5.4.4 Primary School Area

Figure 5.20 shows the proposed primary school areas in the zoning plans distributed throughout the study area.

The analysis indicates a requirement for new primary school areas in only a few regions, with the easternmost part of the study area having the highest need. However, since the majority of this area falls within a zone where residential use is prohibited and the population density is low, it is unnecessary to propose a new primary school area.

The need for the western region, where population density is high, may be re-evaluated in the future through detailed observations.

The zoning plans propose primary school areas that are appropriately distributed throughout the study area based on population density and accessibility.

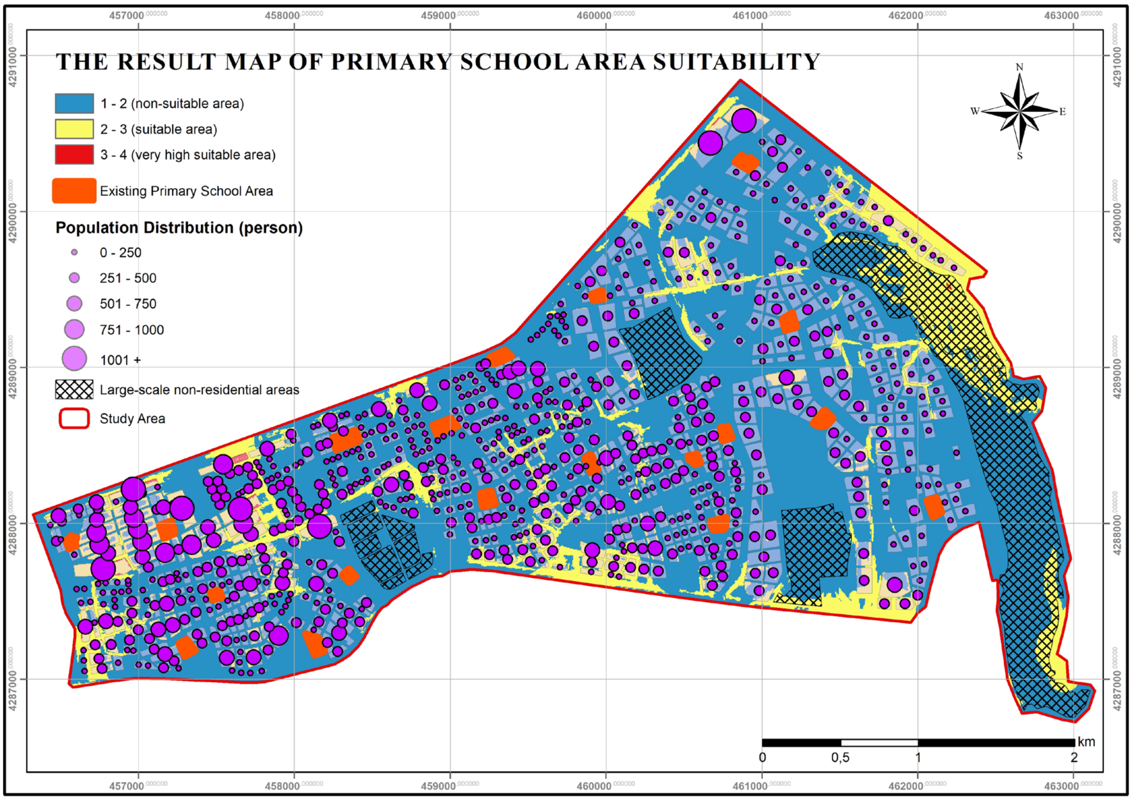



**Figure 5.20 The result map of primary school area suitability**

### 5.4.5 Secondary School Area

Figure 5.21 shows the distribution of the six proposed secondary school areas in various regions of the study area. Two are proposed in the eastern region with low population density, two in the central region with moderate population density, and two in the western region with high population density.

Based on the suitability analysis results, it is evident that the secondary school areas in the eastern region with low population density are inadequate and require new secondary school areas. The proposed areas for new secondary schools should be outside the service radius of existing secondary school areas, while also considering regions where residential use is not permitted.

