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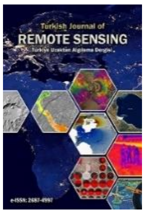

Suitability Analysis based on GIS and AHP for Urban Development Projects

Sinan Levend[*1], **Mehmet Akif Sağ** [1]

[1]*Konya Technical University, Architecture and Design Faculty, Urban and Regional Planning Department, Konya, Türkiye*

Keywords
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Suitability Analysis
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ABSTRACT

As urban areas grow, natural areas around the city become more vulnerable to degradation. Therefore, adopting an approach that balances protection and usage without harming the natural environment is essential to ensure that urban development projects are produced sustainably. For this reason, it is crucial that the suitability analysis, in which the factors related to the planning area are systematically evaluated and integrated, is decisive in determining the urban development areas. In this study, suitability analysis based on Geographic Information System (GIS) and Analytical Hierarchy Process (AHP) was produced for the "Bizim Şehir Project" in Konya. Within the scope of the suitability analysis, six factors were evaluated: soil characteristics, geological conditions, natural disasters, aspect analysis, slope analysis, and property analysis. First, thematic maps were produced and standardized for each factor using GIS. Then, using the AHP method, the percentages of factors affecting the suitability analysis were determined. Finally, by using the spatial analysis capability of GIS, the factors were integrated according to the determined percentage weights and the suitability analysis was produced. The results showed that 54.9% of the case area was suitable for development. This study proposes a method for designing sustainable living areas using suitability analysis.

Kentsel Gelişim Projeleri için CBS ve AHP Tabanlı Uygunluk Analizi

Anahtar Kelimeler:
Kentsel Gelişim Projeleri
Uygunluk Analizi
CBS
AHP
Konya

ÖZ

Kentsel alanlar büyüdükçe, kentin çevresindeki doğal alanlar bozulmaya karşı daha savunmasız hale gelmektedir. Doğal çevreye zarar vermeden koruma ve kullanma arasında denge kuran bir yaklaşımın benimsenmesi, kentsel gelişim projelerinin sürdürülebilir bir şekilde üretilmesini sağlamak için gereklidir. Bu nedenle kentsel gelişim alanlarının belirlenmesinde, planlama alanına ilişkin faktörlerin sistematik olarak değerlendirilip, bütünleştirildiği uygunluk analizinin tercih edilmesi kritik öneme sahiptir. Bu çalışmada Konya'da "Bizim Şehir Projesi" için Coğrafi Bilgi Sistemi (CBS) ve Analitik Hiyerarşi Sürecine (AHP) dayalı uygunluk analizi üretilmiştir. Uygunluk analizi kapsamında toprak özellikleri, jeoloji yapı, doğal afetler, bakı, eğim ve mülkiyet durumu olmak üzere altı faktör değerlendirilmiştir. CBS kullanılarak her bir faktör için tematik haritalar üretilmiş ve standardize edilmiştir. Daha sonra AHP yöntemi kullanılarak uygunluk analizini etkileyen faktörlerin analizi etkileme yüzdelikleri belirlenmiştir. Son olarak, CBS'nin mekânsal analiz kabiliyeti kullanılarak faktörler belirlenen yüzde ağırlıklarına göre bütünleştirilmiş ve uygunluk analizi üretilmiştir. Sonuçlar, örneklem alanın %54,9'unun gelişme/imar için uygun olduğunu gösterdi. Bu çalışma, sürdürülebilir yaşam alanları tasarlamak için uygunluk analizinin üretilmesine yönelik bir yöntem önermektedir.

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***Corresponding Author:** Sinan Levend, sinanlevend@gmail.com, +90 332 205 11 11

1. INTRODUCTION

Sustainability means limiting the damage to natural resources and structures caused by human activities while ensuring that we can meet our future needs in a balanced way (Brundtland & Khalid, 1987). However, unplanned urban growth and sprawl can harm the environment, putting pressure on agricultural areas, forests, and watersheds on the periphery of cities (Malczewski, 2006; Saha & Roy, 2021). That is why planning is crucial for sustainable urban development. Planning helps us find the best way to achieve a specific goal when faced with a problem or situation and involves deciding how to implement these actions (Aydemir, 1999; Ersoy, 2007; Tekel & Altıntaş, 2011; Keskinok, 2020). Urban planning is a multidisciplinary field that requires strategic decision-making at different levels to shape cities (Healey, 2006). Since the publication of the Brundtland Report in 1987, sustainability has been the guiding principle for urban planning activities.

Planning aims to make sustainable decisions for urban development. The future success of urban plans depends heavily on considering scientific data and rationality (Keskinok, 2020). The planning process typically involves research (data collection), analysis and synthesis of the current situation, and decision-making through developing alternatives and implementation (Çalışkan, 2017; Şahin, 2020). The success of the planning process relies on the first step since it determines the success of the following steps and the outcome. Therefore, it is crucial to analyze the planning area with analytic techniques for the proper execution of the planning process (Alkay, 2014).

As a scientific discipline, planning should be conducted rationally. In order to make informed decisions, planners need to analyze the current situation in the planning area holistically and in line with the purpose determined in the planning process. To determine the appropriate location for construction within the context of urban development projects and sustainability principles, planners must evaluate a large number of parameters and information, both quantitative and qualitative. Analytical techniques, such as spatial analysis, data analysis, and mathematical models, are used in the planning process to reach conclusions related to the study area (Çubukçu, 2017). By overlapping these analyses, the planner produces various analyses (maps) considering the factors and determines the appropriate construction areas. However, producing analyses can be complicated depending on the size and nature of the study area. To meet this challenge, planners use GIS's ability to process and integrate complex data. By analyzing and integrating various factors related to the planning area in the GIS environment, planners can determine the most suitable land for construction.

This study aims to develop a robust spatial decision support system for assessing suitability by integrating the AHP, a multicriteria decision analysis approach, into GIS. The study presents the suitability analysis for the Bizim Şehir Project, an urban development initiative within the Selçuklu Municipality of Konya. The spatial analysis tools and mapping capability of GIS software were used to conduct the suitability analysis for the urban development project. In this process, the AHP method was employed to establish the priorities of the factors contributing to the suitability analysis. These priorities were determined through a survey with 14 participants from the three main areas of expertise that shape the space: Architecture, Urban Planning, and Geomatics Engineering. Integrating AHP and GIS in the decision-making process for the Bizim Şehir Project facilitated the identification of suitable areas for construction in the urban development project. The findings of this study provide valuable insights into suitability analyses for urban development projects and contribute to the transparency and acceptability of the decision-making technique.

2. SUITABILITY ANALYSIS

During the planning process, data from various institutions regarding the planned area is transformed into understandable and usable information through several processes (Şahin, 2020). This information includes visual aids such as graphics, diagrams, and maps produced by collecting and analyzing data on the natural, built, and socio-economic environments. Factors such as topography, water resources, climate, geological structure, and soil quality are considered in analyzing the natural environment. In addition, factors such as land use, density, ownership, environmental problems, transportation, and infrastructure related to the existing construction in the planning area are discussed for the built environment. Finally, the socio-economic environment analysis covers the demographic, social, and economic structure, lifestyles, migration analysis, expectations, and priorities of the society (Okumuş, 2014). The diagrams and maps produced in this analysis process facilitate stakeholder involvement in decision-making, directly affecting the planning process's success.

Suitability analysis is a commonly used tool in determining suitable areas for settlement in the planning process for sustainable urban development (Özügül, 2012). Experts in the field evaluate and grade factors used in suitability analysis systematically. They provide data on factors such as land use, geology, geomorphology, slope, soil type, and land ownership, and produce maps. Integrating GIS and AHP evaluates the relevant factors holistically and produces a suitability analysis (Malczewski, 2006). Data collection and processing have become more analytical and faster thanks to developing science and technology. Therefore, GIS is an essential tool in planning to create a spatial decision support system, make data-driven queries, analyze spatial data, and produce maps to present final products.

Factors used in suitability analysis are standardized and synthesized according to the weight values determined in line with the purpose of the study (Saha & Roy, 2021). This spatial analysis plays a crucial role in determining the most suitable areas by analyzing the spatial data related to the area to be planned, taking into account environmental sustainability. As a result, a detailed image of the most suitable areas for the determined purpose is produced, while a spatial model is generated in which the unusable or less preferred areas are filtered (Kumar & Shaikh, 2013; AlFanatseh, 2021).

An expenditure and weighting system can be applied to determine the criteria used during the suitability analysis and end product management (Kumar & Shaikh, 2013). AHP is the most widely used method among multicriteria decision-making methods as it reduces the time and effort required (AlFanatseh, 2021). It can be integrated into the suitability analysis in two ways (Malczewski, 2004). The first method uses it for the initial suitability analysis to weigh and estimate the appropriate parameters. The second method is determining how much the particles are weighted appropriately and affect the suitability analysis produced.

When designing for sustainable urban development, it is crucial to consider and analyze various criteria. In Türkiye, the Spatial Plans Construction Regulation of 2014 mandates threshold analysis when preparing zoning plans and using it as primary data in forming plan decisions (Mekânsal Planlar Yapım Yönetmeliği, 2014). This regulation emphasizes the need to superimpose maps such as topography, hydrology, geology, land use, and protection areas related to the planning area. However, the threshold analyses produced during the implementation process are insufficient to determine suitable residential areas in the urban design process. Alternatively, suitability analysis provides more accurate results in determining the suitability of a particular piece of land for the residential area (Al-Shalabi, et al., 2006; Aburas, et al., 2017). Unfortunately, there is no example of suitability analysis in Türkiye's residential area design process. The Bizim Şehir Project's conformity analysis is expected to serve as an example for future studies in Türkiye. Furthermore, the study determined the relative weights of the factors used in the suitability analysis through expert opinions from experienced urban designers and integrated GIS and AHP. The study is expected to contribute significantly to the literature on this topic.

3. METHOD

3.1. Case Study: Bizim Şehir Project

Konya's urban areas population, the seventh largest city in Türkiye by population, is around 1.3 million inhabitants. The city's population structure reflects the growth of its industrial sector. As a result, numerous urban development projects are being undertaken as the population increases. One such project is Bizim Şehir, located in the western periphery of Konya's urban area and serving as the focus of this study (see Figure 1). At around 350 hectares, Bizim Şehir Project aims to create a sustainable, livable residential area.

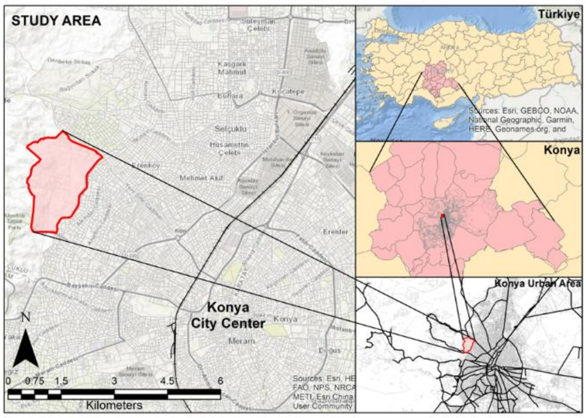

Figure 1. Location of the case study

The suitability analysis presented in the study was produced as part of the analysis and synthesis phase of the urban development project called Bizim Şehir - Konya. The Bizim Şehir Project is an initiative of the Ministry of Environment and Urbanization aimed at exploring the idea of the "*city of future & future of the city*" and the principles of urban planning that can effectively combine past and future developments. Its vision is to bring together the city's historical and contemporary dynamics for a sustainable future. In line with this vision, the Ministry of Environment and Urbanization requested the preparation of "*a plan, project and urban design guide which functions systematically, protects the local identity of the city, meets the needs of the age, is sustainable and includes spatial arrangements with a high quality of life for an area of approximately 350 hectares within Konya Province's Selçuklu District, Sarayköy Neighborhood*" from Selçuk University. A group of professionals from Selcuk University, including architects, engineers, urban planners, and sociologists, worked together on the project. After completing it, they handed it over to the Ministry in 2020.

3.2. Methodology

The Geographic Information System's analysis methods make it easy to produce a suitability analysis for urban planning decisions. This analysis is widely used to evaluate alternative areas to make sustainable decisions by determining the most suitable locations for land use decisions, such as housing, industry and solar farming (Koramaz, 2014; ArcGIS Pro, 2023; ArcGIS, 2023). The suitability analysis is prevalent in urban design because it allows for evaluating many factors in the decision-making process. This is especially important when determining suitable areas for residential use.

When the literature is examined, different methodological approaches have been put forward for suitability analysis for different purposes (Malczewski, 2004; Dong, et al., 2008; Chandio, et al., 2014; Koramaz, 2014; Aburas, et al., 2017; Parry, et al., 2018; AlFanatseh, 2021; Johnston & Graham, 2021; Luan, et al., 2021; ArcGIS Pro, 2023; ArcGIS, 2023). By evaluating these studies, a five-step suitability method was created in this study. (see Figure 2):