New secondary school areas should be proposed in the northern part of the central region due to its distance from existing secondary school areas and moderate population density.

Additionally, it is important to propose new secondary school areas in the western region, which has the highest population density and is currently outside the service radius of existing secondary school areas.

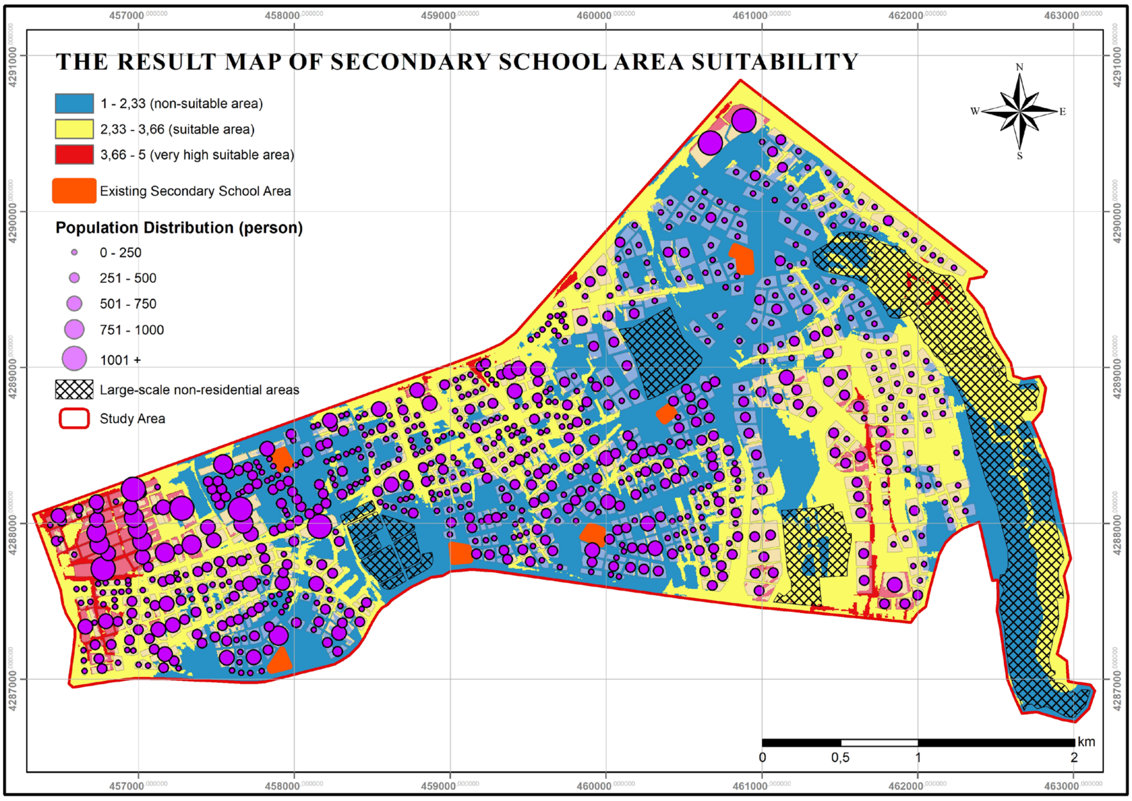



**Figure 5.21 The result map of secondary school area suitability**

## 5.4.6 High School Area

Figure 5.22 shows that 5 out of the 7 high school areas proposed in the zoning plans are located in the eastern region, with 1 in the central region and 1 in the western region.

Despite the fact that the 5 high school areas proposed in the zoning plan are located in the eastern region where the population density is low, 4 of them are located in close proximity to each other. The analysis reveals that there is still a need for new high school areas in the eastern region. New high school areas should be proposed by considering the areas where residential use is not allowed and the service radius of existing high schools in the region.

The analysis shows that the only high school area in the central region with moderate population density does not meet the need, indicating the necessity for new high school areas. Population distribution and accessibility should be taken into consideration when proposing new high school areas.