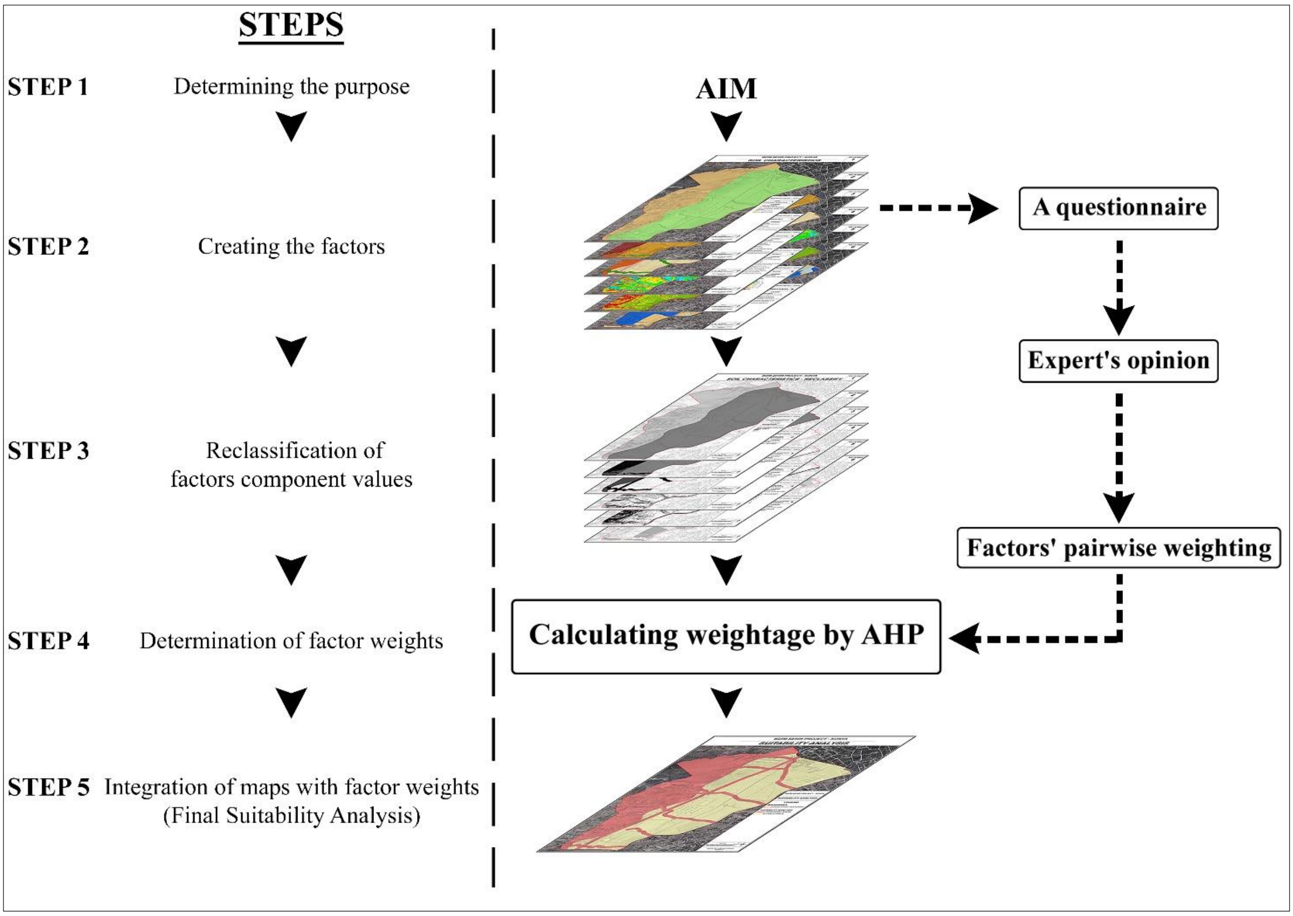

Figure 2. The AHP-Based suitability analysis methodology workflow (visualised by the authors)

Step 1. Determining the purpose:

The purpose of the decision makers (e.g., priority, philosophy) regarding the planning area forms the framework/boundaries of the analysis of suitability for settlement. The decision-makers must determine the factors (analysis) and constraints for settlement suitability analysis. The values/weights assigned to the purpose in the creation process of the analysis are decisive. For example, risk-sensitive location analysis should use detailed data showing the risk factors.

Step 2. Determine and create factors (analyses or limiting criteria):

After the aim of the suitability analysis has been established, the factors related to the analysis should be determined. Each identified factor must be effective in achieving the aim. The factors for suitability analysis are mapped and converted to raster format according to the determined purpose. First, each factor is classified according to its parameters. Then, each factor data is converted to a raster (grid) data type.

Step 3. Standardization and reclassification of parameter values for factors:

At this stage, the analyses related to the field should be reclassified according to a certain standard. Therefore, for the suitability analysis, the factor parameters are reclassified by assigning values between 10 (the most suitable value for settlement) and 0 (the value that cannot be settled) and converted into raster maps. Thus, all factors (analyses) are standardized at specific values.

Step 4. Determination of factor weights in line with the purpose:

For the suitability analysis, a percentage value (with a sum of factor weights of 100) should be assigned to each factor (analysis) to the extent that it affects the suitability analysis. Methods such as AHP can be used to determine the values in question, which allows the evaluation of the many participants' views.

Step 5. Creating a suitability analysis by integrating the analyses with factor weights:

The thematic map is created by integrating the raster data according to the percentage rate (factor weights) determined for each factor (analysis) using the spatial analysis capability of GIS. Thus, suitability analysis is obtained in line with the determined purpose.

This study utilized the Analytic Hierarchy Process (AHP) and Geographic Information System (GIS) to conduct a suitability analysis. These multicriteria decision analysis approaches help create a robust spatial decision support system by prioritizing factors. In addition, GIS enables the creation, storage, association, querying, analysis, and visualization of spatial data and attribute information related to this data in a structured manner (Dunn, 2007; Okumuş, 2014; Malczewski & Rinner, 2015). The suitability analysis for an urban development project was conducted using the GIS software's mapping capabilities and spatial analysis tools. The Konya Metropolitan Municipality provided the data used in the analysis, including property, topography, geology, soil capability, and erosion.

To determine the suitability of a region for a specific use, factors that make up the unique structure of the land are systematically analyzed. Multicriteria decision analysis approaches, such as the AHP method, provide the necessary procedures and techniques for structuring decision problems and forming, evaluating, and prioritizing factors and alternative decisions (Malczewski, 2006; Estoque, 2012). The AHP method in this study is used to objectively determine the weights of the factors that are effective on urban growth and integrated with the GIS environment. The AHP method is a frequently used multicriteria technique in GIS-based analyses for determining the priority weights of factors affecting urban growth (Saaty, 2008; Saaty & Vargas, 2012). The AHP method calculates the priority weights of the factors by comparing all the objective factors in pairwise comparison matrices. (Saaty, 1990; Bhushan & Rai, 2007; Filipović, 2007; Kumar & Shaikh, 2013). To determine the relative weight values for each factor and alternative, the AHP methodology follows the steps of establishing the decision hierarchy, making pairwise comparisons, calculating the factor priorities for each level, checking the consistency ratios, and finalizing the weight values (Saaty, 1989; Saaty, 2008; Saaty & Vargas, 2012; Ullah & Mansourian, 2016).

AHP is a robust and easy-to-understand methodology, making it an ideal tool for group and individual decision-making processes. Integrating with GIS provides an analytical framework for identifying new development areas in urban environments (Levend & Fischer, 2022). To ensure a participatory approach, expert opinions and stakeholder feedback can be integrated into the analytical structure of the suitability analysis. The weights of the factors used for suitability analysis were determined based on information gathered through questionnaires administered to 14 participants with expertise in three main fields: architecture, urban planning, and geomatics engineering.