In the zoning plans, a high school area is proposed for the western part of the region. Due to the high population density and numerous residential areas outside the service radius of the existing high school area, it is necessary to propose new high school areas with appropriate distribution.

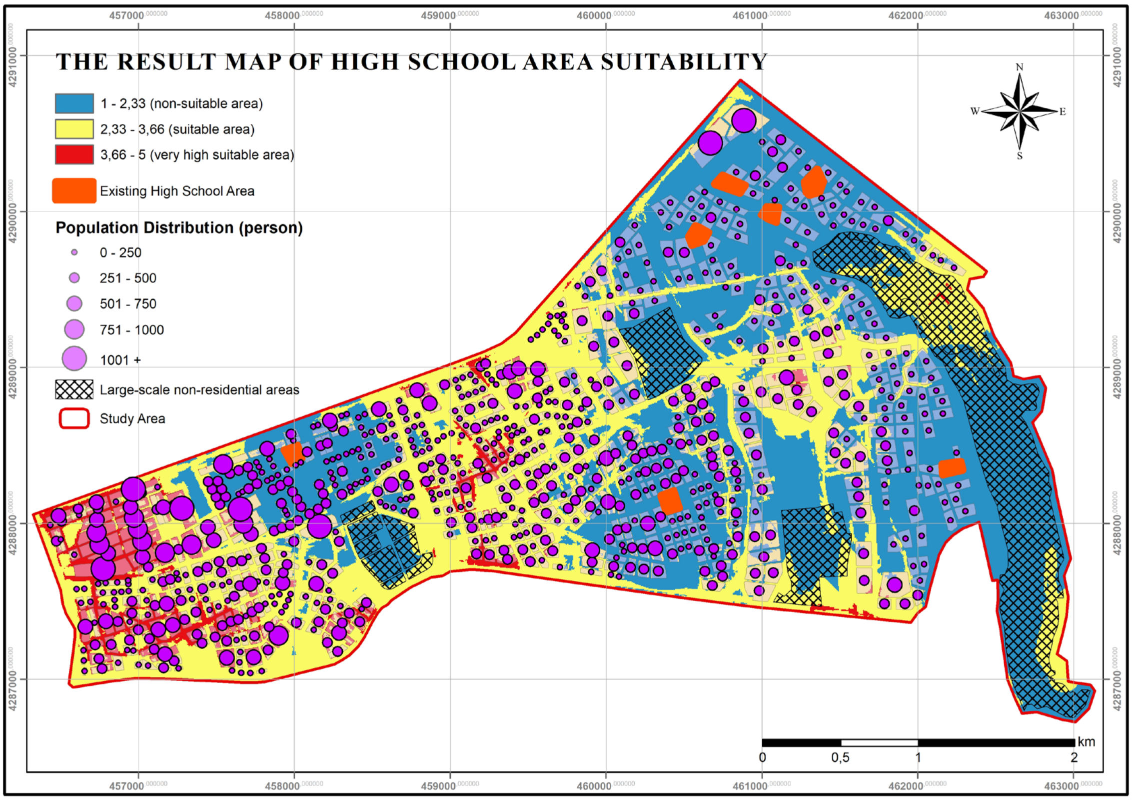



**Figure 5.22 The result map of high school area suitability**

### 5.4.7 Mosque Area

Figure 5.23 shows that proposed mosque areas in the zoning plans are distributed throughout the study area.

The analysis indicates a need for new mosque areas in only a few locations, such as unpopulated areas where residential use is prohibited or areas with low population density. Therefore, proposing a new mosque in these areas is unnecessary.

Detailed observation in the future may re-evaluate the potential need for mosque areas in high population density areas in the west.

In conclusion, the proposed mosque areas in the zoning plans are appropriately distributed throughout the study area based on population density and accessibility.

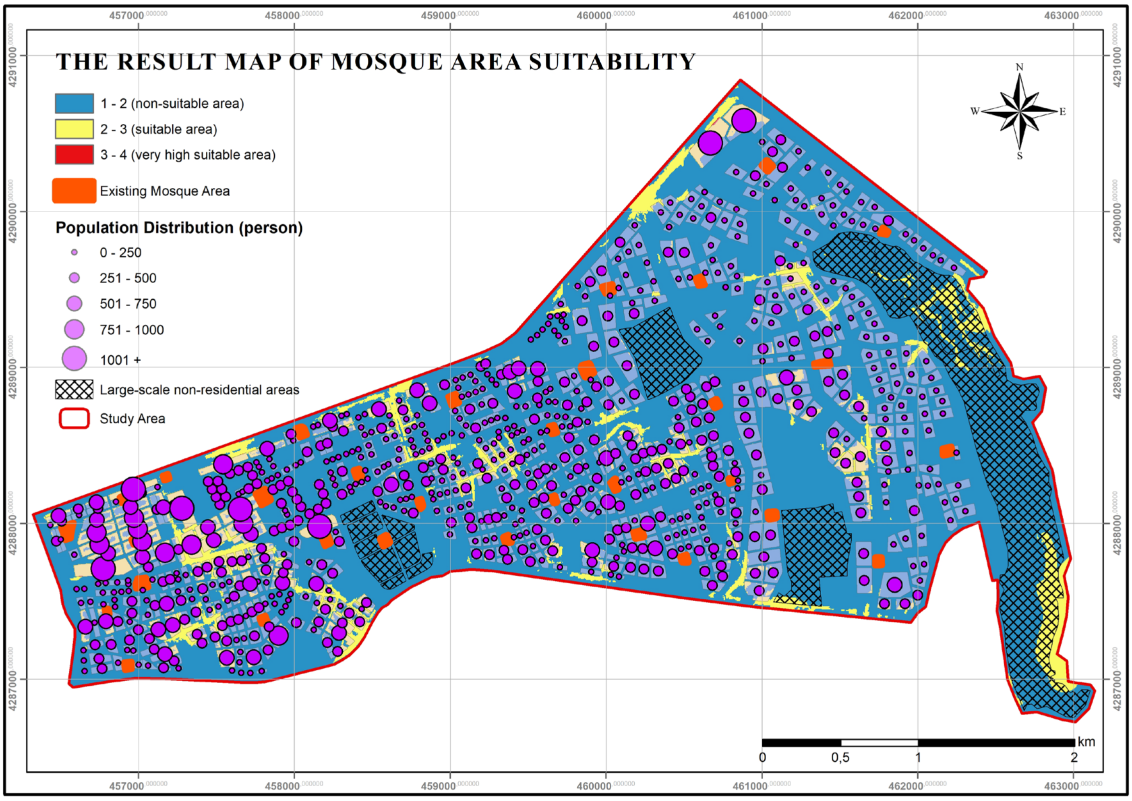



**Figure 5.23 The result map of mosque area suitability**

## 5.5 Discussion

Previous studies have shown that AHP-based suitability evaluation with GIS is typically applied in two distinct study fields. The first assesses the suitability of land for different purposes, mainly residential, using different criteria [32, 33, 34, 35, 36, 37, 38, 39, 40, 41]. The second type of study is the analysis of the selection of new sites for urban use or area [30, 31, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55]. This study combines both subjects to determine the suitability of public facilities.

Within the scope of this study, ten main criteria and their sub-criteria were identified, including slope, population, distance from existing public facilities and road networks, as well as distance from bus and tram stops, power line networks, natural gas networks, clean water networks, and wastewater networks. These criteria were determined based on information obtained from various studies and the characteristics of the study area.

When assigning importance levels to the criteria, consideration was given to the distance of public facilities from users (population), from transport facilities (road network, public transport system) and from technical requirements (infrastructure), as well as the capacity of the service radius (existing public facility) determined on the basis of walking distance. Accordingly, the service radius of any public facility is more suitable when it covers a higher population density and is located closer to transportation and infrastructure services. On the contrary, the suitability of the service decreases as the population density covered by the service radius decreases and the distance from transportation facilities and infrastructure services increases. However, to identify the areas that cannot benefit from public facilities during the analysis, the unsuitable areas mentioned above have been identified as suitable areas for new public facilities.