The study identified the factors affecting the suitability for settling in the case area and created factor maps using the visualization capabilities of GIS. The factors were reclassified and standardized to ensure that the map parameters were comparable and combinable with each other. A joint scale of 0 to 10 was chosen, where higher values indicate more suitable places for urban growth. The weight of each factor affecting the suitability analysis was determined using expert opinions and pairwise comparisons according to the importance of the factors for the factor weights with the AHP method. Finally, using the weighted overlay tool of ArcGIS software, all factor maps were integrated with the line with the weights determined by expert opinions, and the final suitability map was prepared.

3.3. Factors Description

Various factors, such as physical, socio-economic, and environmental structures, influence the design and development of residential areas (Al-Shalabi, et al., 2006). In the Bizim Şehir project, these factors were considered at different stages of the design process. The City 2023 Project (Bizim Şehir - Konya) urban development/design project aims to identify sustainable and livable areas through a suitability analysis considering factors. To achieve this, relevant criteria were carefully chosen for evaluation. The selection process was based on the study's objective, a literature review, experts' opinions, and data availability in the study area. The study evaluated six factors: soil characteristics, geological condition, natural disasters, aspect analysis, slope analysis, and property analysis.

Soil Characteristics

Soil structure is one of the most critical factors in determining settlement areas because of its sensitivity to erosion, surface drainage, and soil fertility. Therefore, decisions regarding site selection for urban use should be based on the compatibility of the proposed function with the soil structure, which leads to a sustainable urban development process. For example, an area well-suited for residential use may not be appropriate for recreational activities (Aburas, et al., 2017; Parry, et al., 2018; McBride, 2019). Thus, settlement areas should be established in areas with low production capacity and soil quality to ensure sustainable urban development.

Geological Condition

The geological structure of the ground plays a crucial role in determining where urban settlements should be built. It affects the bearing capacity of the ground, the construction engineering, and the construction method. Therefore, planning settlements in the most stable geological regions is vital to avoid disaster risks. (McBride, 2019; Deliry & Uygucgil, 2020; Luan, et al., 2021).

Natural Disasters

When choosing areas for settlement, natural disasters such as erosion, earthquakes, and floods should be considered. Areas with a high risk of disaster should not be developed. For example, erosion state maps can show an area's erosion severity (Dong, et al., 2008; Kumar, et al., 2018; Luan, et al., 2021). Geological fault lines should also be considered when planning settlements, and buffer zones should be created to ensure a safe distance from the fault lines. These zones will create conservation areas (Deliry & Uygucgil, 2020). Flooding is another critical factor to consider when choosing a location for structures. Therefore, the hydrological structure should also be considered during the planning process.

Aspect Analysis

Aspect analysis is an essential factor when selecting a site for residential areas. It determines the direction of the land slope. Aspect analysis represents the main directions in the form of north, south, east, west, and intermediate directions related to these directions with general classification. This analysis is used in many design-related issues, such as the positioning of buildings, planting, and ensuring the protection of residential areas from sunlight (Al-Shalabi, et al., 2006; Chandio, et al., 2014; Aburas, et al., 2017; McBride, 2019). Generally, South (S), Southeast (SE), Southwest (SW), East (E) and West (W) aspects in Türkiye are warmer because these aspects receive more sun than the other aspects. On the other hand, the North (N), Northwest (NW) and Northeast (NE) aspects are cooler as they receive few lights. Therefore, it is essential to choose a location compatible with the climate to reduce energy dependence and make maximum use of solar energy. Northern slopes are not preferred because of low radiation levels. In a temperate climate, the upper parts of the southeast-eastern slopes are suitable for settlement in harmony with the climate.

Slope Analysis

The slope is a crucial factor to consider in suitability analysis, as it affects both the visual and functional aspects of construction. Although the slope is primarily related to landscape design, it also significantly determines construction costs, disaster risk, and drainage (Al-Shalabi, et al., 2006; Dong, et al., 2008; Chandio, et al., 2014; Aburas, et al., 2017; Parry, et al., 2018; Akbulut, et al., 2018). To evaluate the slope for different uses and activities, it is categorized according to percentage changes. Generally, the slope classification for construction is as follows: 0-2% is suitable, 2-8% is quite suitable, 8-16% is suitable, but with an upper limit for roads and walkways, 16-24% has significant restrictions, and 24%+ is restricted for residential areas. In addition, different slope categories can be used for particular land use types and facilities (McBride, 2019; Luan, et al., 2021).

Property Analysis

Analyzing properties is crucial in making settlement decisions. When evaluating property data, it is essential to consider both opportunities and constraints related to construction (McBride, 2019). Properties with public land status (such as state and local government) tend to lead to quicker decision implementation.

4. RESULTS AND DISCUSSION

It is essential to identify suitable areas for construction in line with the sustainable urban development approach. In the context of the sample study, various data related to the natural, built and socio-economic environment were systematically evaluated. Six factors were used for suitability analysis, and suitable construction areas were determined using ArcGIS software's weighted overlay tool. Thus, a rational substrate was created for more accurate alternatives and decisions in the decision-making process.

4.1. Determining The Purpose

In the decision-making process, the purpose forms the basis of the settlement suitability analysis. In addition, the purpose determines which analyses are used in assessing the suitability and the weight given to each analysis. The Bizim Şehir Project, which serves as the study's case area, aims to create new living spaces that prioritize human-centred, identity-driven, smart, green, and safe city policies while meeting society's social, cultural, and physical needs. The project aims to design a sustainable settlement that prioritizes ecological and social sustainability, develops the spatial organization of public spaces, is adaptable to global climate changes and unexpected conditions through walkable and accessible transportation options, and integrates tradition and the future through learning and teaching. The primary objective is to use the suitability analysis produced for the Bizim Şehir Project area to determine suitable ecological settlement areas consistent with the principle of sustainability.

4.2. Creating The Factors

In the second stage of the settlement suitability analysis, the factors used for suitability analysis should be determined and mapped in line with the purpose. Then, the maps should be converted to raster format. The factor data used in the study is in vector data format, so six thematic maps were created on the GIS platform. Each factor was classified according to its parameters, resulting in maps for Soil Capability, Geological Structure, Natural Disasters, Aspect Analysis, Slope Analysis, and Property Status (see Table 1). Then, each factor data should be converted to a raster (grid) data type (see Figure 3).

Table 1. Factors, factor weights, factor parameters and standardization value of the parameter

Factors	Factor Weights	Factor Parameters	Standardization Value of Parameter
Soil Characteristics	0.210	II. degree soil lands	5
		VII. degree soil lands	8
Geology	0.228	Geologically unsuitable areas	0
		Stream beds	0
		High slope, transition floors	3
		Alluvial fan	5
Natural Disasters	0.382	II. degree erosion zone	10
		IV. degree erosion zone	2
		Fault avoidance band	0
		Stream band	0
Aspect	0.049	Flat	10
		North (0-22.5 and 337.5-360)	2
		Northeast (22.5-67.5)	4
		East (67.5-112.5)	8
		Southeast (112.5-157.5)	10
		South (157.5-202.5)	10
		Southwest (202.5-247.5)	8
		West (247.5-292.5)	6
		Northwest (292.5-337.5)	4
Slope (%)	0.075	% 0-2	8
		% 2-8	10
		% 8-16	7
		% 16-24	5
		% 24-40	3
		% 40+	0
Property Status	0.056	Public Property (central and local gov.)	10
		Public Property and Private Property	8
		Private Property	7

4.3. Standardizing Parameter Values for Factors and Reclassifying Factors

In this stage, a value ranging from 0 (least suitable for settlement) to 10 (most suitable for settlement) was assigned based on analyzing suitability to the factor parameters. Next, each factor parameter was standardized on a scale of 0 to 10 (see Table 1). These factors were then reclassified based on their standardized values and converted into raster maps (see Figure 4). This step ensures that the field analyses are reclassified based on a set standard for conformity analysis. Table 1 lists the standardization values of the parameters used in the ecologically focused settlement suitability analysis for the Bizim Şehir Project area.

The first analysis focused on the physical structure of the project area is soil capability. The site contained seventh and second-degree soil, classified as marginal agricultural land. Based on this information, a standardized soil capability analysis was conducted, with a high value of 8 assigned to the region with seventh-degree soil and a median value of 5 assigned to the area with second-degree soil.

It is crucial to thoroughly evaluate the geological structure of the ground in the project area, particularly regarding potential disaster risks during construction. As such, alluvial fans, one of the ground condition parameters in the area, were assigned a value of 5. Transition areas with high slopes were given a value of 3. Finally, to prevent settlements in areas with geological quarries (which pose a risk of rockfall) and in stream beds, a standardized value of 0, the lowest possible value, was assigned to the geological structure.

While standardizing natural disasters, the areas with very little erosion, such as secondary-degree erosion areas, are assigned the highest settlement value of 10. Conversely, the areas with severe erosion, such as fourth-degree erosion, are assigned a settlement value of 2. However, the Konya Fault line runs north-south within the study area, and construction is prohibited within the Fault Conservation Band established for this fault line. As a result, the standardization value for this field is taken as 0. Additionally, a 25-meter conservation band has been designated on both sides of the stream beds that may cause natural disasters like the flooding in the area. Since construction is not allowed within this band, the standardization value for the areas within the band lines has been set to 0.

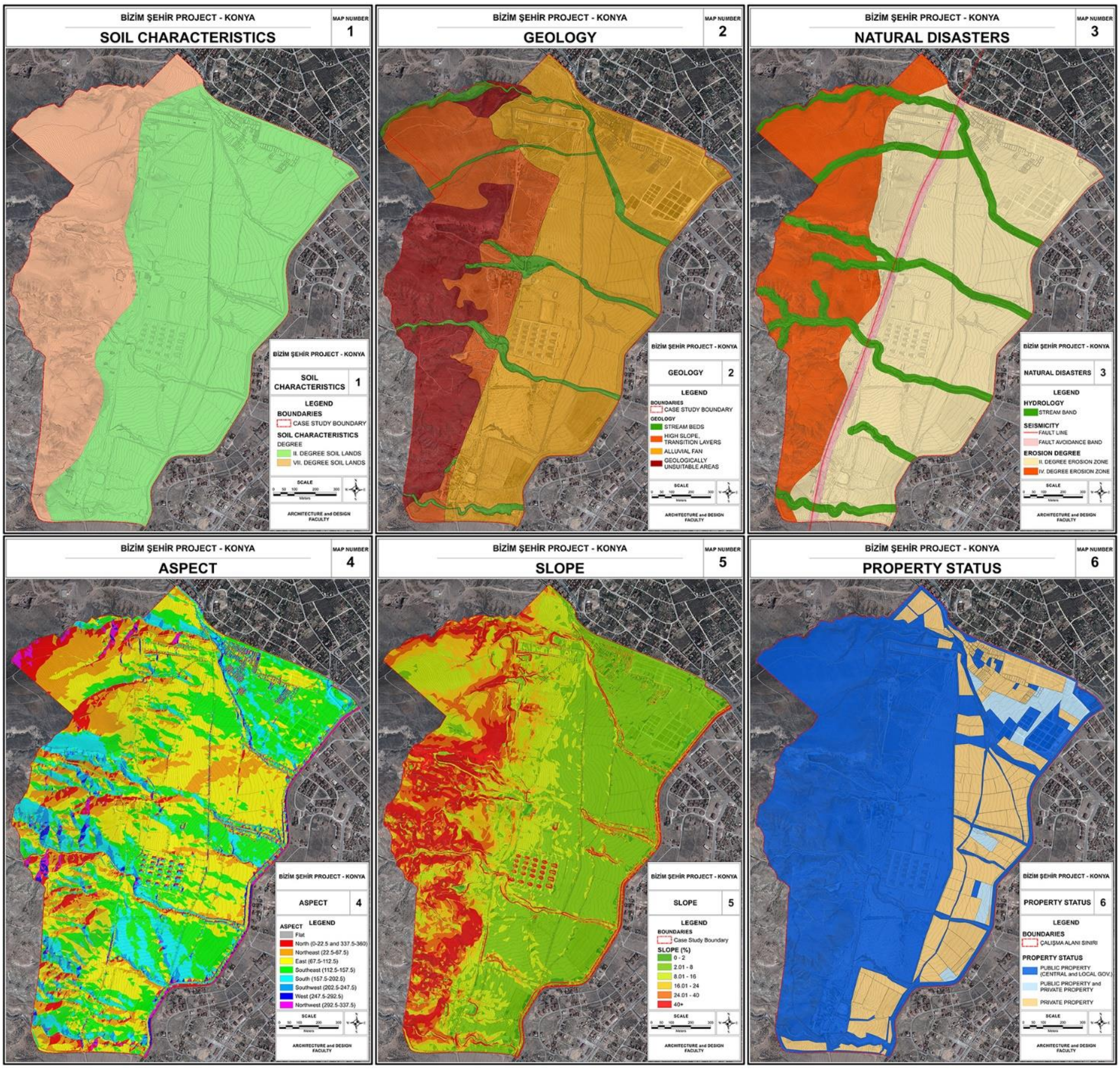

Figure 3. Factors evaluated for suitability analysis; 1) soil characteristics, 2) geology, 3) natural disasters, 4) aspect, 5) slope, 6) property status

In Türkiye, the south and southeast, southwest, east, and west directions (predominantly south and southeast) receive more sunlight and are warmer. Designing houses with these factors in mind can help reduce energy consumption and lower carbon footprint. The cooler fronts, such as the north, northwest, and northeast directions, receive less light, so it is vital to consider a location compatible with the climate to minimize energy dependence and maximize solar energy. Since the northern slopes have a low radiation level, they are not preferred. In a temperate climate, the upper parts of slopes facing southeast and east directions are suitable for settlement in harmony with the climate. To standardize the aspect analysis regarding the placement of residential areas in appropriate directions, the highest value of 10 is assigned to flat areas and areas facing south and southeast (S, SE) directions. The value of 8 is assigned to areas facing southwest and east (SW, E). The median value of 6 is assigned to areas facing the west (W) direction, and the lowest value of 4 is assigned to areas facing northwest and northeast (NW, NE). Finally, the lowest value of 2 is assigned to areas facing north (N).