Previous studies have conducted suitability assessments using multi-criteria decision-making mechanisms with GIS, employing either Weighted Overlay analysis [39, 41, 43, 47, 56, 64, 66, 70, 72, 75] or Weighted Sum analysis [17, 32, 35, 44, 45, 50, 52, 60, 77, 78]. No study was found in which both analyses were performed using the same criteria and the result maps were compared and discussed.

In this study, weight values calculated using predetermined criteria and assigned importance levels are used for both Weighted Overlay and Weighted Sum analyses to compare the suitability of public facilities. The only difference in the input used for the analysis is that weight values are entered as integers in Weighted Overlay analysis and as floating-point numbers in Weighted Sum analysis.

To ensure a balanced distribution of public facilities in urban areas, it is crucial to consider their spatial distribution rather than just their size and number. Therefore, when proposing public facilities in zoning plans, it is important to take into account the walking distances assigned in the Zoning Law No. 3194 and related legislation. For the analysis of public facilities' suitability, the smallest value of 250 meters and multiples of the assigned walking distances were used, except for the green area analysis.

Based on the results of the Weighted Overlay analysis, it has been determined that 19 primary school areas and 31 mosque areas proposed in the zoning plan are suitably distributed within the boundaries of the study area according to walking distances, population densities, and other criteria. Although the walking distance value assigned for the primary school area in Table 1.1 is 500 meters, the analysis conducted with the walking distance criterion of 250 meters indicates that there is no need for a new primary school area in the study area. Additionally, it was concluded that the study area does not need new mosque sites.

The analysis of the primary school and mosque areas using the Weighted Sum method revealed areas of need, particularly in densely populated areas where the facility is more than 250 meters away.

Based on the results of the Weighted Overlay analysis, it has been determined that 6 health facilities, 3 kindergarten areas, 6 secondary school areas and 7 high school areas proposed in the zoning plan are not suitably distributed within the boundaries of the study area according to the criteria. The proximity of these areas, particularly in certain locations, resulted in the identification of numerous areas of need. If the analysis had considered the values assigned to each public facility in Table 1.1 instead of the 250-meter walking distance, there would have been fewer areas of need. However, the walking distances of 250 meters for mosque areas, 500 meters for health facilities, and 1000 meters for secondary school areas lack clear justification. These distances may not be suitable for all urban areas due to factors such as slope and pedestrian access. Therefore, 250 meters was chosen as the criterion.

The Weighted Sum analysis of the health facility, kindergarten, secondary school, and high school areas revealed that the need areas were larger than the Weighted Overlay analysis.

Based on the results of the Weighted Overlay analysis, it was found that 29 green areas larger than 10,000 square meters proposed by the zoning plan were not appropriately distributed within the study area when evaluated using the same criteria. These areas were proposed in close proximity to each other, particularly in areas with low population density, resulting in numerous areas of need. The distance criterion being determined as 50 meters and multiples in the analysis also contributed to this result. However, if the walking distance were to be accepted as 500 meters, as shown in Table 1.1, and green areas of all sizes were to be included in the evaluation, the resulting areas of need would be quite different. Nevertheless, this would be misleading as it would suggest that the need for green space in the urban area is more than met.

As with other public facilities, the analysis of green areas using Weighted Sum revealed more areas of need than the Weighted Overlay analysis.

Both analyses of public facilities have shown that the western and central regions of the study area are lacking in adequate facilities. It is crucial to propose new facilities in these areas.

The Weighted Sum analysis produced more detailed results at a smaller scale, indicating that a greater area of new facilities was needed compared to the Weighted Overlay analysis. Therefore, the study concluded that Weighted Overlay analysis results would be suitable for large-scale evaluations, such as urban areas.

In the study area, the Weighted Overlay analysis results were re-evaluated for each public facility by overlapping their locations with the population distribution and unpopulated areas where residential use is not permitted. This helped to gain a clearer understanding of the areas in need.

The evaluation of the result maps obtained by overlapping is based on the population densities resulting from the construction rights determined by the decisions of the current zoning plans, as well as the number and distribution of the proposed public facilities.