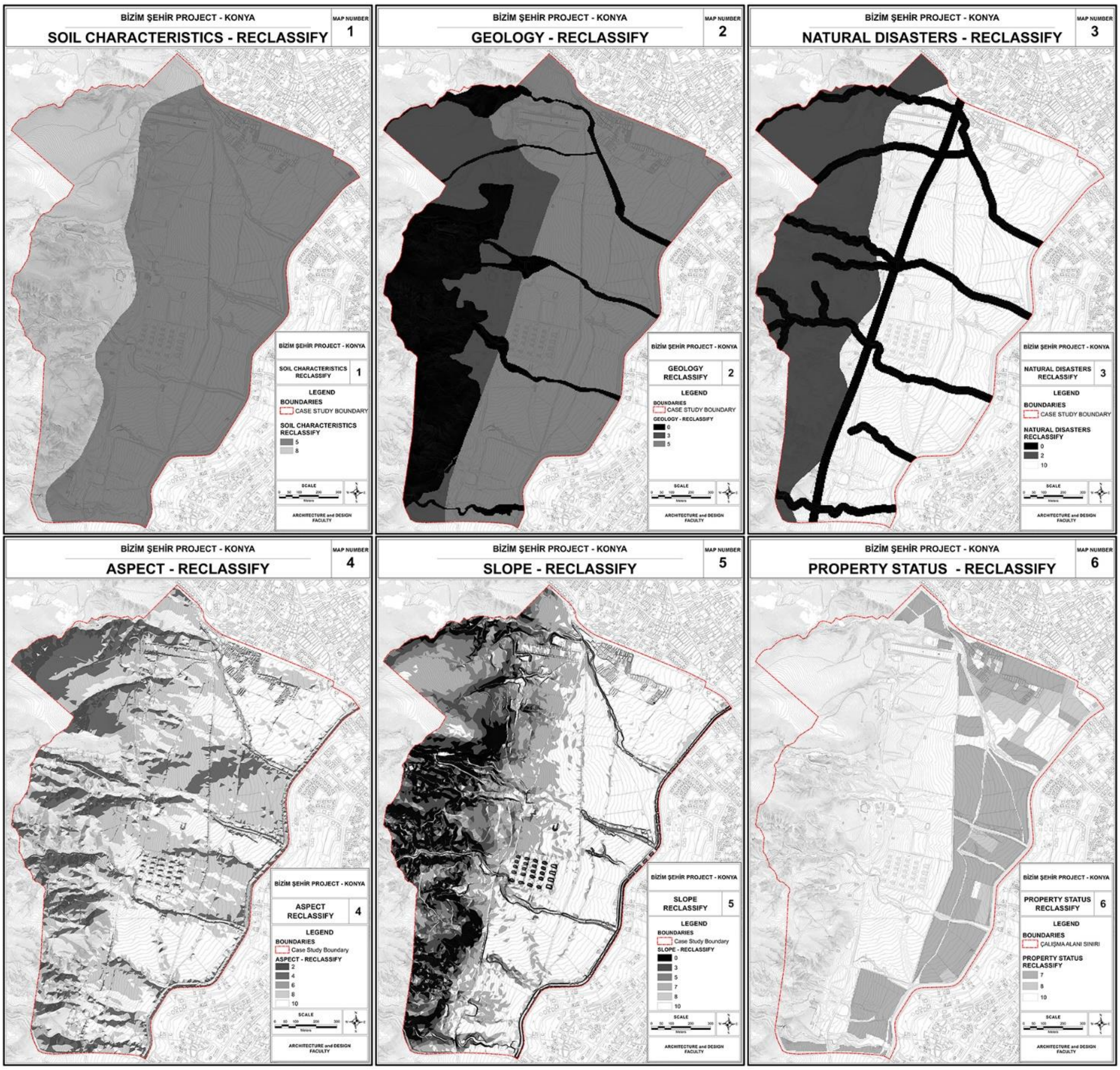

Figure 4. Reclassification of analysis parameters based on the given standardization value

When choosing locations for residential areas, it is essential to consider the slope. Therefore, a score of 8 is given to areas with a slope percentage between 0-2%, 10 for areas with a slope of 2-8%, 7 for areas with a slope of 8-16%, 5 for areas with a range of 16-24%, and 3 for fields in the range of 24-40%. For areas with a slope percentage over 40%, the score is 0. The slope analysis was standardized using these values. Finally, to standardize the property status analysis, the standardization value of public property is 10, the standardization value of public and privately owned property is 8, and the value of private property is 7, among the analysis parameters.

The standardization values of Soil Characteristics, Geology, Natural Disasters, Aspect, Slope, and Property Status analyses used within the scope of settlement suitability analysis are explained above. In addition, these analyzes were classified by the reclassification method, one of the spatial analyzes of geographic information systems. Thus, the values of the parameters of all analyzes were standardized between 0 and 10 (Figure 4).

4.4. Determination of Factor Weights in Line with the Purpose

In producing the suitability analysis, after the factor parameters are standardized, the factors should be integrated using the analysis infrastructure of the geographic information system. At this stage, in line with the suitability analysis's purpose, the factors' effects on the settlement suitability analysis were determined as percentages. These percentages were determined using the AHP method. The Bizim Şehir Project aims to determine the areas suitable for settlement with an ecological focus in line with the principle of sustainability. In this context, the opinions of 14 experts who were informed about the purpose and vision of the project were taken. With a questionnaire prepared for the AHP method, experts were asked to compare the factors pairwise using Saaty's 1-9 ratio scale (Saaty, 1990). The pairwise comparison values of the experts for the factors were entered into a table, and the geometric average was taken (Ullah & Mansourian, 2016). Thus, a single pairwise value was obtained for each pairwise comparison of the factors, and the pairwise comparison matrix was created (Table 2). The Super Decision program was used for all calculations made within the scope of AHP.

When the weights of the factors constituting the conformity analysis with the AHP method are calculated, it is seen that natural disasters are the most critical factors, with a value of 38.2% (Table 2). After natural disasters, factor weights are listed as geological conditions (22.8%), soil characteristics (21.0%), slope analysis (7.5%), property analysis (5.6%) and aspect analysis (4.9%).

Table 2. The pairwise comparison matrix and Factors' Priorities

	Soil Characteristics	Geology	Natural Disasters	Aspect	Slope	Property Status
Soil Characteristics	1	1	1/2	4	3	4
Geology	1	1	1/2	5	3	5
Natural Disasters	2	2	1	7	5	6
Aspect	1/4	1/5	1/7	1	1/2	1
Slope	1/3	1/3	1/5	2	1	1
Property Status	1/4	1/5	1/6	1	1	1
FACTORS	Soil Characteristics	Geology	Natural Disasters	Aspect	Slope	Property Status
PRIORITIES	% 21.0	% 22.8	% 38.2	% 4.9	% 7.5	% 5.6
						Consistency Ratio (CR)= % 0.8

4.5. Creation of Suitability Analysis

The results of the suitability analysis can differ depending on the intended purpose or scenario. Therefore, the assigned values or weights of the objective-related factors play a decisive role in the analysis creation process. In the final stage of preparing the suitability analysis, standardized and reclassified factors and determined factor weights were integrated using spatial analyst tools like map algebra and raster calculator. Suitability analysis was then obtained by integrating factors based on their percentage weights (see Figure 5).

By utilizing Geographical Information Systems and the Analytic Hierarchy Process method, a multicriteria decision analysis method, the suitability values for settlement varied between 1.5 and 7.8. When evaluated in terms of sustainability, the threshold for settlement suitability was determined to be 5.5. Areas below the value of 5.5 were deemed unsuitable for settlement, while areas above 5.5 were deemed suitable (see Figure 5). These results indicated that 54.9% of the case area was suitable for development (200.9 ha), and 45.1% was unsuitable (165.1 ha). Analysis of the settlement suitability revealed that high slope areas, stream beds, and areas within the fault conservation band in the west of the project area were unsuitable for settlement. Conversely, areas to the east of the project area with a relatively low slope facing south, southeast, and east were suitable for settlement.

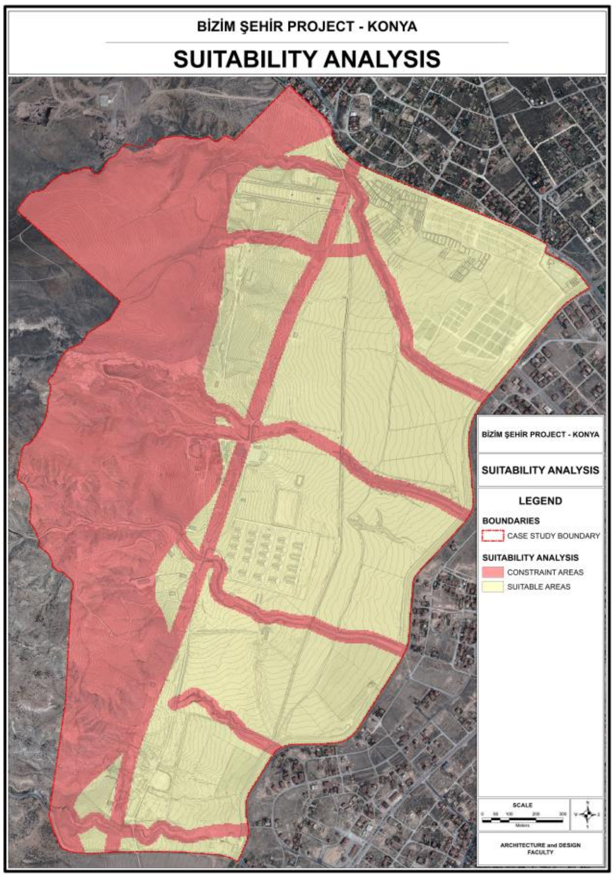

Figure 5. Suitability Analysis: reclassification of analysis parameters based on the given standardization value

5. CONCLUSIONS

Sustainable and livable human settlements can only be put forward with an objective planning approach. Therefore, analysis and synthesis studies, such as suitability analysis, play a crucial role in the success of the design process. The suitability analysis integrates multiple factors affecting construction based on specific weight values, minimizing resource waste in the urban development process. The spatial model generated by the suitability analysis provides decision-makers with a systematic integration of many factors, making each factor's effects visible. This approach enables decision-makers to make more accurate decisions. Within this framework, a suitability analysis based on GIS and AHP was conducted for the Bizim Şehir Project area. The suitability analysis showed that 54.9% of the Bizim City Project area is suitable for development/zoning.

The suitability analysis produced, based on GIS and AHP, provides insights into sustainable urban development and highlights the limitations of the study area in terms of urban development. However, it is essential to remember that the settlement suitability analysis is not a result but a tool to increase the decision makers' capacity to make the right decision. The map obtained by the suitability analysis is not a plan but a synthesis created by integrating data that guides planning and design. Therefore, the relationship between the planned area and the rest of the city should be evaluated before making policy decisions regarding the planning area in line with the sustainability principle. Data on the socio-economic environment should also be analyzed using the correct methods. The planning process is a discipline that should include physical and technical actions and decisions with a strong social dimension. Therefore, the social dimension must not be ignored.

In the planning process of the city, a social phenomenon, it is not sufficient to analyze the physical structure of the planning area with a quantitative approach. Nevertheless, qualitative analyses are necessary to understand the lifestyles and cultures of people and society in the planning process. Also, involving the public in the planning process through participatory methods and identifying the needs and priorities of stakeholders is another critical component of making the right decision.

The suitability analysis conducted within the scope of the study was for the project area of Bizim Şehir, an urban design project. It is important as an example for future sustainable-oriented urban development projects. Additionally, the methodology used in the study can be used to identify suitable areas for different functions.

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Author contributions

S. Levend: He designed the research, collected the datasets, analyzed the data, and wrote;
M. A. Sağ: He designed and investigated the research and reviewed and edited the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

Declaration of research and publication ethics

In the study, the authors declare that there is no violation of research and publication ethics and that the ethics committee permission document of the study has been submitted to the journal.

REFERENCES

Aburas, M. M., Abdullah, S. H., Ramli, M. F., & Asha'ari, Z. H. (2017). Land suitability analysis of urban growth in Seremban Malaysia, using GIS based analytical hierarchy process. *Procedia engineering*, 198, pp. 1128-1136.

Akbulut, A., Ozcevik, O., & Carton, L. (2018). Evaluating suitability of a GIS–AHP combined method for sustainable urban and environmental planning in Beykoz district, Istanbul. *International Journal of Sustainable Development and Planning*, 13(8), pp. 1103–1115.

AlFanatseh, A. (2021). Land suitability analysis of urban development in the Aqaba area, Jordan, using a GIS-based analytic hierarchy process. *GeoJournal*, pp. 1-17.

Alkay, E. (2014). Giriş. In E. Alkay, *Şehir Planlamada Analiz ve Değerlendirme Teknikleri* (pp. 11-15). İstanbul: Literatür.

Al-Shalabi, M. A., Mansor, S. B., Ahmed, N. B., & Shiriff, R. (2006). GIS based multicriteria approaches to housing site suitability assessment. *XXIII FIG congress, shaping the change*, (pp. 8-13). Munich, Germany.

ArcGIS. (2023, 05 13). Site suitability analysis. ArcGIS: https://doc.arcgis.com/en/imagery/workflows/resources/site-suitability-analysis.htm

ArcGIS Pro. (2023, 05 13). The general suitability modeling workflow. ArcGIS Pro: https://pro.arcgis.com/en/pro-app/latest/help/analysis/spatial-analyst/suitability-modeler/the-general-suitability-modeling-workflow.htm

Aydemir, Ş. (1999). Planlama ve planlama Türleri. In Ş. Aydemir, *Kentsel Alanların Planlanması ve Tasarımı* (pp. 33-40). Trabzon: Akademi.