Future changes made by local and national administrations, such as reassigning areas prohibited for residential use in zoning plans for residential purposes, implementing new construction regulations, developing urban renewal projects, reconstructing certain parts of the urban area, and enacting legislative regulations, will impact and alter the results of the analysis obtained from this study.

The variation of the E (the floor area ratio) value, determined by the zoning plans in the study area, has directly affected the population density and led to the formation of regions with different population densities (as mentioned in 3.2.1.2 Population). Therefore, even if a public facility is present in a densely populated area, the analysis results indicate a need for additional public facilities in the same area. This is particularly evident in the analysis of kindergarten areas. Figure 4.5 shows that there are only three proposed kindergarten sites in the study area, all located in the western region where population density is high. Despite this, the analysis indicates a need for additional kindergarten areas in the same region. In contrast, the eastern region is expected to have a high demand for new kindergartens due to the lack of existing facilities. However, this is only appropriate given the low population density in the area.

# Chapter 6

# Conclusions and Future Prospects

## 6.1 Conclusions

Rapid population growth worldwide has led to emerging needs in urban areas for both residential areas and public facilities. Although new residential areas are produced quickly, public facilities cannot keep up with the same pace. This issue with public facilities is not limited to new residential areas but also affects existing ones. To ensure seamless access to public facilities for city dwellers, it is crucial to have a sufficient number of facilities that are evenly distributed throughout the urban area. The objective of this study is to analyze and evaluate the suitability of public facilities proposed in the zoning plan in an existing residential area. Furthermore, unlike previous studies that concentrated solely on the suitability or site selection of a single public facility, such as green areas, health facilities, educational facilities, etc., this study is distinguished by the fact that 7 different public facilities that meet the daily needs of urban residents of all ages in the urban area will be separately evaluated in the designated study area.

Decisions regarding public facilities are made based on the provisions of the Zoning Law No. 3194 and related regulations, as outlined in zoning plans. Therefore, this study evaluates the public facilities proposed by the zoning plan in the study area, which is surrounded by main axis roads in the Central region of Melikgazi District of Kayseri Province. The evaluation takes into account population density, transportation facilities, and technical infrastructure services. The public facilities include health facilities, green areas, kindergarten areas, primary school areas, secondary school areas, high school areas, and mosque areas. This study presents and discusses the results of Weighted Overlay and Weighted Sum analyses, as well as suitability results, using GIS and AHP integration for evaluation purposes.

The evaluation of the suitability of the proposed public facilities in the zoning plans was based on determined criteria that considered both previous studies and the characteristics of the study area. Additionally, the identification of areas requiring new public facilities was conducted. The analysis revealed that the primary school and mosque areas in the study area are suitable and sufficient, while the health facilities, green areas, kindergarten areas, middle school areas and high school areas are not suitable and sufficient and require new facilities.

In urban areas, the suitability of public facilities is directly impacted by population density. Therefore, when determining new settlement areas in cities and making initial zoning plans, the number and spatial distribution of public facilities should be determined in accordance with the density decisions assigned for the population. In areas with low population density, appropriate results may be produced by spatial distribution according to the walking distances determined by the legislation. However, in areas with high population density, a more detailed evaluation of the need is necessary.

The study conducted both Weighted Overlay and Weighted Sum analyses to compare suitability based on determined criteria. The results varied depending on whether the entered value was an integer or not. Weighted Overlay analysis is more appropriate for land suitability analyses in large areas. It is recommended for selecting locations for uses that require large areas, such as solar energy fields, landfills, livestock farms, shopping centers, airports, and hospitals that serve on a regional scale. It is also useful for issues that benefit on a national scale, such as disaster management. However, the Weighted Sum analysis is more suitable for smaller urban areas, such as districts, towns, and neighborhoods, when selecting sites for stores, markets, pedestrian/bicycle paths, public transportation stops, charging stations, and parking areas, as it produces more detailed results.

It was concluded that the results of the Weighted Overlay analysis would be more useful in the study area. Therefore, the analysis was re-evaluated for each public facility by overlapping their locations, population distribution, and unpopulated areas where residential use is not allowed. This was done to gain a clearer understanding of the areas that require attention.

The analyses' findings will guide local governments in revising zoning plans or urban renewal projects. They will also determine the areas and types of public facilities that should be prioritized in investment planning by including needs and cost inputs.

## 6.2 Societal Impact and Contribution to Global Sustainability

As urban populations grow, public facilities providing essential services such as healthcare, education, and recreation become inadequate to meet the needs of the people without interruption. Public facilities that are considered suitable when zoning plans are drawn up are no longer able to meet needs as conditions change over time. Therefore, the preferences of local governments and city dwellers may change. While local governments prioritize investments to meet the housing, transportation, and infrastructure needs of the growing population, city residents prefer public facilities located in different regions, which are far away from them. These preferences result in more construction sites and increased traffic density due to private vehicle usage. This results in a decrease in public areas, destruction of the natural environment and increased pollution. Furthermore, in social terms, it also results in a reduction of social interaction, which is a fundamental human need, as public common areas are reduced.

The provision of public facilities in urban areas, in terms of both quantity and spatial distribution, can have a positive impact on the physical and social environment. It is important to ensure that these facilities are accessible and sufficient to meet the needs of urban residents.

The suitable spatial distribution of public facilities for each need in a residential area will also ensure the protection of the physical environment. In this study, it is recommended that green areas be located within a walking distance of 50 meters and other facilities within 250 meters. This will enable residents to access the facilities on foot, reducing the need for private vehicles and alleviating traffic density. Having 10,000 $m^2$ of green areas with a high density of trees within a 50-meter walking distance in any residential area will contribute to the reduction of air pollution. Additionally, it will be effective in protecting the natural environment by ensuring carbon absorption, temperature balancing, and rainwater mixing into the soil.

The suitable distribution of public facilities will also contribute to the social development of the settlement areas. Effective communication among individuals utilizing shared public areas will ensure socio-cultural development. Furthermore, the inclusion of 10,000 $m^2$ of green space featuring landscaping, seating areas, playgrounds, walking tracks, and sports equipment and fields, will not only facilitate communication among people of all ages, but also promote healthy living and provide opportunities for various recreational activities.

## 6.3 Future Prospects

This study evaluates the suitability of proposed public facilities in the zoning plans of Kayseri Province's Melikgazi District, based on the existing zoning plans. Based on the construction rights determined in this plan, population calculations were made and density values were obtained. In addition, the location, number and distribution of public facilities are also determined by these zoning plans. Due to changes in planning decisions to be made by Melikgazi Municipality, urban renewal projects to be developed, renewals of legal regulations, etc., the analysis results obtained in this study will also change and the analysis will need to be reconsidered in the future.

For this study, AHP method, which is one of the multi-criteria decision making mechanisms, was preferred. Fuzzy logic could also be integrated into such studies, and other multi-criteria decision-making mechanisms may also be useful for suitability assessment.

The study area chosen for suitability evaluation has low slope characteristics and no geological elements that would restrict urban settlement choices within its boundaries. Therefore, it is difficult to determine how these factors would affect the suitability of public facilities. In future studies of similar issues, selecting study areas with geological constraints will enable more detailed evaluation of suitability analyses and site selection decisions.

In Turkiye, population data are determined based on the boundaries of settlement areas such as neighborhoods, districts and cities. However, if the boundaries of the study area are determined by selecting a specific region rather than settlement areas, issues may arise in terms of population data accuracy. Therefore, in this study, population data was obtained through calculations based on residential blocks. However, future studies on similar issues that provide population data separated by age groups would enable the evaluation of the suitability of public facilities in the context.

In future studies, the methodology for evaluating suitability could include information on the capacity of public facilities, such as 3-doctor health centers, 24-classroom schools, and 1000-person mosques.

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SELECTED PUBLICATIONS AND PRESENTATIONS

**J1)** F. Aldemir, E. Yılmaz, and M. Akin, Examples of Geological Surveys in Urban Areas using GIS Applications published in NEVU Journal of Engineering and Architecture (July. 2023).