Bhushan, N., & Rai, K. (2007). *Strategic decision making: applying the analytic hierarchy process*. London: Springer.

Brundtland, G. H., & Khalid, M. (1987). *Our common future*. Oxford, GB: Oxford University Press.

Chandio, I. A., Matori, A. N., Yusof, K., Talpur, H. M., & Aminu, M. (2014). GIS-basedland suitability analysis of sustainable hillside development. *Procedia Engineering*, 77, pp. 87-94.

Çalışkan, O. (2017). Kentsel Tasarım. In S. S. Özdemir, Ö. B. Özdemir Sarı, & N. Uzun, *Kent Planlama* (pp. 387-428). Ankara: İmge.

Çubukçu, K. M. (2017). Kent Planlamada Nicel Teknikler. In S. S. Özdemir, Ö. B. Özdemir Sarı, & N. Uzun, *Kent planlama* (pp. 537-560). Ankara: İmge.

Deliry, S. I., & Uyguçgil, H. (2020). GIS-Based land suitability analysis for sustainable urban development: A case study in Eskisehir, Turkey. *Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi*, 20(4), pp. 634-650.

Dong, J., Zhuang, D., Xu, X., & Ying, L. (2008). Integrated evaluation of urban development suitability based on remote sensing and GIS techniques–a case study in Jingjinji Area, China. *Sensors*, 8(9), pp. 5975-5986.

Dunn, C. (2007). Participatory GIS—a people's GIS? *Progress in human geography*, 31(5), pp. 616-637.

Ersoy, M. (2007). Planlama Kuramına Giriş. In M. Ersoy, *Kentsel Planlama Kuramları* (pp. 9-34). Ankara: İmge.

Estoque, R. (2012). Analytic hierarchy process in geospatial analysis. In Y. Murayama, *Progress in geospatial analysis* (pp. 157-181). Springer: Springer.

Filipović, M. (2007). The analytic hierarchy process as a support for decision making. *Spatium*, pp. 44-59.

Healey, P. (2006). U*rban complexity and spatial strategies: Towards a relational planning for our times*. London: Routledge.

Johnston, K. M., & Graham, E. (2021). ArcGIS Spatial Analyst–Suitability Modeling. *Esri International User Conference* (pp. 1-67). California: Esri.

Keskinok, H. Ç. (2020). Farklı Kademelerde Bölge ve Kent Planlama. In M. Şenol Balaban, *Kent, Planlama ve Afet Risk Yönetimi* (pp. 28-57). Eskişehir: Anadolu Üniversitesi.

Koramaz, T. K. (2014). Uygunluk Analizi. In E. Alkay, *Şehir Planlamada Analiz ve Değerlendirme Teknikleri* (pp. 129-139). İstanbul: Literatür.

Kumar, A., Sharma, R. K., & Kuma, V. (2018). Landslide hazard zonation using analytical hierarchy process along National Highway-3 in mid Himalayas of Himachal Pradesh, India. *Environmental Earth Sciences*, 77(20), pp. 1-19.

Kumar, M., & Shaikh, V. R. (2013). Site suitability analysis for urban development using GIS based multicriteria evaluation technique. *Journal of the Indian Society of Remote Sensing*, 41(2), pp. 417-424.

Levend, S., & Fischer, T. B. (2022). Determining People's Design Priorities for Neighbourhood Units: A Study in Liverpool, Merseyside. *ICONARP International Journal of Architecture and Planning*, 10(1), pp. 21-42.

Luan, C., Liu, R., & Peng, S. (2021). Land-use suitability assessment for urban development using a GIS-based soft computing approach: A case study of Ili Valley, China. *Ecological Indicators*, 123, pp. 107333.

Malczewski, J. (2004). GIS-based land-use suitability analysis: a critical overview. *Progress in planning*, 62(1), pp. 3-65.

Malczewski, J. (2006). GIS-based multicriteria decision analysis: a survey of the literature. *International journal of geographical information science*, 20(7), pp. 703-726.

Malczewski, J., & Rinner, C. (2015). *Multicriteria decision analysis in geographic information science*. New York: Springer.

McBride, S. B. (2019). *Site Planning and Design*. West Virginia University. https://researchrepository.wvu.edu/rri-web-book/1

Mekânsal Planlar Yapım Yönetmeliği. (2014). *Mekânsal Planlar Yapım Yönetmeliği*. Ankara: Resmî Gazete (Sayı: 29030). https://www.resmigazete.gov.tr/eskiler/2014/06/20140614-2.htm

Okumuş, G. (2014). Planlamada Analiz Teknikleri ve Coğrafi Bilgi Sistemleri. In E. Alkay, *Şehir Planlamada Analiz ve Değerlendirme Teknikleri* (pp. 17-32). İstanbul: Literatür.

Özügül, M. D. (2012). Ekolojik planlama. In M. Ersoy, *Kentsel Planlama Ansiklopedik Sözlük* (pp. 107-112). İstanbul: Ninova.

Parry, J. A., Ganaie, S. A., & Bhat, S. M. (2018). GIS based land suitability analysis using AHP model for urban services planning in Srinagar and Jammu urban centers of J&K, India. *Journal of Urban Management*, 7(2), pp. 46-56.

Saaty, T. (1989). Group decision making and the AHP. In T. Saaty, *The Analytic Hierarchy Process* (pp. 59-67). Berlin: Springer.

Saaty, T. (1990). How to make a decision: the analytic hierarchy process. *European journal of operational research*, 48(1), pp. 9-26.

Saaty, T. (2008). Decision Making With The Analytic Hierarchy Process. *International Journal of Services Sciences*, 1(1), pp. 83-98.

Saaty, T., & Vargas, L. (2012). *Models, methods, concepts & applications of the analytic hierarchy process*. London: Springer Science & Business Media.

Saha, A., & Roy, R. (2021). An integrated approach to identify suitable areas for built-up development using GIS-based multi-criteria analysis and AHP in Siliguri planning area, India. *SN Applied Sciences*, 3(4), pp. 1-17.

Şahin, S. Z. (2020). Planlamada Yerel Yönetimlerin Sorumlulukları. In M. Şenol Balaban, *Kent, Planlama ve Afet Risk Yönetimi* (pp. 56-85). Eskişehir: Anadolu Üniversitesi.

Tekel, A., & Altıntaş, Y. (2011). Türk İmar Mevzuatı'nda Tanımlanan Plan Türleri ve Yetkili Kurumlar. In Ç. Varol, A. Gürel Üçer, & A. Uğurlar, *Yasal ve Yönetsel Boyutlarıyla Planlama* (pp. 79-91). Ankara: BİB.

Ullah , K. M., & Mansourian, A. (2016). Evaluation of land suitability for urban land-use planning: case study Dhaka City. *Transactions in GIS*, 20(1), pp. 20-37.